IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION
No. 7:23-CV-897

IN RE:	**NOTICE OF CONTINUATION OF FILING ADDITIONAL EXHIBITS REGARDING UNITED STATES' MOTION TO EXCLUDE PLAINTIFFS' PHASE I EXPERT TESTIMONY IN SUPPORT OF USING ATSDR'S WATER MODELS TO DETERMINE EXPOSURE LEVELS FOR INDVIDUAL PLAINTIFFS**
CAMP LEJEUNE WATER LITIGATION	
This Document Relates To: **ALL CASES**	

The United States files this Notice of Continuation of Filing Additional Exhibits in support of its Motion to Exclude Plaintiffs' Phase I Expert Testimony in Support of Using ATSDR's Water Models to Determinate Exposure Levels for Individual Plaintiffs and Memorandum in Support.

[Signature page to follow.]

Dated: April 29, 2025

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CERTIFICATE OF SERVICE

I hereby certify that on April 29, 2025, I electronically filed the foregoing using the Court's Electronic Case Filing system, which will send notice to all counsel of record.

/s/ Haroon Anwar
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1	Mary P. Anderson & William W. Woessner, *Applied Groundwater Modeling: Simulation of Flow and Advective Transport* (2d ed. 2015)
2	Feb. 13, 2025, Deposition Transcript of R. Jeffrey Davis
3	Jan. 16, 2013, Letter from ATSDR to Veterans Affairs
4	Aug. 3, 2015, Veteran Affairs Press Release
5	Expert Report of Morris Maslia
6	Rebuttal Report of Morris Maslia
7	March 28, 2005, ATSDR Expert Panel Transcript (Day 1)
8	March 29, 2005, ATSDR Expert Panel Transcript (Day 2)
9	April 29, 2009, ATSDR Expert Panel Transcript (Day 1)
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11	Expert Report of Mustafa Aral
12	Feb. 25, 2025, Deposition Transcript of Leonard F. Konikow
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18	*The Handbook of Groundwater Engineering*, Chapter 20 on Groundwater Modeling by Leonard F. Konikow & Thomas E. Reilly
19	ATSDR "Chapter A: Summary of Findings" Report for Tarawa Terrace Model
20	Frank Bove, Morris Maslia et al., *Evaluation of exposure to contaminated drinking water and specific birth defects and childhood cancers at Marine Corps Base Camp Lejeune, North Carolina: a case–control study* 12 Env't Health 104 (2013)
21	Jun. 19, 2008, Navy Letter to ATSDR
22	June 30, 2010, Deposition Transcript of Morris Maslia
23	March 10, 2009, ATSDR Response to Navy Letter
24	ATSDR Disclaimer for Tarawa Terrace Water Modeling
25	ATSDR "Chapter A: Summary of Findings" Report for Hadnot Point/Holcomb Boulevard Modeling
26	U.S. Government Accountability Office Report on Camp Lejeune (May 2007)
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35	Sept. 26, 2024, Deposition Transcript of Morris Maslia
36	Jan. 12, 2007, Email from Morris Maslia
37	Jan. 13, 2007, Email from Robert Faye

Exhibit	Description
38	Sept. 26, 2011 Email from Barbara Anderson

EXHIBIT 6

Rebuttal Response to:

Reports of Alexandros Spiliotopoulos, Remy J.-C. Hennet & Jay Brigham

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Glossary of Abbreviations and Acronyms

Definitions of terms and abbreviations used throughout this report are listed below.

A

AS Alexander Spiliotopoulos, Ph.D., DOJ Expert

ATSDR Agency for Toxic Substances and Disease Registry; codified under CERCLA, section 104(i), 42 U.S.C. §9604(i); https://atsdr.cdc.gov

B

BTEX Benzene, toluene, ethylbenzene, and xylenes

Bz Benzene

C

CERCLA The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund

CLW Camp Lejeune Water document

COC Contaminant or chemical of concern

D

DCE 1,1-dichloroethylene or 1,1-dichloroethene

1,2-tDCE *trans*-1,2-dichloroethylene or *trans*-1,2-dichloroethene

DON Department of the Navy

E

EDRP Exposure-Dose Reconstruction Program developed by ATSDR in 1993

EPA U.S. Environmental Protection Agency, https://www.epa.gov, also see USEPA

F

ft Foot or feet

ft^3/d Cubic foot per day

G

Ga. Tech Georgia Institute of Technology, Atlanta, Georgia

g Grams

gpm Gallons per minute

H

HB Holcomb Boulevard

HBWTP Holcomb Boulevard water treatment plant

HP Hadnot Point

HPFF Hadnot Point fuel farm

HPIA Hadnot Point Industrial Area

HPLF Hadnot Point landfill

HPWTP Hadnot Point water treatment plant

I

J

JB Jay L. Bringham, Ph.D., DOJ Expert

L

LCM Linear control model; a model based on linear control theory methodology developed to reconstruct historical contaminant concentrations in water-supply wells

LHS Latin hypercube sampling

M

MODFLOW A family of three-dimensional groundwater-flow models, developed by the U.S. Geological Survey, https://www.usgs.gov/mission-areas/water-resources/science/modflow-and-related-programs

MT3DMS Three-dimensional mass transport, multispecies model developed on behalf of the U.S. Army Engineer Research and Development Center. MT3DMS-5.3 (Zheng and Wang 1999) is the specific version of MT3DMS code used for the Hadnot Point–Holcomb Boulevard study area analyses

MCL Maximum contaminant level

µg/L micrograms per liter; 1 part per billion

Model calibration The process of adjusting model input parameter values until reasonable agreement is achieved between model-predicted outputs or behavior and field observations

N

ND non-detect

NRC National Research Council

P

PCE Tetrachloroethene, tetrachloroethylene, 1,1,2,2-tetrachloroethylene, or perchloroethylene; also known as PERC® or PERK®

PDF Probability density function

R

RH Remmy J.-C. Hennet, Ph.D., DOJ Expert

ROD Record of Decision

S

SCADA Supervisory control and data acquisition

T

TCE 1,1,2-trichloroethene, or 1,1,2-trichloroethylene, or trichloroethylene

TechFlowMP A three-dimensional multispecies, multiphase mass transport model developed by the Multimedia Environmental Simulations Laboratory at the Georgia Institute of Technology, Atlanta, Georgia

TT Tarawa Terrace

TTWTP Tarawa Terrace water treatment plant

U

USMC U.S. Marine Corps

USMCB U.S. Marine Corp Base

UST Underground storage tank

V

VC Vinyl chloride

VOC Volatile organic compound

W

WDS Water-distribution system

WTP Water treatment plant

1.0 Introduction

I am Morris L. Maslia, P.E., a licensed Professional Engineer in the State of Georgia and a consulting engineer retained by the Camp Lejeune Plaintiffs' attorneys. On December 10, 2024, I was provided with electronic copies of the Expert Reports of Alexandros Spiliotopoulos (**AS**), Remy J.-C. Hennet (**RH**), and Jay L. Brigham (**JB**), who have been retained by the U. S. Department of Justice (DOJ). Their Expert Reports evaluate and review the Agency for Toxic Substances and Disease Registry's (ATSDR) water-modeling analyses and historical reconstruction conducted at U.S. Marine Corps Base (USMCB) Camp Lejeune, North Carolina, for the Tarawa Terrace (TT), Hadnot Point (HP), and Holcomb Boulevard (HB) water treatment plants (WTP), water-distribution systems (WDS), and associated service areas.

Purpose of Report

The purpose of this rebuttal report is to respond to certain positions as set out by the DOJ Expert Reports (authored by AS, RH, and JB), dated December 9, 2024 (Spiliotopoulos 2024, Hennet 2024, Brigham 2024). My responses are grouped by major topical areas discussed and presented in the DOJ Expert Reports and listed below (Section 4.0 of this report). This report is organized as follows:

- **Section 1.0:** Introduction
- **Section 2.0:** Purpose of Rebuttal Report
- **Section 3.0:** Agreed Upon Concepts and Facts
- **Section 4.0:** Response to Department of Justice (DOJ) Expert Reports
    - **Section 4.1:** Start Dates for Sources of Contamination
    - **Section 4.2:** Water-Supply Well Operations
    - **Section 4.3:** Volatilization of VOCs During Water Treatment Process
    - **Section 4.4:** Derivation and Computation of Sorption Parameter Values
    - **Section 4.5:** Model Calibration and Uncertainty Analysis
    - **Section 4.6:** Post-Audit of the ATSDR Tarawa Terrace Models
    - **Section 4.7:** Graphing and Visualization of Data and Model Results
    - **Section 4.8:** Non-Degraded and Degraded PCE Historical Reconstructions
    - **Section 4.9:** Additional Topics
- **Section 5.0:** Summary and Conclusions
- **Section 6.0:** References
- **Appendices A:** Volatilization Issues: Excerpts from ATSDR's Expert Panel Meetings, March 28, 2005 and April 30, 2009

3.0 Agreed Upon Concepts and Facts

Prior to providing responses to DOJ Expert Reports (Spiliotopoulos 2024, Hennet 2024, Brigham 2024), I set forth several fundamental concepts that are accepted as scientifically valid approaches and facts that can be agreed upon. These are listed below.

1. The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal, non-regulatory public health agency codified in the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) of 1980, also known as Superfund (CERCLA 1980); 42 U.S.C. §9604(i).

2. ATSDR, overseen by the U.S. Department of Health and Human Services, is the lead federal public health agency for determining, preventing, and mitigating the human health effects of exposure to hazardous substances. It does this by responding to environmental health emergencies, investigating emerging environmental health threats, conducting research on health impacts of hazardous waste sites (public health assessments, epidemiological studies, and toxicological profiles), and building capabilities and providing actionable guidance to state and local health partners.

3. When data are limited or unavailable, ATSDR conducts exposure-dose reconstruction studies, which can include the use of environmental data, models (air, soil, water, and pharmacokinetic) or biomarkers to estimate and quantify environmental concentrations and exposures to toxic substances.

4. Historical reconstruction is an analysis and diagnostic method used to examine historical characteristics of groundwater flow, contaminant fate and transport, water-distribution systems, air dispersion, and exposure to contaminants (chemical and radiological) when data are limited or unavailable. It is an accepted method of analysis having been applied since the 1930s and described in many peer-reviewed publications (*e.g.*, Costas et al. 2002, Grayman et al. 2004, Konikow and Thompson 1984), Maslia ad Aral 2004, NRC 199), Rodenbeck and Masli,1998, Rogers 1996, Samhel et al. 2010).

5. The mathematical, analytical, and numerical models (e.g., groundwater flow, contaminant fate and transport, and water-distribution system) used by ATSDR are accepted tools and practices among engineers, researchers, and scientists. These models approximate the physics of groundwater flow and contaminant fate and transport, which do not depend on professional judgment. The uncertainty in these models can be reasonably bounded and quantified to provide useful results of chemical exposure (EPA 1998).

6. The rationale and justification for using the historical reconstruction process, including models, at Camp Lejeune is precisely because historical data were limited and not available to ATSDR. As such, the models play an important role in providing insight, information, and quantitative estimates of environmental and exposure concentrations when data are missing, insufficient, or unavailable (Konikow and Thompson 1984, Maslia and Aral 2004).

4.0 Response to Department of Justice (DOJ) Expert Reports

In this section, I present rebuttal responses to DOJ Expert Reports by topical subject matter. The opinions in this report are based on my review of the DOJ Expert Reports, published literature, data and documents made available to me while consulting on this case (e.g., Plaintiffs' and DOJ's Expert Reports) and my work and analysis during my work on the Camp Lejeune studies as an employee of ATSDR. I have reviewed and am relying upon the rebuttal expert reports of Dr. Leonard F. Konikow, Dr. Norman Jones/Mr. R. Jeffrey Davis, and Dr. David R. Sabatini. I hold the opinions expressed in this report to a reasonable degree of scientific and engineering certainty. I will produce a list of all materials I considered in reaching these opinions within seven days of service of this report. Many of the materials, documents, and data are also listed in the publicly available ATSDR reports on Tarawa Terrace (Maslia et al. 2007) and Hadnot Point-Holcomb Boulevard (Maslia et al. 2013, Appendix A2).

4.1 Start Dates for Sources of Contamination

4.1.1 ABC One-Hour Cleaners

The ATSDR Tarawa Terrace (TT) fate and transport modeling analysis applied a 1,200 gram/day (g/d) tetrachloroethylene (PCE) mass loading rate as the contaminant source at ABC One-Hour Cleaners. ATSDR used a contaminant (source) release date of January 1953. DOJ Experts (AS, RH, and JB) posit that July 1954 is a more appropriate start date for releases of PCE at ABC One-Hour Cleaners (Spiliotopoulos 2024, Section 4.1.2.1; Hennet 2024, Opinion 3; Brigham 2024, Section IV.B). ATSDR relied upon the deposition (sworn testimony) of Victor Melts (owner of ABC One-Hour Cleaners) who testified on April 12, 2001 that he started ABC One-Hour Cleaners in 1953 and that he operated the company in the same location since 1953 (Melts 2001, p.6–7)[1]. Additionally, in remedial investigation reports of the ABC One-Hour Cleaners site by Roy F. Weston, Inc. (1992, 1994)[2] a specific date for start of operations is not provided; rather, these documents indicate that ABC One-Hour Cleaners is a North Carolina corporation registered with the Secretary of State as of March 4, 1958. The U.S. Environmental Protection Agency's (EPA) Record of Decision (ROD) for the ABC One-Hour Cleaners Site (Section 2.1 Facility Operations and History)[3] also does not provide a specific date for start of operations—it also indicates that ABC One-Hour Cleaners is a North Carolina corporation registered with the Secretary of State as of March 4, 1958. Without documented information and data as to the specific date for start of operations at ABC One-Hour Cleaners, ATSDR relied upon the sworn testimony of Victor Melts (Melts 2001, p. 6-7).

To test the effect of varying the start date for operations at ABC One-Hour Cleaners on reconstructed PCE concentrations, Plaintiffs' experts conducted a sensitivity analysis using the calibrated (and published) ATSDR Tarawa Terrace MODFLOW and MT3DMS input files (Maslia et al., 2007, provided on DVD). The sensitivity analysis consists of applying the following start date of operations (source release dates) at ABC One-Hour Cleaners:

- January 1953 (ATSDR calibrated model start date used in Faye 2008)
- January 1954 (+1 year from calibrated model start date)
- July 1954 (+1.5 years from calibrated model start date posited by DOJ Experts AS, RH, and JB)

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[1] CLJA document 00897_PLG_0000067569 – 00897_PLG_0000067570.

[2] CLJA_WATERMODELING_09-0000083841; CLJA_WATERMODELING_09-0000084255.

[3] CLJA_EPA01-0000383135 – CLJA_EPA01-0000383136.

- January 1955 (+2 years from the calibrated model start date)

Results of varying the start dates of operations at ABC One-Hour Cleaners (source release date) are shown in Figures 4.1A and 4.1B for reconstructed PCE concentrations at water-supply well TT-26 and the Tarawa Terrace water treatment plant (TTWTP), respectively. These results show that the calibrated TT modeled PCE concentrations are insensitive to these variations in source release date throughout much of the exposure period since these variations make a negligible difference in PCE concentrations from the calibrated reconstructed concentrations for the duration of the epidemiological study (1968-1985)[4], as listed in Table 4.1. Additionally, the dates that the maximum contaminant level (MCL) for PCE of 5 ug/L is exceeded at water-supply well TT-26 and at the TTWTP, the duration of exceedance (in months), and the maximum reconstructed concentrations are listed in Table 4.2. Note the negligible changes from the calibrated ATSDR model results due to the variable start dates (Maslia et al. 2007; Faye 2008). Based on this sensitivity analysis, I conclude that the ATSDR calibrated models for reconstructing PCE concentrations are not sensitive to the start date of operations (source release date) at ABC One-Hour Cleaners. I stand by the ATSDR start of operations at ABC One-Hour Cleaners of January 1953, as documented in the sworn testimony of Victor Melts (2001) and applied by Faye (2008) as a more reliable start date.[5]

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[4] Reconstructed concentrations are shown for the start of the epidemiological study of January 1968 and the last in-service date of TT-26.

[5] The evidence for ABC One-Hour Cleaners opening in 1954 as presented by Dr. Jay Brigham is circumstantial. Advertisements are subject to a lag in publication so that they may come out well after things have changed on the ground. Similarly, grand openings often occur well after a business has opened, when operations are more fully established. The sworn testimony of Mr. Melts is more reliable than the information provided by Dr. Brigham.

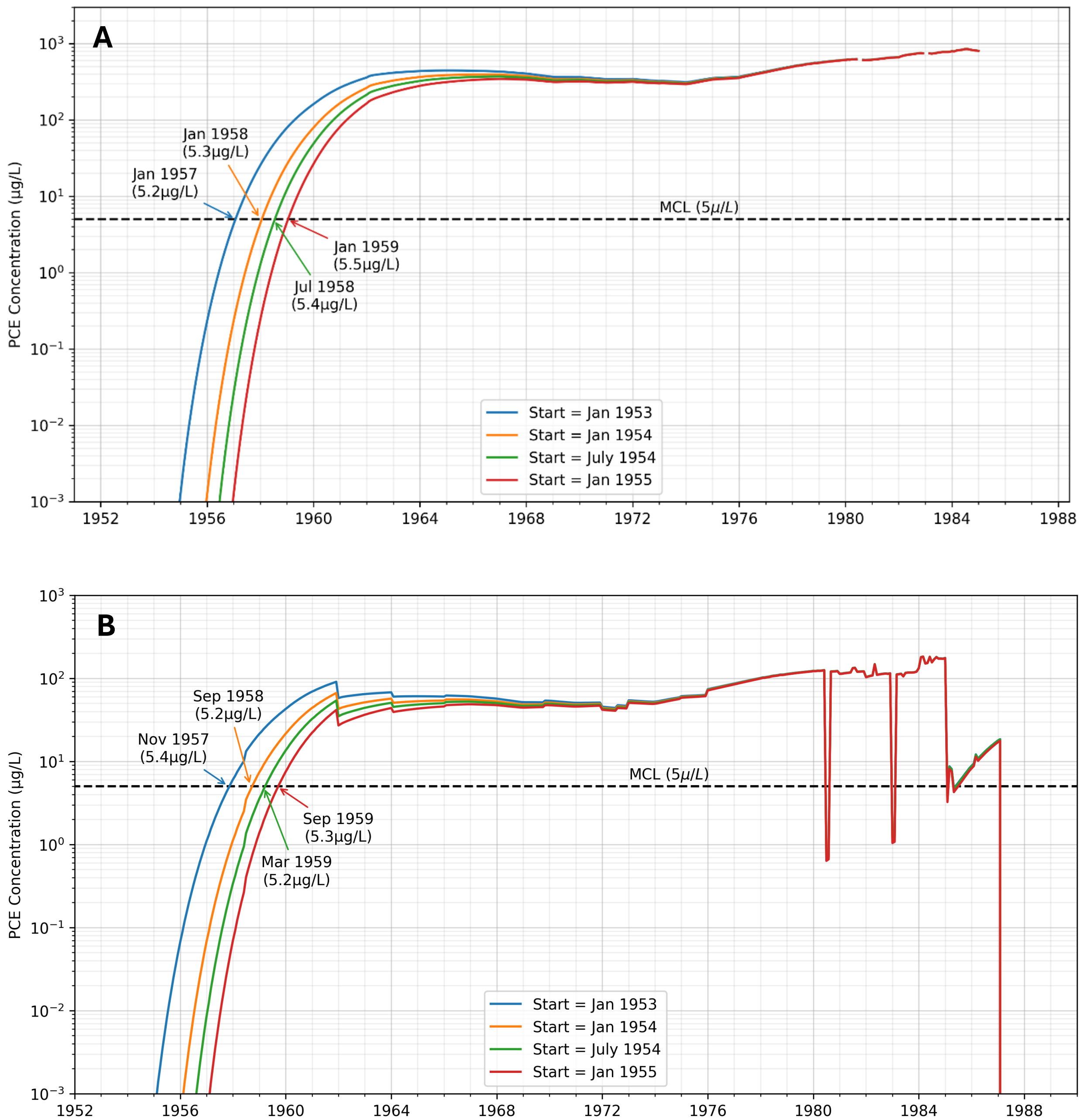

Figure 4.1. Plot of Modeled Concentration of tetrachloroethylene (PCE) with source release date variation: A, water-supply well TT-26 and B, Tarawa Terrace water treatment plant (TTWTP)

Table 4.1. Reconstructed PCE concentrations for variations in source release date at water-supply well TT-26 and the Tarawa Terrace water treatment plant (TTWTP)+

[μg/L, micrograms per liter, PCE, tetrachloroethylene]

Date*	January 1953+	January 1954	July 1954	January 1955
Water-supply well TT-26				
January 1968	402	373	356	336
January 1985	804	802	801	800
Tarawa Terrace water treatment plant (TTWTP)				
January 1968	57	53	51	48
January 1985	176	176	175	175

+Using calibrated ATSDR model parameter values and published model input files (Maslia et al. 2007)

*January 1968 is start of ATSDR's epidemiological study; January 1985 is last operating month for well TT-26

Table 4.2. Date reconstructed PCE concentration exceeds the MCL (5 μg/L), duration of exceedance, and date of maximum concentration for variations in source release date, at water-supply well TT-26 and at Tarawa Terrace water treatment plant (TTWTP)+

[MCL, maximum contaminant level; μg/L, micrograms per liter; PCE, tetrachloroethylene]

Source release date	Date exceeding MCL (5 μg/L)	Duration exceeding MCL, in months	Maximum PCE, in μg/L (date of occurrence)
Water-supply well TT-26			
Jan 1953+	Jan 1957	361	851 (Jul 1984)
Jan 1954	Jan 1958	349	849 (Jul 1984)
Jul 1954	Jul 1958	343	849 (Jul 1984)
Jan1955	Jan 1959	337	847 (Jul 1984)
Tarawa Terrace water treatment plant (TTWTP)			
Jan 1953+	Nov 1957	351	183 (Feb 1984)
Jan 1954	Sept 1958	341	183 (Feb 1984)
Jul 1954	Mar 1959	335	182 (Feb 1984)
Jan1955	Sept 1959	329	182 (Feb 1984)

+Using calibrated ATSDR model parameter values and published model input files (Maslia et al. 2007)

4.1.2 Hadnot Point Industrial Area and Landfill

In Section 4.2.3.2 (Spiliotopoulos, 2024, pp. 78-79), AS notes that ATSDR recognizes the lack of explicit data defining source locations and mass loadings but criticizes ATSDR for "arbitrarily assigning these quantities to the model to fit the limited water-quality data available starting in 1982." However, AS's critique goes to the heart of the model calibration, history matching, and parameter estimation processes used in groundwater modeling. In these processes, parameter values are adjusted (either manually or automatically) to improve the fit (Hill and Tiedeman, 2007).

Furthermore, ATSDR conducted meticulous and detailed source characterization analyses, as documented in Maslia et al. (2013, Tables A6, A7, and A8). Table A8, shown below as Table 4.3 of this report, provides specific information relevant to documented source areas, timelines, primary contaminants, and locations of major dissolved sources for the HPIA and HPLF areas.

Table 4.3. Maslia et al. (2013), Table 8.

Table A8. Identification of documented source areas, timelines, primary contaminants, and location of major dissolved-phase sources, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[HPFF, Hadnot Point fuel farm; UST, underground storage tank; AS/SVE; air sparging/soil vapor extraction; MW, monitor well; µg/L, microgram per liter; gal, gallon; LUST, leaking underground storage tank; CERCLA, Comprehensive Environmental Response, Compensation, and Liability Act of 1980; TCE, trichloroethylene; PCE, tetrachloroethylene]

[1] Source-area timeline [reference documents]	Primary contaminant; number of major sources	Location of major dissolved-phase sources
Hadnot Point Industrial Area (see Figure A13)		
Hadnot Point fuel farm events **1941**, HPFF USTs installed [UST #669, UST #670] **1942**, Building 1115 USTs installed [UST #670] **1993 January**, HPFF and Building 1115 USTs removed [UST #1186, UST #670] **2000 December**, Piping removal (extensive) at HPFF/Building 1115 [UST #417] **Building 1613 events** **1950s**, USTs installed [UST #548, UST #546] **1995 January**, USTs and contaminated soil removed [UST #535, UST #548] **1998–2004**, AS/SVE remediation system operated **Building 1601 events** **1940s**, Building 1601 built [UST #172, UST #195] UST removal date unknown	Benzene; three sources	HPFF/Building 1115/Building 1101 free product footprint Building 1613 free product footprint Building 1601 locations of maximum measured benzene in groundwater (78-GW75-1 and 78-GW74) and former location of USTs and dispenser island at southeast corner of building; MW 78-GW75-1 (5,500 µg/L in 2003; 3,200 µg/L in 2004); MW 78-GW74 (3,200 µg/L in 2004) (See Figure A9 for building and monitor well [MW] locations)
Building 1601 events **1940s**, Building 1601 built [UST #172, UST #195] **1942**, 1,500-gal UST install date listed in LUST study completed in 1990 by Geraghty and Miller [UST #504, UST #507] **1993 June 29**, UST excavated/removed [UST #624] **Building 901/902/903 events** **1948**, Buildings 900, 901, 902, 903 constructed [CERCLA #258, p. 149] TCE UST installation date unknown; removal/abandonment date unknown, but probably occurred prior to onset of remediation efforts around January 1995 [Sovereign Consulting, Inc. 2007]	TCE; two sources	Building 1601 locations of maximum measured TCE in groundwater (MW 78-GW09-1 (old) and (new)) and former location of 1,500-gal waste UST on north side of building; MW 78-GW09-1 (old) (5,000–14,000 µg/L during 1987–1991); MW 78-GW09-1 (new) (at/above 1,000 µg/L during 1993–1996) Building 901/902/903 locations of max measured TCE in groundwater (MW 78-GW23; 13,000 µg/L in 1987), maximum measured vinyl chloride in groundwater (MW 78-GW44; 1,600–6,700 µg/L during 2000–2004), and former locations of USTs containing TCE/solvent waste at Building 901 and between Buildings 902/903. (See Figure A9 for building and monitor well [MW] locations)
Hadnot Point landfill area (see Figure A14)		
Landfill **1940s**, reportedly used as a waste disposal area (Site 6 and Site 82; Figure A8) beginning in the 1940s	PCE and TCE; one source	Location of maximum measured concentration of TCE and PCE in groundwater (MW 06-GW01D) TCE ranged from 6,400 to 180,000 µg/L during 1992–2004; PCE ranged from 210 to 6,500 µg/L during 1992–2004 (See Figure A10 for monitor well [MW] locations)

[1] UST # refers to UST Web Management Portal file number (see References section of this report for complete details); CERCLA # refers to CERCLA Administrative Record file number (provided on digital video disc [DVD] in Maslia et al. 2007)

ATSDR does indeed discuss the lack of data to define the source loading terms for the model in the Hadnot Point Industrial Area (HPIA) and Hadnot Point landfill (HPLF) areas. However, as Dr. Konikow (2025) notes and I agree, there is no doubt that these chemical contaminants (including TCE and PCE) were present in the groundwater at toxic concentrations (substantially exceeding the MCLs[6]) in these areas, and that they were pumped out of the aquifer by several operating water-supply wells shown in Maslia et al. (2013, Figures A9 and A10) and provided below as Figures 4.2 and 4.3.

In AS's summary for his Opinion 14 (Spiliotopoulos, 2024, p. 79), ATSDR is criticized for having "assumed constant mass loading of the same magnitude at all sources for more than 40 years," which he believes is "highly uncertain, if not impossible." I disagree. ATSDR applied an average rate over the critical period because there was no basis for determining how the loading might have varied over time. This approach aligns with accepted groundwater flow and contaminant fate and transport modeling best practices. The fact that the model with a constant mass loading adequately reproduced observed concentrations supports ATSDR's method for modeling the sources at Hadnot Point Industrial Area and Hadnot Point landfill. (Konikow 2025)

Finally, ATSDR reviewed an EPA study (USEPA 1986, 1986) of 12,444 leak incident reports to estimate the timing of UST releases at Hadnot Point. This is certainly not "arbitrary and uncertain." Reliance upon such a comprehensive study is an accepted methodology; it is not "arbitrary." In summary, ATSDR based parameter values on the best data it had available, including site-specific and published data. ATSDR also made appropriate adjustments to parameters to fit site-specific conditions.

[6] MCL, maximum contaminant level; 5 μg/L for PCE and 5 μg/L for TCE.

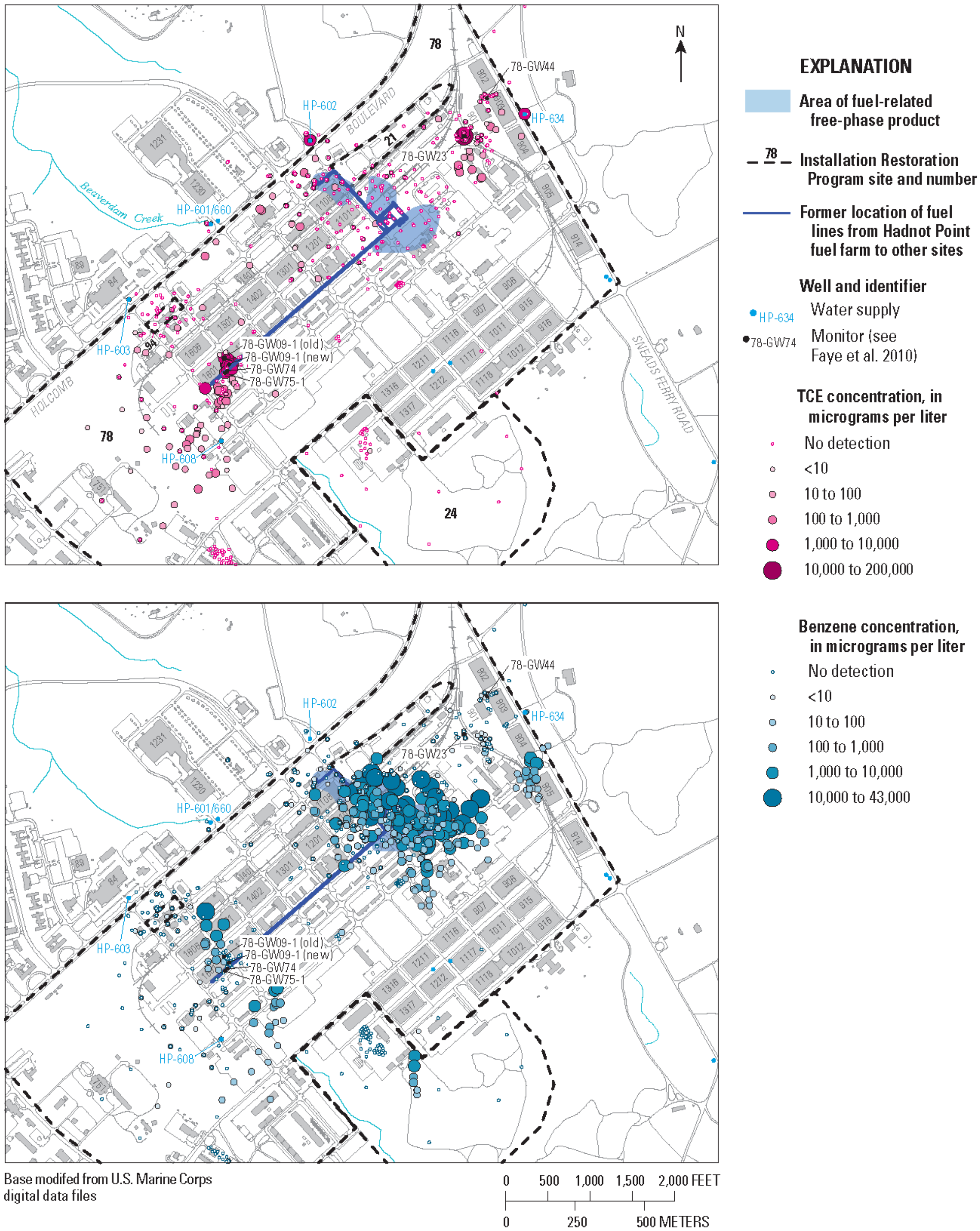

Figure A9. Sampling data for trichloroethylene (TCE), benzene, and fuel-related free product in groundwater for the Hadnot Point Industrial Area, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina. (See Figure A8 for location and Figure A13 for selected building numbers.)

Figure 4.2. From Maslia et al. (2013), Figure A9

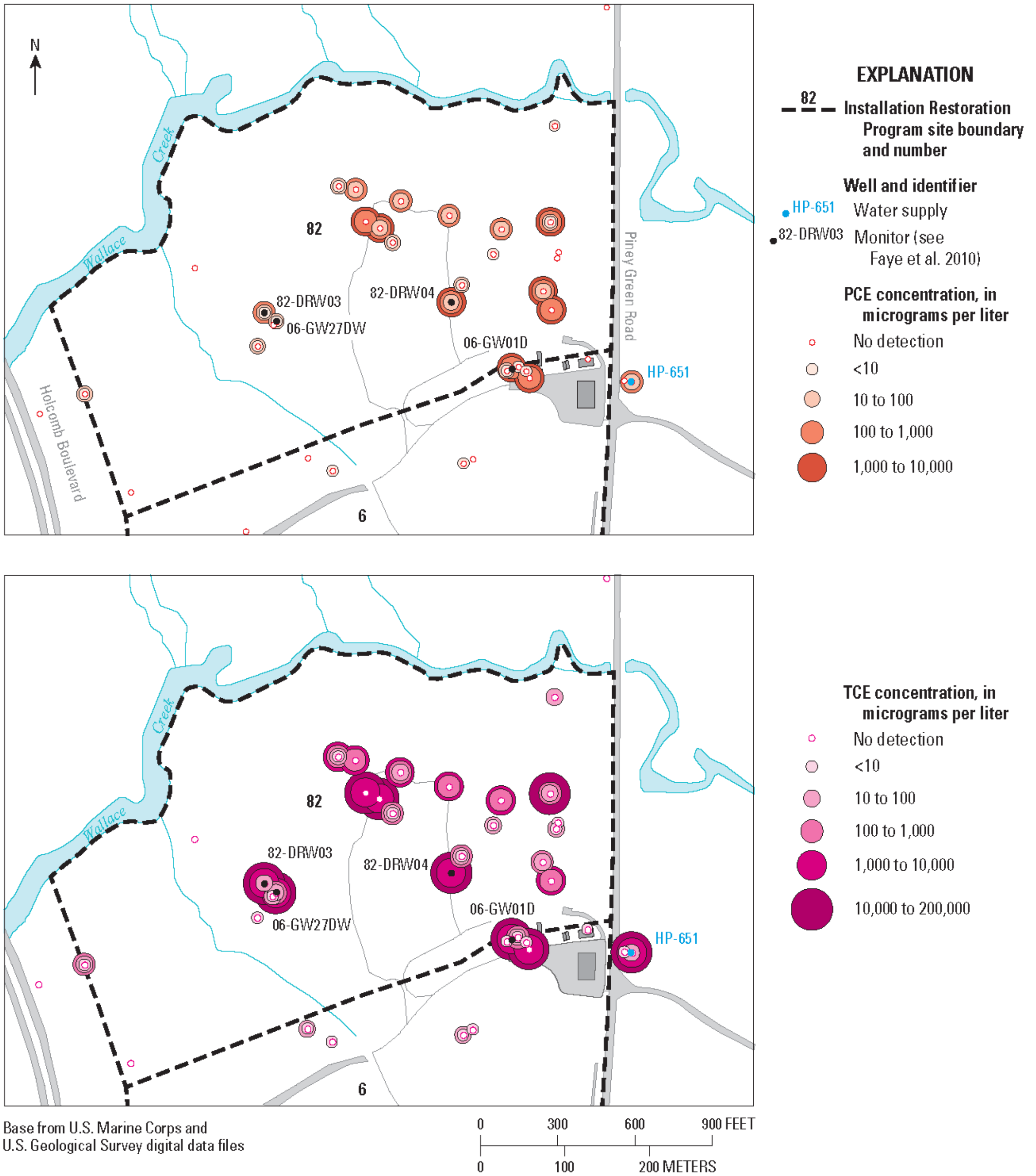

Figure A10. Sampling data for tetrachloroethylene (PCE) and trichloroethylene (TCE) in groundwater for the Hadnot Point landfill area, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina. (See Figure A8 for location.)

Figure 4.3. From Maslia et al. (2013), Figure A10

4.2 Water-Supply Well Operations

4.2.1 Tarawa Terrace

In his opinion 5, Spiliotopoulos (2024, Section 4.1.2.6) posits that the ATSDR groundwater model for TT resulted in "biased-high estimates of monthly contaminant concentrations" at water supply well TT-23. (his Section 4.1.2.6). I concur with Dr. Konikow's assessment of opinion 5:

> Section 4.1.2.6 (p. 42) offers no clear evidence that the discrepancy at this one well (out of many) has a substantial impact on the overall results. Based on ATSDR Table E2, of the nine unique sampling dates for this well, six had an observed level of PCE or TCE above the MCL. Furthermore, with respect to the overall effect on concentrations estimated at the WTPs, it is important to note that TT-23 was operational for only about 9 months or less, starting in 1984, and had the shortest operational (pumping) period of any of the 16 pumping wells operating in the TT area (see Table H3 in Chapter H of the TT series of reports). When it was pumping, the contribution from this well provided only a small fraction of the total groundwater inflow to the WTP with concentrations far less than well TT-26 (with its modeled concentrations likely being underestimated). Thus, if indeed the estimates for this well were too high (by less than two times), the effect on calculated concentrations in the WTP would be minimal both in magnitude and in duration.
>
> (Konikow 2025).

With respect to calibrated ATSDR models being "biased high" as posited by DOJ experts, the opposite is true. For example, Figure 4.4 from Faye (2008, Figure F16)[7] shows a plot of observed data (5 of the 6 samples were obtained within a week's time) and reconstructed PCE concentrations for water-supply well TT-26. Note that the highest and first sample was taken during the period when this well was in service, as compared to the remaining samples when this well was out of service. If anything, it could be argued that the model is under-predicting the concentrations. Furthermore, note that reconstructed PCE concentrations fell almost exactly at the midpoint of the range of observed values (about 800 ug/L)—countering the claim of being biased high and confirming the adequateness and acceptability of the calibrated ATSDR models including the reconstructed supply-well operations. As with well TT-23 discussed above, the first sample from well TT-26 was taken when it was operating, and the remainder of the samples were taken after well TT-26 was permanently removed from service.

[7] CLJA_WATERMODELING_01-0000488379.

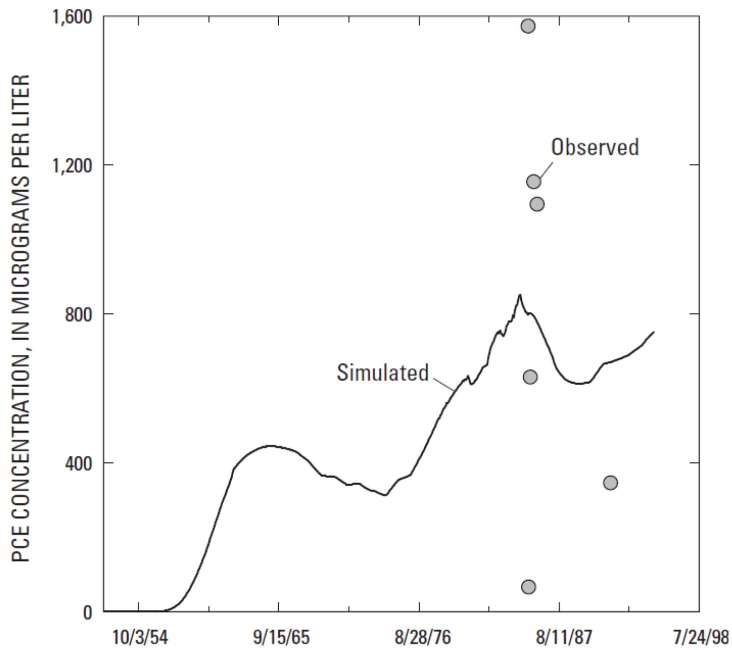

Figure F16. Simulated and observed tetrachloroethylene (PCE) concentrations at water-supply well TT-26, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina, January 1952–December 1994 (see Figure F6 for location).

Figure 4.4. From Faye (2008), Figure F16.

4.2.2 Hadnot Point

In Section 4.2.2 (Spiliotopoulos, 2024, p. 72), the claim is made that ATSDR "made arbitrary assumptions to reconstruct pumping history…" I agree with Dr. Konikow who, after reviewing the ATSDR's historical reconstruction, concluded:

> In my opinion, the assumptions were not arbitrary, but rather were well-informed, well-reasoned, and carefully documented. Assumptions had to be made about the pumping history, and they were made, but they were not arbitrary. For example, Dr. Spiliotopoulos notes that "Yearly volumes are available for some years prior to 1980. A trendline was used to estimate raw-water flows for years prior to 1980 when no data exist." This appears to be a sound statistical approach, and the use of a trend line is certainly not arbitrary.
>
> In Section 4.2.2 (p. 72-73) Dr. Spiliotopoulos offers a further criticism that "it was assumed that a well would be operated in the historical period based on a pattern similar to the more recent 'training period,' with further adjustments to account for information on the varying capacity of wells, where available." Dr. Spiliotopoulos' statement actually

contradicts his assertion that estimates were arbitrary. Here he describes a reasoned and reasonable approach to estimating a pattern of past water use (well pumpage)—an approach that is not "arbitrary."

In several additional paragraphs on p. 73 (as well as elsewhere), he repeats the claim that pumping rates were based on arbitrary assumptions. ATSDR uses sound statistical methods (such as regression and correlation) to estimate pumpage. This is neither arbitrary nor unreasonable."

(Konikow 2025)

ATSDR developed and applied a sophisticated and novel pumping schedule algorithm for the nearly 100 water-supply wells serving Hadnot Point and Holcomb Boulevard. They did this by using a "training period" when pumping data are known (typically, present-day) and a "predictive period" when pumping data were unknown. Details of this methodology are provided in Telci et al. (2013)[8] and are the basis for the pumping schedules assigned to wells supplying the HP-HB service areas. Similar wells managed by the same operating authority (e.g., the Camp Lejeune Water Utilities Department) are likely to have been operated in a similar manner—however, in the early years of operations they simply were not required to maintain as detailed records (e.g., SCADA data) as would be expected today. AS does not offer a better or more reasonable approach than the one used by ATSDR.

4.2.2.1 HP-634

In Section 4.2.3 (Spiliotopoulos 2024, p. 77), AS states that model calibration was "improperly influenced" by "erroneous concentrations reported for well HP-634 … while non-detections were ignored." Documentation and discussion below provide evidence that the concentration in well HP-634 (sampled on 1/16/1985) of 1,300 μg/L of TCE was not an erroneous concentration. Furthermore, non-detections were not ignored. They are clearly listed and labelled in many tables presented in the ATSDR reports (e.g., Maslia et al. 2013, Table A4) and in many other places in ATSDR reports (Faye et al. 2008; Faye et al. 2012).

There are certain documents that show that well HP- 634 was (temporarily) shut down on 12/10/84 when methylene chloride was found in the sample; however, the documents below demonstrate that well HP-634 was operating until early February 1985.

The first document is cited in RH's footnote 111 (Hennet 2024, p. 5-31, footnote 111) .[9] In the callout of the wells out of service on 1/16/1985, HP-634 is not among those listed, suggesting that the well was still in service on this date. January 16th is when the 1,300 μg/L sample was taken at HP-634.

[8] CLJA_WATERMODELING_05-00001005675 – 05_00001005810.

[9] CLJA_CLW00000004559

WELLS SHOWING NO DETECTABLE CONCENTRATIONS, ASSUMING A DETECTION LIMIT OF 10 UG/L:

606	632	640
609	633	641
611	635	642
613	636	652
614	638	653
616	639-O	655
620	639-N	LCH 4007
621		
627		

WELLS OUT OF SERVICE AND COULD NOT BE SAMPLED ON 16 JAN 1985:

610
615
654
LCH 4006

*LEGEND

a = Trichloroethylene
b = 1,2-trans-dichloroethylene
c = chloroform
d = benzene
e = bromodichloromethane
f = methylene chloride
g = toluene
h = 1,1-dichloroethane
i = tetrachloroethylene

RECEIVED
FEB 27 1985
WILMINGTON REGIONAL OFFICE
DEM

CLW

0000004559 31

- **Event #1:** Well HP-634 is tested with other wells on 12/10/1984.
- **Event #2:** Test samples from 12/10/84 are back with "Wells 634 and 637, previously showing nothing, showed significant levels of Methylene Chloride (MC). 634 and 637 were shut down."
- **Event #3:** This is a key statement: On Jan. 16, 1985, "Sampled all operating wells for HP and Holcomb Blvd Water Plant (HB). 37 wells". The key being all **operating** wells.

Further documentation that supports the fact that HP-634 was operating on 1/16/1985 when the sample was taken is provided in CLW4546,[10] which is a chronological listing of events from 11/30/1984 to 2/25/1985. A portion of that document covering 12/10/84 to 1/16/85 is shown below.

1	10 Dec	Sampled HP treated water, plus Wells 601, 602, 608, 634, 637 and 642
	13 Dec	Took Quality Control (QC) samples of 602, split three ways.
	13-19 Dec	Took daily samples of HP raw water.
2	14 Dec	Received results of 10 Dec 84 sampling (Table [2]). Treated water levels dropped. Wells 634 and 637, previously showing nothing, showed significant levels of Methylene Chloride(MC). 634 and 637 were shut down.
	19 Dec	Took a distribution sample from HP. Location was FC-540, far point from plant.
	21 Dec	Received results of daily HP samples (Table [3]), plus JTCs QC sample and FC-540. The QC samples from JTC and Grainger (received later) confirmed the presence of TCE and DCE.
3	16 Jan 85	Sampled all operating wells for HP and Holcomb Blvd Water Plant (HB). 37 wells.

On page 6 of the same document (Table [5])[11] the 37 wells tested on 1/16/85 are listed and HP-634 is on the list, and shows a sampled concentration for TCE of 1,300 μg/L.

Table [5]

LAB: JTC Sampled: 16 January 1985 Detection Limit: 10ppb

	Well	DCE	TCE	PCE	VC	11D
1	601	8.8	26	ND	ND	ND
2	634	700	1300	10	6.8	ND
3	651	3400	3200	386	655	187
4	652	ND	9.0	ND	ND	ND
5	653	ND	5.5	ND	ND	ND

None Dectected:

6	603	16	632	26	642		
7	606	17	633	27	643		
8	609	18	635	28	644		
9	611	19	636	29	646		
10	613	20	637	30	647		
11	614	21	638	31	648		
12	616	22	639(OLD)	32	650		
13	620	23	639(NEW)	33	655		
14	621	24	640	34	LCH 4007		
15	627	25	641				

Broken Samples:

35	602
36	608
37	645
	651

See Note 3.

[11] CLJA_WATERMODELING_09-0000424938

Further support for the fact that HP-634 was only temporarily closed comes from an email dated 4/11/1989 (Bates CLJ16100/CLW1818) from the Supervisory Chemist to the Director of the Natural Resources and Environmental Affairs Division with the subject "WATER MONITORING RELATED TO THE INSTALLATION RESTORATION (IR) PROGRAM".

On page 2 of the document (CLJ161101/CLW1819) bullet 6 states certain wells were tested on 12/4/1984 including HP-634:

> 6. On 4 Dec 84, the Hadnot Point Water Treatment Plant's raw and treated water was sampled as well as any drinking water wells within a mile of the Hadnot Point Fuel Farm or Bldg 602. The Bldg numbers sampled were:
>
> 601 603 608 634 642

Bullet 8 on the same page states that methylene chloride was found in wells 634 and 637 during a 2nd sampling on 12/10/1984. "The wells were temporarily closed until it was determined that the methylene chloride was probably a laboratory contaminant."

> 8. From 10-31 Dec 84, duplicate and quality control samples were run to confirm the presence of TCE, DCE and PCE in the wells. Wells 634 and 637, on the second sampling showed Methylene chloride. The wells were temporarily closed until it was determined that the methylene chloride was probably a laboratory contaminant. It was determined that all drinking water wells would be analyzed for volatile organic chemicals (VOCs) to start in January 1985.
>
> CLW 0000001819

Bullet 9 (CLJ611102/CLW1820) states 37 wells serving HP and HB were tested on 1/16/1985.

> 9. 16 Jan 85. 37 wells serving the Hadnot Point and Holcomb Blvd water plants were sampled.

Bullet 13 on the same page states "On 1 Feb 85, the 31 Jan 85 samples showed that there was still a contaminated well operating in the Hadnot Point system. The results of the 16 Jan 85 sampling were phoned into Natural Resources and showed high levels of TCE in 651." At the end of the bullet text it states, "Well 634 showed TCE also and was shut down".

> 13. On 1 Feb 85, the 31 Jan 85 samples showed that there was still a contaminated well operating in the Hadnot Point system. The results of the 16 Jan 85 sampling were phoned into Natural Resources and showed high levels of TCE in 651.
>
> Well 651 is located on the back side of DRMO's disposal storage lot. It was not initially sampled as being in proximity to a NACIP site. It had the highest levels of TCE found. The concentration was in the 17,000 to 18,000 ppb range. Well 651 was shut down. Well 634 showed TCE also and was shut down.

This statement supports the facts that HP-634 was "temporarily closed", as stated in bullet 8, and that the well was shut down for TCE - not methylene chloride.

Therefore, based on the documentation regarding water-supply well HP-634, the claims made by the DOJ Experts (Spiliotopoulos 2024, Hennet 2024) are incorrect. HP-634 was operating on the date it was sampled on Jan. 16, 1985; the result was 1,300 µg/L of TCE; and the well was shut down due to this high TCE concentration.

4.2.2.2 HP-651

RH (Hennet 2024, p. 5-28 and 5-29) posits that well data covering 11/28/1984 to 2/5/1985 (CLJA_CLW00000006590 – 6593) should be used as the basis for determining HP-651's contribution to the HPWTP finished water concentrations from 1972 to 1985. The paragraph below summarizes RH's position:

> "The average concentration measured for TCE in HP-WTP over the period January 21 to February 5, 1985,99 is 582 ug/L. During this period it is known that HP-651 was being pumped (RH, p. 4-19, Exhibit I-9). Considering that HP-651 was being pumped 39% of the time (0.39 frequency of pumping; Exhibit I-9) yields a TCE long-time average concentration of 227 ug/L for HP-WTP supplied water.
>
> $$0.39 \times 582 \text{ (ug/L)} = 227 \text{ (ug/L)}."$$

RH presents a table that represents the data in CLJA_CLW00000006590 – 6593 in an Excel™ spreadsheet. Using these data he determines that over the 69 days covered, well HP-651 only was operating 39% of the time so this is the value that should be used over the entire life of well HP-651, which is from 7/72 to 2/85 or 12.6 years. In doing so RH either fails to realize or does not disclose that these two months of well operation from 11/28/1984 to 2/7/1985 are anything but ordinary and therefore, should not be used as the basis for any long-term forecasting of pumping schedules. Below I discuss the reasons why the 69-day period selected by RH is not reliable and should be disregarded.

- **Point 1:**

The 11/28/1984 to 2/5/1985 period should be broken into months and not as a 69-day pumping period. The ATSDR pumping schedules are based on months as their base unit. If this is done for well HP-651 the results for days of operations and percentage of time operating are as listed in Table 4.4.

Table 4.4. Monthly pumping schedule for well HP-651, December 1984 – and January 1985.

Month	Days of Operation	Percentage on
December 1984	2	6%
January 1985	18	58%

These results should make the modeler question whether there is an explanation for the HP-651's low operation in December. The most logical explanation involves wells New 623, New 622, New 629, New 661 and New 662. These 5 wells were new wells brought online from 6/1984 to 10/1984 and represent over 1,200 (gallons per minute (gpm) of combined capacity. The frequency with which they were in operation ranged from a low of 61% to a high of 94% (Table 4.5). Certainly, the addition of these 5 new wells had an effect on the pumping schedule at HPWTP.

Table 4.5. Characteristics of New Hadnot Point Wells, June–October 1984.

[DOB, construction completion date; gpm, gallons per minute; HP, Hadnot Point; %, percent]

HP Well ID	Other Name	Well DOB	Original Capacity, in gpm	Dec 84 — Jan 85 Capacity, in gpm	Well age as of 2/85	December 84 Operating Days	%	Jan 85 Operating Days	%	Total Days	% On
611	(New 623)	8/1/1984	360	242 (9/85)	0.5	27	87%	30	97%	61	87%
614	(New 622)	6/1/1984	323	320 (9/85)	0.7	23	74%	30	97%	57	81%
621	(New 629)	10/1/1984	NA	NA	0.3	26	84%	16	52%	43	61%
627	(New 661)	8/1/1984	192	280 (10/84)	0.5	28	90%	31	100%	66	94%
639 (New)	(New 662)	10/1/1984	146	146 (10/83)	0.3	26	84%	26	84%	59	84%

- **Point 2:**

The lack of use of well HP-651 in December 1984 had nothing to do with the well's capacity as demonstrated by its capacity tests. Well HP-651 Capacity Data listed on page S1.71 of the HPHB Chapter A–Supplement 1 (Sautner et al. 2013)[12] Descriptions and Characterizations of Data Pertinent to Water-Supply Well Capacities, Histories, and Operations show the last capacity test

[12] CLJA_WATERMODELING_05-0000826112, found in CLJW_WATERMODELING_05-0000826036 – 05-0000826153

was 10/29/1984 and the well operated at 242 gpm—which ranks in the Top 10 highest capacity wells at the time.

Table 4.6. Sautner et al. (2013), p. S.71.

Well HP-651

[gpm, gallon per minute; —, no data; VOC, volatile organic compound; USGS, U.S. Geological Survey]

Date	Capacity, in gpm	Operational status	Data source
12/30/1971	200	Construction completed	Driller[1]
7/1/1972	—	In service	Estimated date
1/1976	—	In service	CLW-4039
3/31/1977	190	In service	Well capacity test
1/1978	—	In service	Operation records
1/10/1979	167	In service	Well capacity test
2/13/1980	178	In service	Well capacity test
7/26/1981	232	In service	Well capacity test
1/1982	—	In service	Operation records
9/14/1983	239	In service	Well capacity test
10/29/1984	242	In service	Well capacity test
1/1985	—	In service	Operation records
2/1985	—	"Contaminated"	Operation records
2/4/1985	—	Out of service	CLW-4913[2]
2/4/1985	—	Service terminated	CLW-4913[2]
6/1994	—	Abandonment	AH Environmental Consultants[3]

[1]Corbin Construction Company, written communication, December 30, 1971

[2]Well secured due to VOC contamination

[3]AH Environmental Consultants, Inc., electronic communication, September 3, 2004

Data sources:

CLW, Camp Lejeune Water Documents 3559–3561, 3573–3575, 3585–3587, 3588–3590, 3641–3643, 3644–3646, 3772–3774, 3775–3777, 3996–3997, 3998–4000, 4044–4046, and 4047–4049

USGS, operation records, written communication, March 2004

- **Point 3:**

When compared to other wells that were supplying raw water during that time, well HP-651's age is also not a reason for its lack of operation in December 1984. Well HP-651's completed construction date (a/k/a/ DOB) was 7/1/1972 making it only 12.6 years old as of 2/1/1985. In comparison, well HP-616 operated at 57% in December 1984 and its DOB is 1/1/1943 making it 42.1 years old on 2/1/1985. Its last capacity test placed it at 210 gpm—still substantial, especially considering its age. The same holds true for well HP-632. In December 1984 it operated at 64% at an age of 27.7 years (DOB 5/27/1957). When tested on 10/1984 its capacity was 201 gpm.

- **Point 4:**

The fact that well HP-651 only operated at 6% could also be attributed to the pumping schedule being used at the time. As outlined extensively in ATSDR's reports (Telci et al. 2013),[13] ATSDR used current (2008) pumping data as a "training period" to reconstruct well operations during the historical period ("predictive period"). On those wells that were shut down due to contamination, "surrogate wells" were used for the "training period" (Telci et al. 2013, Table S2.2)[14]. HP-651 was shut down in February 1985 so well HP-633 was used as its surrogate. If we look at the historic pumping schedule that was created for HP-651 based on HP-633 we see there is a cycle:

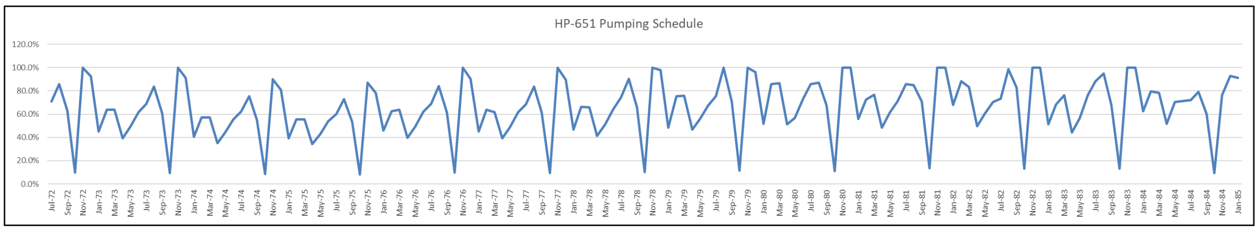

Figure 4.5. Reconstructed historical pumping operations for well HP-651 (from Telci et al. 2013)

In the reconstructed pumping operations cycle, well HP-651 drops below 10% every October. This cycling was common for several reasons, including substantial reductions in consumption and demand owing to deployment of troops and climatic conditions where October and generally Fall to early Winter are "wet months." It is very possible that the actual low-cycle month for HP-651 was December and not October, which would explain the 6% value of operation time for December of 1984.

In addition to those points outlined above there are other reasons why this period should not be used to represent normal operation of not only HP-651 but the well field in general.

- **Reason 1**

The first and foremost reason why this is not a representative time period is because November 30, 1984 marked the start of the investigation into the sources of contamination at HP. Well HP-602 was shut down on 11/30/1984. Additional testing on 12/4/1984 and 12/10/1984 resulted in well HP-608 being shut down permanently on 12/6/1984 and wells HP-634 and HP-637 being shut down temporarily on 12/14/1984. This disruption is not a normal occurrence and therefore adds to the reasons why this period of time should not be used to determine historic pumping schedules for any wells.

- **Reason 2**

As outlined in my Expert Report (Maslia 2024) the HBWTP had to be shut down from 1/27/84 to 2/7/85 due to a fuel line contaminating the HB water supply. During this time HPWTP had to supply

[13] CLJA_WATERMODELING_05-00001005675 – 05-00001005810.
[14] CLJA_WATERMODELING_05-00001005695.

all finished water for the HB area, in addition to its own, which is not representative of normal operation.

- **Reason 3**

Based on ATSDR's research into Camp Lejeune's water treatment plant's operations, it became apparent that the WTP operators would not cease operating a 12.6-year-old well (HP-651) that at 12 years of age is still producing more than 240 gpm. In July 1972, well HP-651 would have been operated very similar to that of the new wells discussed previously—wells New 623, New 622, New 629, New 661 and New 662, which were operated at 70% – 100% capacity.

- **Reason 4**

Camp Lejeune is a military base. Therefore, production and consumption of water are determined by demands for: (a) fire protection, (b) housing , facilities, and recreation,(c) utility requirements (steam and heat production), (d) troop deployments, (e) leave for rest and relaxation, and (f) a combination of (a)-(e) above. ATSDR staff observed an example of the impact of troop deployment on production and consumption of water supplies during the conduct of a field test of the HPWTP service area during May 2004 (Sautner et al. 2005). During this field test, ATSDR requested that Camp Lejeune water utility operators increase normal water production of the HPWTP from about 1,600 gpm to about 2,100 gpm so ATSDR could conduct tracer tests. On the final day of the test, water utility staff told ATSDR that they would need to reduce production back to the 1,600 gpm at the HPWTP because they were "spilling water from the elevated storage tanks." Camp Lejeune water utility staff indicated that a substantial reduction in demand was being observed because of troop deployments.

RH's position on well HP-651 is an attempt to lower concentrations that occurred at Camp Lejeune during 1953 – 1987 using incorrect and/or select, non-representative data. RH's contentions regarding HP-634 are incorrect and the same holds true for HP-651. Supply well HP-651 was a major contributor to the raw water supply from June 1972 – February 1985, and the ATSDR reconstructed pumping schedule accurately reflects well HP-651's overall operation. RH's claim of 39% lifetime operation is made without a thorough review of the documents he is relying on to support his position.

4.3 Volatilization of VOCs During Water Treatment Process

DOJ expert (RH) posits that a substantial portion of chemicals of concern in the raw water was unavoidably lost during subsequent storage, treatment, and distribution (Hennet 2024, Section 5, Opinion 2). His report goes through numerous calculations that he claims show substantial percentages of VOCs volatilizing off during the water treatment and storage process at the WTPs (Tarawa Terrace and Hadnot Point).[15] For example, in Hennet's Exhibits 2-4 and 2-5 (2024, p. 5-6 – 5-11) he computes an "Overall Evaporative Removal" of VOCs of concern at the HPWTP as: 18.34% (PCE), 17.07% (TCE), 22.41% (1,2-tDCE), 32.48% (VC), and 15.12% (Benzene). For the TTWTP, Hennet computes the "Overall Evaporative Removal" of VOCs of concern as 18.84% (PCE), 17.63% (TCE), 23.23% (1,2-tDCE), 33.41% (VC), and 15.68% (Benzene). These calculations

[15] The Holcomb Boulevard WTP (HBWTP) was never supplied with contaminated raw water.

substantially exceed values of volatilization computed by the consultant to the U.S. Marine Corps (USMC), AH Environmental Consultants in its December 2004 report on Estimation of VOC Removal (AH Consultants 2004).[16] Specifically, Section 5 (Summary) of the AH Consultants report states:

> "The calculations revealed that VOC removal due to volatilization from quiescent basins was negligible at MCB Camp Lejeune. The only significant VOC removals must have occurred at the spiractor effluent pipe, where the falling water undergoes some aeration. Considering the uncertainty in the estimates for the fall height over the weir formed by the pipe, the removals for TCE and PCE were likely to be less than 15%."[17]

Earlier in its report, AH Environmental Consultants (2004, (pages 4-1 – 4-2) found that "volatilization due to aeration at the spiractor effluent pipe resulted in TCE and PCE removals of 6.1% and 7.7% at the design flow rate 700 gpm, respectively. ... A sensitivity analysis showed that the fall height has the largest effect on VOC removal at a weir." This sensitivity analysis conducted by AH Environmental Consultants (2004) found that removal of PCE and TCE is nearly proportional to the fall height from the spiractor. AH Environmental Consultants (2004) went on to explain that the fall height at Hadnot Point was only 1 foot but at Holcomb Blvd it was 2 feet. It was this uncertainty along with "additional uncertainties ... introduced by varying head losses in the pipes caused by calcium carbonate scale build-up and manual cleaning" that led AH Environmental Consultants (2004) to state at page 4-4 that "it is estimated that PCE and TCE removals due to aeration at the spiractor effluent pipes are likely to be *no larger than* 15%."

To assess the DOJ expert's (RH) calculations and conclusions, Dr. David R. Sabatini conducted a detailed analysis of the volatilization of VOCs for the Camp Lejeune WTPs including volatilization from mobile water units (a/k/a water buffaloes[18]), and this analysis is adopted and incorporated by reference into this report. Results of this analysis are summarized by Sabatini (2025, Section 5.1.4) for the TTWTP and HPWTP are listed Table 4.7 (Sabatini (2025, Table 5.3).

Table 4.7. From Sabatini (2025), Table 5.3.

Source	TCE (%)	PCE (%)	1,2-tDCE (%)	VC (%)	Bz (%)
Spiractor (Sec 5.1.1)	5.2	6.2	5.9	9.9	4.3
Storage tanks (Sec 5.1.2)	<1	<1	<1	<1	<1
Other losses (Sec 5.1.3)	<1	<1	<1	<1	<1
My Estimate - overall losses	**<7.2**	**<8.2**	**<7.9**	**<11.9**	**<6.3**
AH Environmental (2004), p.5-1	<15	<15	-	-	-
Hennet (2024) Exhibit 2-6, p.5.14	17	18	22	32	15

[16] CLJA_WATERMODELING_01-0000334594 – 01-0000334660.
[17] CLJ_WATERMODELING_01-0000334634.
[18] Detailed analyses and discussions of the water buffalo types used at Camp Lejeune and the filling process during the historical period of VOC exposure are provided in Appendix A to Dr. Sabatini's report and are not discussed in this report.

As Sabatini (2025) states in his report, "As such, I conclude that Hennet (2024) overestimated the potential losses in the water treatment processes. The actual loss values, in my opinion, were less than 6 to 12% for the VOCs of interest versus 15% to 32% as suggested by Hennet (2024)."

For the mobile water units (water buffaloes), Sabatini (2005, Section 5.3) concludes:

"Hennet's calculations overestimated the VOC losses during filling of the water buffaloes; he estimated 41% to 61% for the range of VOCs while I estimate much lower (15 to 22% through filler pipe/strainer and 4.2 to 6.7% through the manhole, including daily use not accounted for by Hennet) for the range of VOCs, I thus conclude that the water buffalo water was only mildly to moderately lower in VOCs, not substantially lower as Hennet (2024) states."

Sabatini's (2025), Table 5.7, provided in this report as Table 4.8, lists a summary of the overall VOC losses in water buffaloes based on Hennet's (2024) calculations and Sabatini's (2025) estimates for filling the water buffaloes from the filler tank and from the manhole cover.

Table 4.8. From Sabatini (2025), Table 5.7.

[My estimate refers to Sabatini (2025)]

Source	TCE (%)	PCE (%)	1,2-tDCE (%)	VC (%)	Bz (%)
(1) Hennet – filler pipe/strainer - Overall loss (see Table 5-6, Row 2))	41	44	54	61	45
(2) My estimate – filler pipe/strainer overall filling losses (see Table 5.6, Row 3)	14	15	18	20	15
(3) My estimate – filled by standpipe through manhole cover – 5.6% of Hennet's Row 1 values in Table 5.6	3.0	3.2	4.0	4.5	3.3
(4) My estimated losses during daily use of water buffaloes (Exhibit C.4)	1.2	1.0	1.9	2.2	1.2
(5) My estimate – overall losses – filler pipe strainer plus daily use (Row 2+4)	15	16	20	22	16
(6) My estimate – overall losses – standpipe filling through manhole plus daily use (Row 3+4)	4.2	4.2	5.9	6.7	4.5

In summary, the detailed calculations of both AH Environmental Consultants (2004) and Dr. Sabatini (2025) demonstrate that the DOJ expert (RH) has vastly overestimated alleged VOC losses during storage, treatment and distribution. In addition, RH's assertion that ATSDR did not account for such VOC losses (Hennet 2004, Opinion 10, p. 5-36) is incorrect. First, ATSDR analyzed sampling data of water from both pretreatment and post treatment. Table 4.9 lists sampling data for the HPWTP including sampling status (treated or untreated) where known. Out of the 20 water samples taken at the HPWTP, 7 were from treated (finished) water, 4 were from untreated, and 9 had unknown treatment status. Furthermore, for TCE samples taken on 7/27/1982, results show that the concentration for untreated water was 19 μg/L and for treated water was 21 μg/L. Allowing for measurement error, these data indicate no losses to volatilization of TCE during the treatment process.

Table 4.9. Treatment status of water samples from the Hadnot Point water treatment plant

Date	Measured in μg/L	Treatment Status	Reference or Citation	Bates Identification
Tetrachloroethylene (PCE)				
5/27/1982	15	Unknown	CLW 0606	CLJA_USMCGEN_0000003332
7/27/1982	100	Unknown	CLW 0606	CLJA_USMCGEN_0000003332
12/4/1984	3.9J	Treated	CLW 5632	CLJA_USMCGEN_0000009913
2/5/1985	7.5J	Treated	CLW 5509	CLJA_USMCGEN_0000005529
Trichloroethylene (TCE)				
5/27/1982	1400	Unknown	CLW 0606	CLJA_USMCGEN_0000003332
7/27/1982	19	Untreated	CLW 0606	CLJA_USMCGEN_0000003332
7/27/1982	21	Treated	CLW 0606	CLJA_USMCGEN_0000003332
12/4/1984	46	Untreated	CLW 5632	CLJA_USMCGEN_0000009914
12/4/1984	200	Treated	CLW 5632	CLJA_USMCGEN_0000009913
12/12/1984	2.3J	Treated	CLW 5644	CLJA_USMCGEN_0000003979
12/19/1984	1.2	Untreated	CLW 4546	ATSDR_WATERMODELING_01-0000886764
2/5/1985	429	Unknown	CLW 5509	CLJA_USMCGEN_0000005529
***Trans*-1,2 Dichloroethylene (1.2-tDCE)**				
12/4/1984	83	Treated	CLW 5632	CLJA_USMCGEN_0000009913
12/4/1984	15	Untreated	CLW 5632	CLJA_USMCGEN_0000009914
12/12/1984	2.3J	Treated	CLW 4546	ATSDR_WATERMODELING_01-0000886764
2/5/1985	150	Unknown	CLW 5509	CLJA_USMCGEN_0000005529
Vinyl Chloride (VC)				
2/5/1985	2.9J	Unknown	CLW 5509	CLJA_USMCGEN_0000005529
Benzene				
11/19/1985	2500	Unknown	CLW 1355	CLJA_USMCGEN_0000007001
12/10/1985	3	Unknown	CLW 1355	CLJA_USMCGEN_0000007001
12/18/1985	1	Unknown	CLW 1355	CLJA_USMCGEN_0000007001
Note 1: J = Estimated				
Note 2: Data from Faye et al. (2010, Tables C11 and C12); Maslia et al. (2013, Table A18)				

At the TTWTP a triplet of measured water samples obtained on 7/28/1982 show results as follows: 104 μg/L in "finished water", 76 μg/L in "untreated water", and 82 μg/L in "treated water",[19] indicating no PCE loss to volatilization during the treatment process.

Additionally, in contrast to RH's contention that ATSDR ignored or did not account for VOC losses during storage, treatment and distribution, this issue (including the results of the AH Environmental Consultants report [2004]) was discussed in detail with the Expert Panels convened by ATSDR in 2005 and 2009 (Maslia, 2005, 2009). During the first day of the meeting in 2005 (March 28) panel members Dr. Tom Walski (Bentley Systems) and Dr. Peter Pommerenk (AH Consultants and consultant to the USMC) responded to a question from panel member Dr. James Uber (University of Cincinnati) to Morris Maslia about whether there are any potential chemical biological processes taking place in the distribution system.[20] Additional discussion occurred during the 2009 Expert Panel meeting (April 30) by Dr. Pommerenk.[21] Excerpts from the verbatim transcript are provided in Appendix **A**. The consensus was that there was negligible volatilization (at most 10% from the spiractors). "So although we said it's probably negligible, and I agree with Tom's number here. At 90 percent, what's going in is coming out on the other end." (see Appendix **A**). In light of the conclusions of AH Environmental Consultants (2004) and the recommendations of its Expert Panels, ATSDR made the decision to consider any potential VOC losses from storage, treatment and distribution as negligible.

Additional support for this decision comes from the eight-day period, January 28-February 8, 1984, when the HBWTP was shut down and not operating. At that time, the HPWTP provided finished (and contaminated) water to the HB water-distribution system by operating booster pump 742 and opening the Marston Pavilion valve (Maslia et al. 2013, p. A2, p. A65). Water samples taken on January 31, 1985, indicated TCE concentrations ranged from 24.1 mg/L to 1,148.4 mg/L, with a sample taken at the HPWTP (Building 20, treatment status unknown) having a TCE concentration of 900 mg/L.[22] Although not a direct indication of negligible TCE loss to volatilization during the treatment process at the HPWTP, these samples, taken from the HB water-distribution system (supplied by contaminated HPWTP finished water), suggest that any loss of VOCs owing to volatilization in the treatment process were consistent with the advice of the ATSDR Expert Panels (Appendix A) and the findings of AH Environmental Consultants (2004) and Sabatini (2025).

4.4 Derivation and Computation of Sorption Parameter Values

DOJ experts AS and RH posit that selected geochemical parameters (sorption parameters) were incorrect (Spiliotopoulos 2024, Section 4.1.2.2) and that ATSDR failed to consider site data to parameterize models (Hennet 2024, Opinion 12). Both opinions are incorrect. A detailed response pertinent to sorption parameters for the TT analyses is presented below and is also provided in Konikow (2025).

ATSDR applied and calibrated the MT3DMS model to evaluate the occurrence and migration of contaminated groundwater at TT. MT3DMS, a multi-species, mass transport model, is a widely

[19] CLJA_USMCGEN_0000009869.
[20] CLJA_WATERMODELING_01-0000942379 – 01_0000942381.
[21] CLJA_WATERMODELING_02-0001111469 – 01-0001111472.
[22] CLW 4552, CLJA_WATERMODELING_09-0000424939.

used public domain model code used to simulate the migration of solutes/contaminants in groundwater (Zheng and Wang, 1996; Zheng 2010).

To account for sorption, MT3DMS computes a retardation factor (R), which, in turn, requires the selection of an equilibrium isotherm. A linear equilibrium isotherm was selected for the TT MT3DMS model. The retardation factor and the linear equilibrium isotherm are related by the following formula:

$$R_f = 1 + (K_D \times \rho_b)/n_e \qquad (1)$$

where

R_f = the retardation factor, dimensionless

K_D = the distribution coefficient, in L^3/M

ρ_b = the bulk density, in M/L^3

n_e = the effective porosity of the porous media, dimensionless

(M=mass; L=length))

The K_D is a parameter that accounts for adsorption to mineral and/or organic material in the soil. While a chemical is adsorbed to soil, it does not move with the groundwater, so that the chemical migrates through the subsurface more slowly than the average groundwater velocity. This slower chemical velocity is quantified by the retardation factor, which is the ratio of the average water velocity to the chemical velocity. A R_f of 2, for example, indicates that the chemical moves at half the average groundwater velocity because of adsorption.

As seen in Equation (1) above, the R_f depends on the product of the ρ_b (bulk density) and K_D. Different combinations of K_D and ρ_b (and effective porosity, n_e) can thus result in the same retardation factor and will calibrate a model equally well. For example, a K_D value of 0.5 and a ρ_b of 2.0 would result in the same R_f as a K_D value of 0.6 and a ρ_b of 1.67, because 0.5 x 2.0 = 1, and 0.6 x 1.67 also equal 1. Because contaminant movement in groundwater depends on the R_f, an erroneous ρ_b and an erroneous K_D can compensate for each other because they are multiplied together, resulting in a R_f that best calibrates a model even though the individual ρ_b and K_D are not correct or are unknown.

During model calibration, the ρ_b and n_e were held constant while K_D was varied (i.e., K_D is a model calibration parameter). This approach was largely dictated not only by the several divergent methodologies used to determine K_D, generally batch and column experiments, but also by the high uncertainty and variability of reported K_D values, regardless of methodology. The EPA in its Volume II of *Understanding Variation in Partition Coefficient, K_D, Values* (USEPA 1999, Volume II, p 3.4) states *"The K_D values reported in the literature for any given contaminant may vary by as much as 6 orders of magnitude."* Similarly, Spiliotopoulos (2024, Appendix A) tabulates site-specific K_D values for total organic carbon (TOC) at Camp Lejeune that vary by at least 3 orders of magnitude.

The initial K_D values used during calibration of the Tarawa Terrace MT3DMS model were derived largely from Hoffman (1995) and were determined from column experiments performed on sediment samples collected from 240 boreholes drilled into a plume contaminated with PCE and trichloroethylene (TCE). Borehole samples were composed largely of sand, silt and gravel, similar to the subsurface at Tarawa Terrace. Borehole sediments also contained low concentrations of total organic carbon. The K_D values for PCE reported by Hoffman (1995) related to silt and sand ranged from about 0.20 to 0.80 milliliters per gram (ml/g) and averaged 0.40 and 0.39 ml/g, respectively. The K_D determined from the completion of MT3DMS model calibration was 0.14 ml/g and was somewhat less than values determined by Hoffman (1995). The retardation factor (R_f) determined from MT3DMS calibration was 2.93 (Faye 2008) and is very close to other values reported in the literature for similar geologic materials (e.g., Rogers 1992)

In his report, Konikow (2025) also discusses Hennet's (2024, Opinion 11) criticism of ATSDR for having failed to consider available site-specific data for f_{oc} (fraction of organic content) to estimate K_D . However, as Konikow (2025) points out:

> "Rogers (1992, p. 51) in discussing the K_d parameter says "Numerous researchers have used theoretical methods correlating the organic carbon content (OCC) of the subsurface material and the K_d (Karickhoff, 1984). Others have used the partitioning between octanol and water to predict the K_d (Kenega, 1980). **These methods are not considered appropriate where the OCC is less than approximately 0.1%**." OCC is equivalent to TOC, and 0.1% is equivalent to a fraction or 0.001. Hennet's Expert report lists (Exhibit 3-2, and p. D-11 to D-12) 21 Camp Lejeune samples where f_{oc} is given. The median value is 0.0013, barely above the indicated limit, and 9 samples (43% of the samples) have values <0.001, indicating that the use of f_{oc} to estimate K_d is not appropriate. If ATSDR had used this approach, it would have introduced additional errors and sources of uncertainty."

Following calibration of the Tarawa Terrace MT3DMS model and the subsequent peer reviews and publication of model results, a member of the 2009 ATSDR Expert Panel (April 29–30) indicated in his pre-meeting comments on published ATSDR analyses that a wet rather than a correct dry bulk density was input to MT3DMS (Maslia 2009, p. 117)[23] . Because transport models depend on the retardation factor which, in turn, is determined by the product of K_D and bulk density (Equation 1), the erroneously high bulk density implied that the value of K_D was too low. Accordingly, project staff resumed calibration of the Tarawa Terrace MT3DMS model by assigning a corrected bulk density (ρ_b) of 1.65 g/ml (46,725 g/ft^3) to MT3DMS and testing simulated results by varying K_D values ranging from 0.20 to 0.40 g/ml (Hoffman, 1995). Test simulations were determined to be relatively insensitive to changes in K_D; however, K_D values near the low part of the range (0.20 ml/g) were determined most comparable to best calibration. Finally, a corrected TT MT3DMS model was achieved using a dry bulk density of 1.65 g/ml and applying Equation (1) to compute a paired K_D value of 0.23 ml/g, thus maintaining the calibrated retardation factor (R) of 2.93 and model results as published (Faye 2008). Thus, the initial erroneous bulk density value had no effect on the final model calibration, which depended only on the product of K_D and ρ_b through the R_f. Note, the K_D value of 0.23 ml/g input to the corrected MT3DMS model is within the lower part of the range for this value applicable for PCE published by Hoffman (1995).

[23] CLJA_UST02-0000059851

By comparison, and as Dr. Konikow discusses in his report (Konikow 2025), "Kret et al. (2015) studied a Quaternary sandy aquifer to estimate sorption coefficients for PCE fate and transport modeling. They estimated K_D from both batch and column experiments and concluded that reasonable values for R_f for PCE are typically between 1.1 and 3.6." The ATSDR calibrated value of 2.93 is very near the mean of this range. As Dr. Konikow points out, Rogers (1992) also supports the ATSDR's calibrated value. There, a groundwater transport model was developed for the Lawrence Livermore National Laboratory (LLNL) site in California, which includes "several hundred feet of complexly interbedded, unconsolidated alluvial sediments" with an upper boundary represented by an unconfined water table condition. Their calibration and history matching resulted in reasonable matches for R_f values between 1.0 and 3.0, with their conclusion that "a spatially averaged retardation factor of approximately 3 is recommended…".

The values used by Spiliotopoulos (2024) for ρ_b (1.65 g/cm^3) and for K_D (0.30 and 0.40 mL/g) result in R_f values of 3.48 and 4.30, respectively, which are on the high-side of many literature-reported values and the calibrated value of 2.93. Using the Spiliotopoulos (2024) values in effect slows the movement of PCE through the aquifer and increases the time at which PCE-contaminated groundwater arrives at water-supply wells and the TTWTP (Spiliotopoulos 2024, Figures 7 and 8). Spiliotopoulos (2024, p. 37-38) also posits a R_f of 6.44 but provides no supporting evidence or reference for this value. What Spiliotopoulos has done is in essence conduct a sensitivity analysis using R_f as the varied parameter. However, Dr. Spiliotopoulos did not adjust ρ_b and/or n_e to best calibrate the model using his higher K_D values. The higher R_f based on Dr. Spiliotopoulos' larger K_D values do not calibrate the model as well as the R_f used by the ATSDR team. In addition, as shown in Faye (2008), the calibrated TT fate and transport model is relatively insensitive to changes in R_f (K_D being the varied parameter in R_f). Instead, the model is substantially more sensitive to changes in mass loading rate and pumping variation.

ATSDR documented the above modifications to ρ_b and K_D in an email (and attachment) dated February 28, 2011.[24] ATSDR had planned to issue an errata pertinent to the updated ρ_b (dry) and K_D as a forthcoming TT Chapter K report (mentioned in the Foreword Section of all published TT reports). Agency budgetary and project completion time constraints prevented the errata and any supplemental information from being formally published and publicly released as the TT Chapter K report.

To test the effect that variations in R_f have on PCE concentrations at water-supply well TT-26 and the TTWTP, a series of simulations were conducted wherein the calibrated retardation factor of 2.93 (Faye 2008) was increased to 3.48 and 4.3 as speculated by AS and RH. As these sensitivity analyses (variations in retardation factor) demonstrate in Figure 4.6 below, the model is insensitive to changes (increases) in the retardation factor. After 1960, simulated results show PCE concentrations at TT-26 and at the TTWTP more than the MCL for PCE of 5 μg/L.

[24] ATSDR_WATERMODELING_01-0000887322 and 01-0000887324.

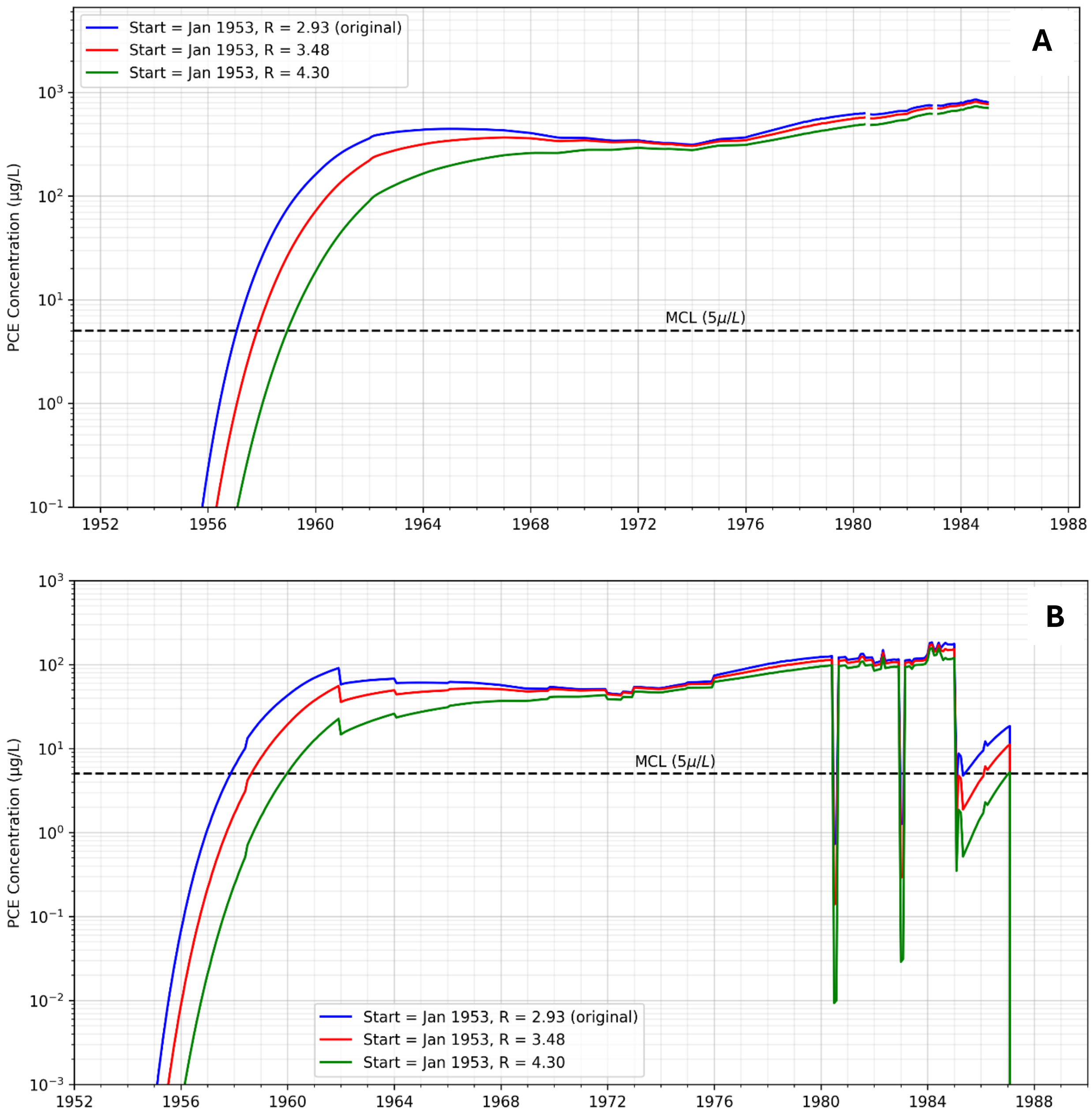

Figure 4.6. Comparison of tetrachloroethylene (PCE) reconstructed concentrations for variations in retardation factor for: (A) water-supply well TT-26, and (B) Tarawa Terrace water treatment plant (TTWTP). Note: R = 2.93 is calibrated retardation factor from Faye (2008).

4.5 Model Calibration and Uncertainty Analysis

Rebuttal responses to criticisms related to model calibration and uncertainty analysis raised by AS (2024) and RH (2024) are provided below.

4.5.1 Model Calibration

In Opinion 1, AS posits that the ATSDR models were not "calibrated to observed data for the first 30 years of simulation" (Spiliotopoulos, 2024, p. 30). However, it is crucial to understand that concentration data for that period do not exist, which is exactly why reconstruction was performed. The ATSDR models were designed to estimate those concentrations in a state-of-the-art manner, consistent with principles of groundwater flow and fate and transport processes. These models did not generate arbitrary random numbers; rather, the results are reasonable and realistic. The presence of error bands or uncertainty ranges around the estimates is to be expected and is readily acknowledged (Konikow 2025).

In his Opinion 2, AS (2024, p. 33) reproduces ATSDR's Figure F16 (Faye 2008)[25] of TT historical reconstruction results at water supply well TT-26, and states that ASTDR's work resulted in "biased high estimates." As Dr. Konikow notes, Figure F16 (provided in this report as Figure 4.4 in Section 4.2.1) illustrates the opposite and instead "shows 5 measured PCE concentrations in samples from well TT-26 collected within weeks of each other in early 1985. Over this relatively short time span, the concentrations varied greatly (bracketed between a high of 1,580 μg/L on 01/16/1985 to a low of 3.8 μg/L on 02/12/1985)—a rate of change that cannot be replicated in a model using monthly time steps. Most importantly, the plot shows that the model results fell almost exactly at the midpoint of the range of observed values (about 800 ug/L)—countering the claim of being biased high." (Konikow 2025)

The plot shown in Spiliotopoulos (2024, Figure 13) is discussed in AS's Section 4.1.3.2 (p. 50, paragraph 8). It is noted that the results of the calibrated model, as AS states, "sits at the upper bound of the retardation-factor uncertainty range." However, as Dr. Konikow notes and I agree, "that is not true for the majority of the simulation period. It is close to the middle of the range during the period of 1962 through the end (around Dec. 1987). And prior to 1962, it still lies within the uncertainty bounds, which is acceptable and not indicative of bias." (Konikow 2025). Furthermore, calibrated model results do not always lie at the center of the uncertainty band because the response of the model to some parameters can be non-linear, and a model can be insensitive to changes in a model parameter at either high or low extremes.

For water-supply well HP-651, ATSDR applied the Linear Control Model (LCM) to reconstruct concentrations of TCE, PCE, and PCE degradation products (TCE, 1,2-tDCE, and VC). In Opinion 16 (Spiliotopoulos 2024, Section 4.2.4, p. 82-83) AS argues that the model for volatile organic compound (VOC) degradation products was based on limited data, and ATSDR's historical reconstruction prior to December 1984 "cannot be verified."

[25] Figure 4.4 of this report, previously discussed in Section 4.2.1

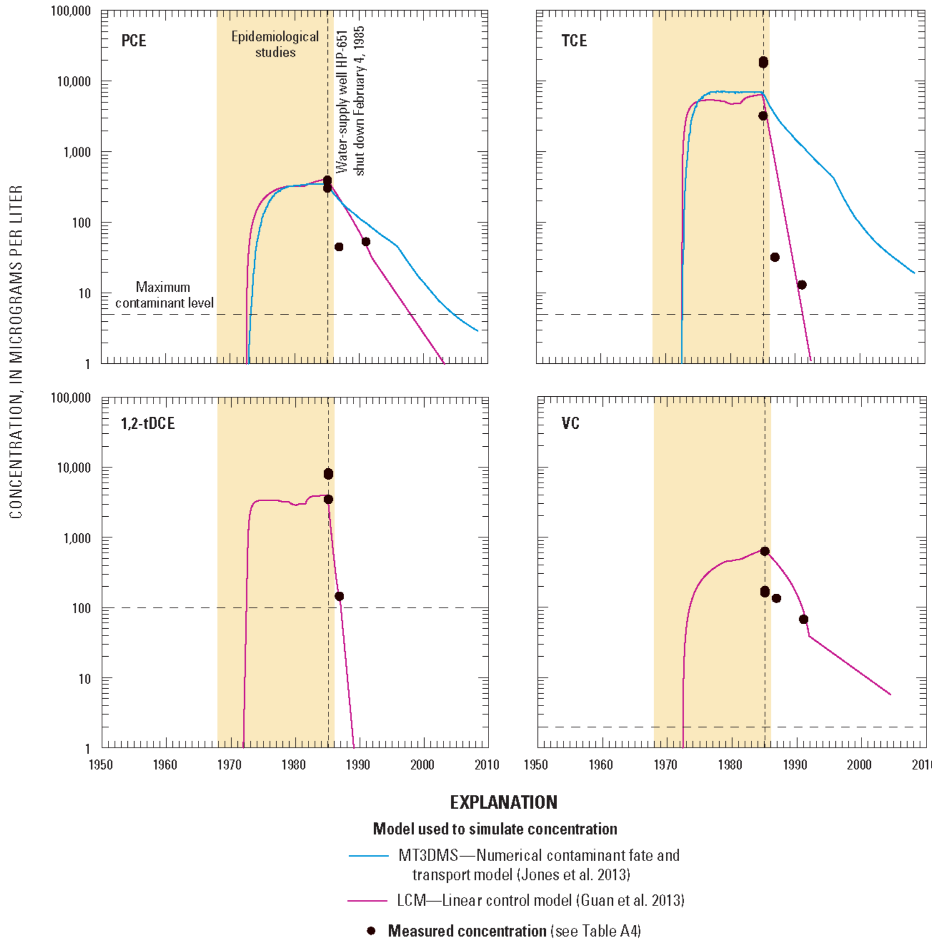

Figure A25. Reconstructed (simulated) concentrations of tetrachloroethylene (PCE), trichloroethylene (TCE), *trans*-1,2-dichloroethylene (1,2-tDCE), and vinyl chloride (VC) at water-supply well HP-651 using numerical (MT3DMS) and linear control methodology (TechControl) models, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina. (See Figure A14 for well location.)

Figure 4.7. From Maslia et al. (2013), Figure A25.

In section 4.2.4 (p. 82-83), AS states that "As illustrated in Figure 33 [ATSDR Figure A25], the historical reconstruction prior to 1985 cannot be verified, due to lack of observed data for the period." As I have stated previously, and as Dr. Konikow also opines, this is the reason why a simulation model was needed and was developed. For the four contaminants shown in Figure 4.7 the agreement between simulated values and observed data where data was available is excellent in all four plots. If anything, the model results for TCE and 1,2-tDCE are below the peak sampled data points, again suggesting that the model is under-predicting these concentrations. "This close agreement when observations are available builds confidence in the reliability of the model and its predictions," including for the historical reconstruction results for times prior to 1985. (Konikow 2025). The objective was to use a technically sound model that would be calibrated to available data in and after 1985, and to estimate the values during the 15 or so years prior to that calibration period to inform the epidemiological studies.

The objective was to use a technically sound model that could be calibrated to available data in and after 1985 and to estimate the values during the 15 or so years prior to that calibration period to inform the epidemiological studies. As Konikow (2025) observes, for PCE and TCE, the fit with the LCM model was slightly better than with the MT3DMS model, which was not designed to simulate degradation products. The excellent quality of the fit is illustrated in Figure 4.7.

4.5.2 Uncertainty Analysis

ATSDR is transparent in its analyses and publications that uncertainty exists about conditions during both the historical reconstruction and calibration period. Results include assessments of uncertainty (Maslia et al. 2007, p. A52; Maslia et al. 2013, p. A92), including an entire Chapter Report (Chapter I) in the Tarawa Terrace report series (Maslia et al. 2009). In fact, the EPA in its Superfund Exposure Assessment Manual (1988, Section 4.4), discusses "Approaches for Dealing with Uncertainty" and the use and application of sensitivity analysis and Monte-Carlo (MC) simulation.

In his Opinion 8 (Section 4.1.3.2, p. 50, paragraph 3), AS criticizes the Monte Carlo (MC) simulation approach used by ATSDR "… because ATSDR implemented a 'probability distribution function' … to describe how values closer to the mean value of the range are more probable than those away from the mean." This is not a problem or issue as posited by AS, but rather, this is one of several accepted methods "for random sampling of parameter values for a MC analysis when information or theory indicates that a parameter has a statistically normal or log-normal distribution." (Konikow 2025). Tung and Yen (2005, Section 6.1, p. 213) state, ". . . due to the complexity of physical systems and mathematical functions, derivation of the exact solution for the probabilistic characteristics of the system response is difficult, if not impossible. In such cases, Monte Carlo simulation is a viable tool to provide numerical estimations of the stochastic features of the system response." Additionally, Bobba et al. (1995) state, "A Monte Carlo model is basically constituted by a deterministic portion (the deterministic model), of variable complexity, that is used to represent mathematically the system under observation, and a probabilistic portion, constituted by the probability distributions of both the parameters of the deterministic model (if available) and the observed variables (conditions)."

In Section 4, Basis for Opinions (p. 29), AS quotes Dr. T.P. Clement's comments about ATSDR's uncertainty analysis (Clement, 2011): "The figure also shows that closer to the initial starting point, the confidence band is almost 100%, implying that our knowledge of initial conditions, initial source loadings, and initial stresses is almost exact." Contrary to Dr. Clement's observations, both Dr. Konikow and I are confident that there was no (or negligible) PCE in the groundwater from ABC One-Hour Cleaners (or any other source) prior to January 1953, and likely very little for several months thereafter. (see Konikow 2025)

Additionally, uncertainty analysis is a process associated with simulations (Bobb et al. 1995). One cannot produce an uncertainty band at the start of simulations. If there is no simulation, there is no uncertainty. Thus, uncertainty at the start is zero when there is no simulation, and it expands as the computation process progresses forward. ATSDR did not consider uncertainty at the start of our source characterization. Instead, ATSDR assumed that prior to the start of operations at ABC One-Hour Cleaners, the concentration of PCE in groundwater was perfectly known, and it was 0 μg/L.

Another point to be made is that the graph in question in AS's critique (Maslia et al. 2007, Figure A26)[26] is the concentration time history at the TTWTP. This plot was created using a mass balance equation:

$$C_{TTWTP} = \frac{\sum_{i=1}^{NW} C_i \, Q_i}{\sum_{i=1}^{NW} Q_i} \qquad (2)$$

where C_{TTWTP} is the concentration of water at the TTWTP for a specific month, *NW* is the number of operating wells for a specific month, C_i is the concentration of well *i* for a specific month, and Q_i is the pumping rate of well *i* for a specific month, featuring water pumped from a variety of supply wells. Most of the PCE comes from Well TT-26. All these wells are down-gradient from the source at ABC One-Hour Cleaners. While the fringe of the plume with very low concentrations arrives fairly soon, it takes several years for the bulk of the plume to arrive. Consequently, the parameter variations in the model instances within the MC simulation will lead to variations in the PCE plume. However, these variations do not manifest at the TTWTP for several years. Therefore, a narrow band early in the TTWTP timeline is expected. Even with the application of source concentration variations by ATSDR, the uncertainty band at the TTWTP would remain relatively narrow in the initial years.

In summary, ATSDR used and applied an accepted methodology for conducting an uncertainty analysis—Monte Carlo simulation using probability distribution functions. This method is described in several references including EPA's Superfund Exposure Assessment Manual (1988, Section 4.4), Tung and Yen (2005), and Zheng and Bennet (2002, p. 353). ATSDR provided specific details on how it carried out its uncertainty analysis with respect to both groundwater-flow model and contaminant fate and transport model parameters (and assigned probability distributions) in the Tarawa Terrace Chapter I report (Maslia et al. 2009, p. I30).[27] I agree with Dr. Konikow's assessment of the ATSDR uncertainty analysis where he states:

> "I do not see a problem here as this is an option within standard practice for random sampling of parameter values for a MC analysis when information or theory indicates that a parameter has a statistically normal or log-normal distribution. Zheng & Bennett (2002, p. 353) say "The Monte Carlo method is by far the most commonly used method for analysis of uncertainty associated with complex numerical methods." They further state (p. 356) "The heart of the Monte Carlo method is the generation of multiple realizations (or samples) of input parameters that are considered to be random variables. Each random variable is assumed to follow a certain probabilistic model characterized by its probability density function (PDF). The probability distributions commonly used in hydrogeologic studies include *normal*, *lognormal*, *exponential*, *uniform*, *triangular*, *Poisson*, and *beta* distributions." It is worth noting that when this book was published, co-author Bennett was an employee of SSP&A and first author Zheng was a former employee and affiliate of SSP&A" (Konikow 2025).

[26] ATSDR_WATERMODELING_01-0000909018.
[27] CLJA_WATERMODELING_01-0000772752.

4.6 Post-Audit of the ATSDR Tarawa Terrace Models

Jones and Davis (2024) conducted a post-audit of the Tarawa Terrace groundwater flow and contaminant fate and transport models by extending the TT simulations from 1995–2008 using additional ABC One-Hour Cleaners site data that had become available after ATSDR published results for TT in July 2007 (Maslia et al. 2007). Jones and Davis (2024, Executive Summary) state,

"In summary, this post-audit found that the original Tarawa Terrace groundwater flow and transport models were developed using sound methodology and continue to provide reliable insights into the migration of PCE contamination. Despite the inherent challenges in simulating complex subsurface conditions and dealing with incomplete data, the model effectively simulates long-term trends in contaminant migration. Based on this post-audit, we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model."

In his Opinion 13, AS states "Prior to offering opinions as experts in this litigation, Mr. Maslia and Dr. Aral should have used the data that Dr. Jones and Mr. Davis used to conduct the Tarawa Terrace Flow and Transport Model Post-Audit to update the calibration of the dose reconstruction groundwater model." (Spiliotopoulos 2024, p. 3).

There are few post-audits for calibrated contaminant fate and transport models to compare approaches with the Tarawa Terrace post-audit (e.g., Person and Konikow, 1986). Most post-audits have been conducted for calibrated groundwater-flow models. The literature on post-audits of groundwater and hydrological model predictions remains limited (Kidmose et al., 2023). Anderson and Woessner (1992) reviewed five post-audits from the 1990s and concluded that original model failures were primarily due to errors in conceptual models or defining future stress (such as pumping).

In reviewing the literature on post-audits (Alley and Emery, 1986; Konikow, 1986; Kidmose et al., 2023), the outcomes are generally used to identify where additional data are required and to enhance the understanding of hydrogeology and transport phenomena (conceptual model improvement). Post-audits are not necessarily conducted, as AS posits in his Opinion 13, to re-calibrate or update a calibrated model based on additional (and future) data.

Alley and Emery (1986) provide general perspectives on groundwater modeling gained from post-audit analysis, noting that "post-audit analysis of groundwater modeling studies is a valuable exercise, particularly considering that historically groundwater modeling studies have not included a strong model verification stage." In conducting a post-audit of a solute-transport model, Person and Konikow (1986) concluded that "the nature of the errors indicated a need to incorporate an additional process into the model (salt transport through the unsaturated zone)."

In extending ATSDR's original TT groundwater-flow and contaminant fate and transport model, Jones and Davis used additional site data such as recovery-well locations and operations, additional monitor-well locations, changes in recharge during the post-audit period (1995–2008), and observed PCE concentration data. Re-calibration of the TT models was not an objective and would not have yielded substantive changes to the original ATSDR results and conclusions because no conceptual model flaws (groundwater flow and contaminate fate and transport) were noted. Thus, AS's Opinion 13 is a moot point.

Finally, it needs to be noted that after the publication of ATSDR's TT Models in 2007 (Maslia et al. 2007)[28], ATSDR modeling staff recognized the value of conducting a post-audit of the TT models and they communicated this to ATSDR Senior Management and representatives of EPA Reion IV. The extension of the TT models from 1994–2007 would have required additional agency resources, modeling time, and coordination with the EPA (Region IV) to obtain all the additional data required for the post-audit.[29]

4.7 Graphing and Visualization of Data and Model Results

Konikow (2025) discusses AS's position that the presentation of results of the uncertainty analysis conducted by ATSDR for the TT model is "visually misleading" (Spiliotopoulos, 2024, Section 4.1.3.1). I agree with Dr. Konikow. The cited reason is that "they used a logarithmic scale, which visually compresses the uncertainty range around their calibrated model [results]." However, as Dr. Konikow notes, using a logarithmic scale is an accepted and common approach in engineering and scientific studies, and it is not considered misleading by scientists and engineers. Concentration data often vary over many orders of magnitude, which is why it is frequently presented using a log scale.

Furthermore, AS notes that the plot ranges over six orders of magnitude on the axis for PCE concentration, yet the width of the uncertainty bands does not span an equally wide range. Again, I concur with Dr. Konikow: "When values span such a large range, it is normal and standard to use a log plot. Using just an arithmetic scale would effectively hide all the changes in the lower part of the scale." (Konikow 2025)

AS also states (p. 46, para. 4) that "the difference between the high and low values in his Figure 11 (Maslia et al., 2009, Figure I29) is not significant enough to justify the use of a logarithmic scale." However, because the observed values span more than two orders of magnitude (excluding non-detects) and the simulated values span more than five orders of magnitude, plotting these data and results using a logarithmic scale is reasonable and informative. It is the only way to portray the early time results of the simulation in the same graphic (Konikow 2025).

4.8 Non-Degraded and Degraded PCE Historical Reconstructions

In his Summary of Opinions 10 and 11, Spiliotopoulos (2024, Section 4.1.4, p. 58) states,

"ATSDR applied two different numerical codes for modeling dose reconstruction. The results of the two codes are not in agreement. This is due, in part, to inconsistent application of contaminant source terms in the two models. Neither ATSDR, Mr. Maslia, nor Dr. Aral, provided sufficient scientific justification for selecting the higher estimated monthly contaminant concentrations for their dose reconstruction".

ATSDR has been open and transparent about the application of different models to reconstruct historical concentrations of PCE and PCE degradation products (TCE, 1,2-tDCE, and VC). All models are approximations of the real world and site-specific conditions, and modeling objectives determine the simplicity or complexity of a model to be used. Models that include different

[28] Results of the Tarawa Terrace models were publicly release during July 2007.
[29] CLJA_WATERMODELING_01-0000840256 – 01-0000840257; CLJA_WATERMODELING_01-0000070593, 01-0000070594, 01-0000065999, 01-0000021042, 01-0000837170 – 01-0000837172; CLJA_WATERMODELLING_01-0000837170 – 01-0000837171.

physical processes will naturally produce different results. This is an accepted modeling approach practiced by groundwater modelers. In the TT Chapter A report, Summary and Conclusions section (Maslia et al. 2007, p. A70)[30], both the non-degraded analysis for PCE (MODFLOW/MTDMS) and the degraded analysis for PCE (TechFlowMP) are discussed and summarized. ATSDR did not, as AS states “select[ing] the higher estimated monthly contaminant concentrations for their dose reconstruction” (Spiliotopoulos 2024). The water-modeling staff, being blinded to the epidemiological study through the entire water-modeling process, provided both the non-degraded (MODFLOW/MT3DMS) and degraded (TechFLOWMP) historical reconstruction results to the ATSDR health studies staff.

For the Tarawa Terrace historical reconstruction analysis, ATSDR applied a simplification of the biochemical processes such as volatilization and biodegradation taking place in the subsurface and used a model (MODFLOW/MT3DMS) that does not consider the biodegradation of PCE. ATSDR’s philosophy was to “start simple” to try to understand aquifer and transport characteristics before attempting a more complex modeling effort that included biochemical processes such as volatilization and biodegradation of PCE. Again, this is a common and accepted modeling approach. Using a four-stage, hierarchical calibration approach, ATSDR achieved acceptable or better calibrations for predevelopment and transient groundwater flow, contaminant fate and transport (using MT3DMS), and the simple mixing model, as evidenced by the comparison of reconstructed and observed PCE concentrations at the TTWTP (Maslia et al., 2007, Figure A39; Fay 2008, Table F14 and Figure F27). Table 4.10 of this report, which is taken from Faye (2008, Table F14), shows that the model achieves acceptable matches between reconstructed and observed PCE concentrations at the TTWTP. In fact, even for observed non-detections, most reconstructed PCE concentrations are within the published detection limits (a non-detect does not imply zero concentration, but that the sampling and testing methodologies were not sensitive enough to detect concentrations). At the TTWTP storage tank (STT-39), the reconstructed PCE concentration was 176 μg/L compared to an observed PCE concentration of 215 μg/L—quite an impressive match for water-quality data—resulting in a geometric model bias of solely 1.5 (Maslia et al. 2007).[31]

[30] ATSDR_WATERMODELING_01-0000909028.

[31] ATSDR_WATERMODELING_01-0000908983 – 01-0000908984.

Table 4.10. From Faye (2008). Table F.14.

Table F14. Computed and observed tetrachloroethylene (PCE) concentrations in water samples collected at the Tarawa Terrace water treatment plant and calibration target range, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[µg/L, microgram per liter; TTWTP, Tarawa Terrace water treatment plant; ND, not detected]

Date	PCE concentration, in µg/L		Calibration target range, in µg/L
	Computed[1]	Observed	
[2]TTWTP Building TT-38			
5/27/1982	148	180	25–253
7/28/1982	112	[3]104	33–329
7/28/1982	112	[3]76	24–240
7/28/1982	112	[3]82	26–259
2/5/1985	176	[3,4]80	25–253
2/13/1985	3.6	[5]ND	0–10
2/19/1985	3.6	[6]ND	0–2
2/22/1985	3.6	[5]ND	0–10
3/11/1985	8.7	[6]ND	0–2
3/12/1985	8.7	[6,7]6.6	2.1–21
3/12/1985	8.7	[6,8]21.3	6.7–67
4/22/1985	8.1	[5]1	0.3–3.2
4/23/1985	8.1	[5]ND	0–10
4/29/1985	8.1	[5]3.7	1.2–11.7
5/15/1985	4.8	[5]ND	0–10
7/1/1985	5.5	[5]ND	0–10
7/8/1985	5.5	[5]ND	0–10
7/23/1985	5.5	[5]ND	0–10
7/31/1985	5.5	[5]ND	0–10
8/19/1985	6.0	[5]ND	0–10
9/11/1985	6.0	[5]ND	0–10
9/17/1985	6.0	[5]ND	0–10
9/24/1985	6.0	[5]ND	0–10
10/29/1985	6.0	[5]ND	0–10
[2]TTWTP Tank STT-39			
2/11/1985	176	[5]215	0–10

[1]Weighted-average computation

[2]See Plate 1, Chapter A report, for location (Maslia et al. 2007)

[3]Detection limit is unknown

[4]Analysis of tap water sample for Tarawa Terrace, address unknown

[5]Detection limit = 10 µg/L

[6]Detection limit = 2 µg/L

[7]Sample collected downstream of TTWTP reservoir after operating well TT-23 for 24 hours

[8]Sample collected upstream of TTWTP reservoir after operating well TT-23 for 22 hours

Next, ATSDR set out to apply a more complex and more sophisticated approximation of transport in the subsurface by using a model that would degrade PCE into TCE, 1,2-tDCE, and VC. As PCE migrates in the subsurface it continues to undergo transformation through physical and biochemical processes such as volatilization and biodegradation. To quantify historical concentrations of PCE degradation by-products observed in groundwater samples reported in Faye and Green, Jr. (2007, Figures E1-E14) and in soil (vapor phase) requires a model capable of simulating multiphase flow and multispecies mass transport such as TechFlowMP (Jang and Aral 2008). ATSDR summarized the second and more complex modeling approach in Maslia et al. (2007, p. A41) and described the detailed development and application of the TechFlowMP model at Tarawa Terrace in Jang and Aral (2008). MT3DMS and TechFlowMP use two entirely different numerical schemes. MT3DMS uses a finite difference scheme to approximate the partial differential equations of saturated groundwater flow and contaminant fate and transport. TechFlowMP uses a Galerkin finite-element based approach with upstream weighting and mass lumping of the time derivative matrices to simulate multiphase flow and multispecies mass transport in the vadose zone and saturated zone.

To simulate groundwater flow conditions at TT, TechflowMP applied the calibrated hydraulic and aquifer properties from MODFLOW, reported in Maslia et al. (2007, Table A11). A correlation between geologic and hydrologic units and the MODFLOW/MTD3DMS and TechflowMP models is provided in Jang and Aral (Table G1), with the main difference between the two modeling approaches being that TechFlowMP has 5 layers assigned to the variably saturated zone. For predevelopment and transient groundwater flow, TechFLowMP applied the same initial and boundary conditions and pumping schedules used in MODFLOW reported in Faye and Valenzuela (2007). Comparisons of simulated groundwater heads between the TechFlowMP and MODFLOW-96 models show good agreement, and comparisons between the two modeling approaches are shown in Jang and Aral (2008, Figure G3) for model layers 1, 3, and 5 (main water-bearing units). Slight differences between groundwater-head simulations obtained using the two models were most likely due to the different numerical methods used by the two models to approximate the equations of groundwater flow. Recall that TechFlowMP uses a finite-element technique, whereas MODFLOW uses a finite-difference technique.

As discussed above, the TechFlowMP model uses a more complex approach for simulating fate and transport of biochemical processes such as volatilization and biodegradation taking place in the subsurface. Additional chemical and physical properties required by TechFLowMP for PCE and its degradation products (TCE, 1,2-tDCE, and VC) are listed in Jang and Aral (2008, Table G2). Other fate and transport properties used for the MT3DMS simulation are listed in Maslia et al. (2007, Table A11). For the source concentration (PCE) at ABC One-Hour Cleaners, MT3DMS applied a mass-loading rate of 1,200 g/d (calibrated) to the saturated zone (MODFLW/MT3DMS model Layer 1). At ABC One-Hour Cleaners the altitude of the source ranges from 0 to 13 ft, which implies that in TechFlowMP the source PCE was partially released into the unsaturated zone and partially released into the saturated zone.

PCE concentrations simulated by TechFlowMP are less than those using MT3DMS (Maslia et al. 2007, Appendix A2; Expert Report of M. Maslia (2024, Appendix H1). This is partially due to TechFlowMP simulating (1) the release of PCE from the subsurface (groundwater) to the atmosphere, (2) PCE partitioning from the water phase to the soil vapor phase, and (3) the placement of the contaminant source at the ABC One-Hour Cleaners site in the unsaturated and saturated zones. The difference between MT3DMS and TechFlowMP in simulating PCE transport at Tarawa Terrace and vicinity is (1) TechFlowMP considers PCE in both water and gas phases while MT3DMS considers PCE only in the water phase and (2) in MT3DMS the source concentration is released solely to the saturated zone. In MT3DMS simulations (Faye 2008), there is no PCE transfer into the gas phase. In TechFlowMP simulations, however, because PCE could be present in the gas phase, a portion of PCE in the gas phase could be released from the subsurface into the atmosphere through the ground surface. This results in the reduction of PCE concentration in the subsurface. The differences in simulated PCE concentrations at Tarawa Terrrace were clearly and transparently presented by ATSDR in Appendix A2 (Maslia et al. 2007) and in the Expert Report of Maslia (2024, Appendix H1). In these appendices, column 3 represents the MODFLOW/MT3DMS simulation of PCE whereas column 4 represents the TechFlowMP simulation of PCE (the same simple mixing model was applied to both simulation methods to obtain PCE concentrations at the TTWTP).

Based on the explanations given above for simulated PCE differences between MODFLOW/MT3DMS and TechFlowMP, it is not clear, evident, or apparent what issue Spiliotopoulos (2024, p. 55) has with simulating different concentrations of PCE using the two different modeling methods. The simulated PCE concentrations using MODFLOW/MT3DMS and TechFlowMP must be different and the PCE concentrations simulated by TechFlowMP should be (and were) less than those simulated by MODFLOW/MT3DMS.

4.9 Additional Topics

Below I briefly respond to several additional topics raised in the Expert reports of AS (Spiliotopoulos 2024) and RH (Hennet 2024).

4.9.1 Benzene Contamination

RH posits in his Opinion 4 that the TTWTP was likely not contaminated with benzene (Hennet 2024, p. 5-22). I agree with that opinion because ATSDR analyses indicated that benzene was not detected or detected at trace levels at the TTWTP.

RH posits incorrectly in his Opinion 6 (Hennet 2024, p. 5-32) that the HPWTP was likely not contaminated with benzene. He bases this opinion on a flawed and erroneous assumption that water-supply well HP-602 was operated solely 39% of the time (frequency of use of 0.39). This is the same flawed reasoning that RH used for water-supply well HP-651and which I conclusively discredit (see Section 4.2.2.4 in my report).

Well HP-602's operational log demonstrates the well's long-term operation; even with short-term operation and repairs, it was kept as part of the group of operating wells, even though it was not a high-volume producing well (Sautner et al., 2013, p. S1.17).[32] The last three capacity tests for well HP-602, however, indicated capacities of 130 gpm (8/17/1983), 100 gpm (6/20/1984), and 154 gpm (10/24/1984).

[32] CLJA_WATERMODELING_05-0000826058.

RH's claim that benzene is a recent short-term event does not consider the expansive remediation effort that has taken place at the HPIA and HPFF (Faye et al. 2010, p. C26)[33] and the volumes of estimated benzene in the subsurface as discussed below.

Measured concentrations of benzene have been documented. HPHB Chapter C (Faye et al. 2013), Figure C34[34] shows substantial benzene concentrations from samples within the HPIA. Table C80 (Faye et al 2013)[35] shows substantive benzene concentrations at IRP Sites: 6 (32J μg/L), 22 (29,000 μg/L), 78 (HPIA, 5,500 μg/L), 84 (3,800 μg/L), and 94 (17,300 μg/L). In addition the model TechNAPLVol (Jang et al. 2013)[36] confirmed previous LNAPL (floating benzene) volumes using the SpillCAD™ model (Engineering Science & Technology 1993) and Order of Magnitude analysis (CH2M HILL 2001). Additionally, Faye et al. (2013, Table D10)[37] summarize BTEX contaminants at selected RCRA investigations sites and occurrences of BTEX in nearby supply wells for the HP-HB area—HP-608 (Buildings 1502 and 1601), and HP-602 (HPFF, Building 1115, and Michael Road Fuel Farm). Three samples at the HPWTP, collected after all contaminated water-supply wells had been removed from service show the following benzene concentrations: 11/19/1985 (2,500 μg/L), 12/10/1985 (38 μg/L), and 12/18/1985 (1.0 μg/L). These data in addition to the erroneous assumption of a 39% operational frequency for well HP-602 demonstrate the flaw in RH's logic and reasoning that the HPWTP was likely not contaminated with benzene.

4.9.2 Site-Specific Data

Both RH and AS posit that ATSDR did not consider site-specific data to parametrize models (RH Opinion #11, page 5-37). Their *only* example of this is ATSDR not using site-specific f_{oc} data, and that has been rebutted above in the section on Derivation and Computation of Sorption Parameter Values. ATSDR provided a long and comprehensive list of documents and data that it used for the historical reconstruction analysis (Maslia et al. 2013, Appendix A2)[38], whose title is "Information sources used to extract model-specific data for historical reconstruction analysis." Examples of the site-specific data sources include water-quality laboratory analyses by Granger laboratory, JTC environmental laboratories, the CERCLA Administrative Record files, solid waste management unit reports, installation restoration program site reports, as well as hundreds of consulting reports providing site-specific data (e.g., AH Environmental Consultants, Baker Environmental, CH2HILL). The claim by AS and RH that ATSDR did not use site-specific data is simply false.

4.9.3 Travel Time for PCE to Reach TT-26

RH posits that travel time to TT-26 is in the range of 15-25 years (RH 2024, p. 5-15, 5-16, 5-22, and his Attachment D). Konikow (2025) provides a detailed discussion and response to RH, with which I agree and provide below:

> "Dr. Hennet estimates a range of values for travel times of PCE between ABC Cleaners and TT-26 that are stated to be "in the 15 to 25 years range", based on three assumed

[33] CLJA_WATERMODELING_05-0000777129.
[34] CLJA_WATERMODELING_05-0000777170.
[35] CLJA_WATERMODELING_05-0000777384.
[36] CLJA_WATERMODELING_05-0001005553.
[37] CLJA_WATERMODELING_05-0001004009.
[38] CLJA_WATERMODELING_05-0000777681 – 05-0000777688.

"representative" flow paths, indicating the arrival didn't occur until the 1970s. He presents supporting material and calculations in his Attachment D. Dr. Hennet assumes the horizontal travel distance in the shallow aquifer is either (1) 200 ft in the shallow aquifer and 800 ft in the pumped aquifer, (2) 500 ft in the shallow aquifer and 500 ft in the pumped aquifer, or (3) 800 ft in the shallow aquifer and 200 ft in the pumped aquifer. He further assumes that the hydraulic gradient in the layer 2 confining unit is the same in all cases (i.e., at three different distances from the pumping well). This is not a reasonable assumption (for example, see TT Figs. C19 & C21). In the pumped aquifer, a cone of depression will form with lowest heads adjacent to the well and higher heads further from the well. In the shallow aquifer, the heads will not change much due to pumping in the deeper aquifer. This drawdown effect is strongest near the well, and results in a greater hydraulic gradient (and faster velocity) across the confining layer closer to the well.

Pumping also results in a steeper horizontal gradient (and faster velocity) closer to the well in model layer 3, and a shallower gradient further from the well. Dr. Hennet's calculations assume the same horizontal velocity in the pumped aquifer regardless of the distance from the pumped well, which is not a valid assumption.

Examining the heads for model layers 1 and 3 as shown in TT Figs. C18 and C19, and looking at a point about halfway between ABC Cleaners and TT-26 and at a point very close to TT-26, the head difference between the two layers (across the confining bed) is about 10' – 9' = 1 ft at the halfway location and about 5' – 2' = 3 ft at a location close to TT-26. Therefore, the hydraulic gradient potentially driving downward flow is about 3 times greater close to the well than it is halfway between the well and the contaminant source. So this large spatial change in vertical hydraulic gradient must be accounted for, and the assumption that it is the same at all locations cannot be supported. Dr. Hennet does not account for the steeper vertical gradient in layer 2 for the path closer to the pumped well, nor does he account for the faster velocity in layer 3 when the travel distance is only 200 ft.

It is more likely that the travel distance in the shallower aquifer for much of the contaminated shallow groundwater would be more than 800 ft and the corresponding travel distance in the pumped aquifer would be less than 200 ft because (1) the vertically downward transport is more likely to occur where the vertical gradient is the strongest in the confining layer, which is closest to the pumping well, (2) the downward velocity would be fastest where the gradient is steeper close to TT-26, and (3) according to Dr. Hennet's calculations, the downward flux is only about 5% of the horizontal flux in the shallow aquifer, so that even if some contaminant leaked downward at further upgradient distances from TT-26, much would remain in the shallow aquifer to migrate to locations closer to, or even adjacent to, TT-26, where downward leakage would be the fastest. Thus, Dr. Hennet's three "representative" flow paths did not include a more critical flow path in which travel in the shallower aquifer is close to 1,000 ft. For this critical flow path, the travel time would be much less than 15 years—on the order of 3.5 to 5 years. For these several reasons, Dr. Hennet's estimates of travel times from ABC to TT-26 are erroneous, misleading, biased-high, and based on unreliable assumptions." (Konikow 2025).

Based on my and Dr. Konikow's analysis, a summary of my response to RH is as follows:

- **Travel Time Estimates**: RH estimates a 15–25-year range for PCE travel time between ABC Cleaners and TT-26, but his calculations show a 14.9-19.7-year range.
- **Retardation Factor**: RH uses a retardation factor of 3.5, whereas the calibrated value for the TT model is 2.9, overestimating travel times by 20%.
- **Horizontal Travel Distance**: RH assumes horizontal travel distances of either 500 ft in both the shallow and pumped aquifers or 800 ft in the shallow aquifer and 200 ft in the pumped aquifer.
- **Hydraulic Gradient Assumptions**: RH incorrectly assumes consistent hydraulic gradients in layer 2's confining unit at both distances from the pumping well.
- **Cone of Depression**: In the pumped aquifer, a cone of depression forms with the lowest heads near the well and higher heads farther away.
- **Shallow Aquifer Heads**: Heads remain relatively unchanged in the shallow aquifer, affecting horizontal gradients.
- **Gradient Variation**: The hydraulic gradient near the well is three times greater than halfway between the well and the contaminant-source.
- **Gradient and Velocity**: RH does not account for the steeper vertical gradient closer to the pumped well or the higher velocity in layer 3 over a 200 ft travel distance.
- **Travel Distance Plausibility**: It's more likely that the travel distance in the shallow aquifer exceeds 800 ft, with a shorter distance in the pumped aquifer, due to the concentration of vertical downward transport and gradients near the pumping well.
- **Downward Flux**: RH's calculations indicate that downward flux is only about 5% of the horizontal flux in the shallow aquifer.
- **Misguided Assumptions**: RH's estimates are based on an overly simplistic and unreliable methodology.

4.9.4 Purpose of ATSDR Modeling

AS claims that the ATSDR models cannot be used for the purpose of estimating Plaintiffs' exposures because that was not the stated purpose of the model (Spiliotopoulos 2024, p. 18). This is a flawed rationale because the stated purpose of a model does not limit or determine the value and use of the model and its results.

ATSDR is a Public Health Agency. Therefore, reports reflect (and state) the ATSDR policy that analyses were not being conducted or extrapolated by ATSDR to individuals. This agency policy is not an indication or determination as to the applicability of the model and historical reconstruction results to individuals.

The methodology used by ATSDR was appropriate and reasonable to provide mean monthly contaminant concentrations in finished water. These model results may be used by health professionals for an epidemiology study and/or to estimate past exposures of residents on an "as likely as not" or "more likely than not" basis. The methods used were rigorous and scientifically sound. ATSDR appropriately told the public that "ATSDR's exposure estimates cannot be used *alone* to determine whether you, or your family, suffered any health effects as a result of past exposure to TCE-contaminated drinking water at USMCB Camp Lejeune." A determination of health effects requires interpretation of the exposure and dose data by a health professional.

5.0 Summary and Conclusions

I have provided detailed responses to eight topical areas addressed in DOJ's Expert Reports (Brigham 2024, Hennet 2024, Spiliotopoulos 2024). None of the opinions found in the DOJ Expert Reports would substantively or even moderately change any of the conclusions from ATSDR's historical reconstruction and water-modeling analyses reported in Maslia et al. (2007, 2013, and other supporting reports and documents), or the opinions in my October 2024 expert report. In summary, in response to DOJ's expert reports, I offer the following opinions and conclusions within reasonable scientific certainty:

- ATSDR calibrated its models using a four-stage, hierarchical calibration process. Results of the model-calibration process indicated excellent model and observed data comparisons in finished water at the WTPs, which resulted in geometric model biases of solely 1.5 (TTWTP) and 2.3 (HPWTP). This provides confidence that model behavior (i.e., results) for all four calibration stages provide reasonable accuracy and concordance with system behavior. Neither RH (2024) nor AS (2024) address the merits of the four-stage calibration process in their reports.

- AS (2024) repeatedly accuses ATSDR of making "arbitrary" assumptions and of not basing parameter values on site-specific data. Neither accusation has merit. For example, AS (2024) takes the position that adjusting a model parameter value (e.g., mass loading) to fit water quality data, which are of course site-specific data, is an "arbitrary" decision. (For example, AS Report, pages 78-79.) This is not true. Making such an adjustment is an accepted and best-practices part of the methodology of model calibration. As another example, AS asserts (at page 84) that the use of a U.S. EPA study (USEPA 1986, 1987) of 12,444 leak incident reports to estimate the timing of UST releases at Hadnot Point is "arbitrary and uncertain." Again, this is not true. Reliance upon such a comprehensive study is an accepted methodology; it is not "arbitrary." In summary, ATSDR based parameter values on the best data it had available, including site-specific and published data. ATSDR also made appropriate adjustments to parameters to fit site-specific conditions.

- It is precisely because there was limited data prior to 1980 that ATSDR applied the historical reconstruction process, which included information gathering, data analyses, and model simulation to reconstruct historical concentrations of finished water delivered to the residents of Camp Lejeune. Models play an important role in providing insight and information when data are missing, insufficient, or unavailable. Historical reconstruction has been utilized since the 1930s, is a widely accepted analysis method, and has been applied to other high-profile public sites (Konikow 1977, Konikow and Thompson 1984, Rogers 1992, NRC, 1996). This method has also been reviewed extensively by Samhel et al. (2010) and others.

- Owing to the four-stage, hierarchical calibration process that ATSDR used in calibrating its models, the presentations in Tarawa Terrace Chapter A (Maslia et al. 2007) and Chapter F (Faye 2008) reports comparing computed and observed PCE concentrations at the TTWTP comprise a major part of TT model calibration. Such comparisons indicate that, regardless of simulated concentrations at individual supply wells, the calibrated Tarawa Terrace MT3DMS model delivered a reasonably accurate total PCE mass to the TTWTP during the 1980's.

- ATSDR applied models that have been tested and verified, and that are available in the public domain, as part of its historical reconstruction process for Camp Lejeune. These models approximate the physics of groundwater flow and chemical transport and are not "professional judgment." Professional judgment and experience were used when selecting values for model parameters, but those values were based on both field and literature sources and were adjusted over reasonable ranges during calibration to best replicate the observed data, which is the generally accepted methodology in the hydrogeology and modeling fields.

- Selecting model parameters based on professional judgment is a normal, standard, and accepted practice. Data are always limited, requiring professional judgment to determine how to handle this paucity of data and how much weight to assign to the limited number of measurements. Groundwater modelers always wish for more data, but the reality is that there is never enough data available to avoid relying on professional judgment.

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Appendix A — Volatilization Issues: Excerpts From the ATSDR Expert Panel Meetings of March 28, 2005 and April 30, 2009

<u>2005-03-28 Panel Meeting Transcript at 55:2-57:14</u>

Panel members Thomas Walski and Peter Pommerenk (AH Environmental consultant) respond to a question from Dr. James Uber to Morris Maslia about whether there are any potential chemical biological processes taking place in the distribution system.

<u>Dr. Thomas Walksi, 55:2-56:1</u>: "To give you a little answer to your question, Jim, on the processes, most of the things that happen to the VOCs in pipes don't really -- I mean, there's not much that can happen to them. I mean, in pipes, the only place where you could have much of a process affecting them is usually in tanks where you have a free water surface and they can volatize. But when Ben and I did the work in Phoenix/Scottsdale, we looked at that, then went back to Henry's Law and looked at stuff like that. And we did -- you know, since you don't really -- it's hard to measure these kind of things, and there's not a lot of literature on Henry's Law in a perfectly still tank. Usually, if it's for stripping towers and stuff like that, you have a lot of literature data.

But going back and trying to reconstruct this, we estimated 97 percent of what went into a tank came out. Very little is really lost through the surface, and that's about the only process that you lose VOCs is through the surface of the tank. So basically, assuming that it's -- what goes in the system goes to the tap is probably, you know, a reasonable assumption if there's not processes occurring. At least, we couldn't figure out any processes that would knock down the concentration significantly."

<u>Dr. Pommerenk, 56:2-57:14:</u> "Yeah. I have some supporting information on that. Because that question was asked by Camp Lejeune to us as their consultants, we looked into literature and tried to come up with a rough estimate of would there be any removal within the treatment plant. And since, you know, we had to review all of the drawings of the existing plants, we knew the surface areas that are available. We made certain assumptions: You know, is the water quiescent in that tank, or, you know, is there any agitation anywhere?
In all the tanks that we looked in -- and some of the tanks are newer. There's more surface area available today than there used to be early in the seventies. But removal due to volatilization was negligible. I mean, it was less than a tenth of percent. The only location where there would be some removal was in the spiractors that were operated in all these Hadnot Point, Holcomb Boulevard, and Tarawa Terrace plants. And even there, there was a certain uncertainty, depending on they had conditions downstream you would get some agitation at the effluent pipe. So although we said it's probably negligible, and I agree with Tom's number here. At 90 percent, what's going in is coming out on the other end."

2009-04-30 Panel Meeting Transcript

<u>Dr. Pommerenk, 178:18-181:19:</u> " . . .there's a big five treatment plant in between, between the groundwater collection system and the distribution system.

It consists -- and correct me if I'm wrong -- of a [ground storage –ed.] tank. I don't remember what the size is, but it's probably a million gallon or larger. The Hadnot Point plant has a pump station that pumps water from that water collection tank into what are called catalytic softening units or [spiractor –ed.] cones to which [lime –ed.] is injected to facilitate softening and it overflows into a central pipe.

It goes from there through a rectangular basin that used to be a re-carbonation base, and I'll get back to that. And from there into gravity filters and you know after chlorination and fluorination into a finished water clear well.

Obviously, in this facility there's several quiescent or not so quiescent surfaces from which volatile –ed.] organic compounds can escape. And that kind of depends on the physical properties of these compounds, PCE more so than TCE and so on. We made an estimate a few years ago, a rough estimate, that probably PCE and TCE, we didn't look at BTEX, removal would be incidental, minor, probably. The tanks are covered so there's no way effluents could stir up things.

However, what was not looked at that was, because of lack of information is the re- carbonation basin. The re-carbonation basin serves to, it's typically a small, flow-though basin to which you inject carbon dioxide that is generated from a propane generator or from gas bottles. And carbon dioxide is an [acid –ed.] in water and [decreases –ed.] the pH which has been pretty high prior to, because of lime addition.

So that's how this whole softening process works. You bring the pH up you're still going to have calcium carbonate. Bring the pH back down within the allowable limits. So as far as I know, and as far as I can recall, I've never seen this basin in operation. It was just water flowing through. However, it was put in for a purpose originally some time in the '40s, and nobody can tell me exactly if it ever has been operated and how long it has been operated. Because if it has been operated, it could have [caused –ed.] substantial removal of PCE and TCE. It would have been in the 90 percent removal.

And it kind of depends on the gas flow rates. It kind of depends on the turbulence that got generated. So there's a variety of factors that would have presented. But it could have affected removal of these compounds in the plant. And again, we just looked at PCE and TCE as from volatilization from the basins that are there, not [re-carbonation –ed.] because we didn't have any additional information.

But it might be worth looking into BTEX volatilization from the basins, you know, whether that as a source is uncertainty again. And I'm not trying to get exact numbers or anything, but it's another source of uncertainty for the exposure calculations for what could potentially be the removal of these compounds from the plant, A. And B, finding out whether this has ever been online, this re-carbonization basin

EXHIBIT 7

THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

convenes the

EXPERT PEER REVIEW PANEL

ATSDR'S HISTORICAL RECONSTRUCTION ANALYSIS

CAMP LEJEUNE, NORTH CAROLINA

VOLUME I

The verbatim transcript of the meeting of the Peer Review Panel, held at 1825 Century Boulevard, Room 1A/B, Atlanta, Georgia, on Monday, March 28, 2005, taken by Diane Gaffoglio, Certified Merit Court Reporter.

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C O N T E N T S

Volume I
March 28, 2005

Legend of the transcript:

[sic]	Exactly as said
[phonetic]	Exact spelling unknown
--	Break in speech continuity
...	Trailing speech or omission when reading written material
[inaudible]	Mechanical or speaker failure
[microphone]	Speaker is off microphone

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P R O C E E D I N G S

8:38 a.m.

MR. MASLIA: Good morning. Welcome, everybody, to our expert panel meeting. We're going to wait a few minutes for some other people to arrive that are part of the program this morning. But in the meantime, I thought I would go through some housekeeping rules, if that's okay with everybody. And just to our panel members and everybody else that had to fly in, either yesterday or this morning, through the weather, thank you for making the effort. We appreciate it.

And -- so real briefly, for those not familiar with ATSDR campus, we're right over here. And there's a cafeteria here and down here as well is the restaurant in the Century Center hotel plus some other restaurants around. And so, on campus, there's two cafeterias and the restaurant. There will be two buses for lunch from the hotel. We've made arrangements to eat at the restaurant or the dining area at the Century Center hotel.

And I'm going to ask for those other guests, the nonpanelists, to allow the panelists to take the first bus -- it holds 12 -- so they can get to the business of eating and getting back. And then there's a second bus that will take anyone else to that, or you're free to go any place off-campus. There's a variety of foods and other establishments.

Located on the first floor behind the guard station through the metal detector that you passed through are restrooms and candy machines and Coke machines, if the bottled water or the candy that Ann brought will not suffice.

Messages will be at a board near the registration desk, if you need someone to -- if you've got messages. And there's also a telephone out in the outer alcove for you to use. And any copying, faxing, or other needs, Ann Walker, who's staying by the door right there, and Joann -- I don't see Joann. She's out in the hallway -- Joann Flesner have been very gracious to stand by at a moment's notice and at the panel's needs to do anything you need.

And you are being recorded, audiotaped. So we ask you to speak into the microphones, primarily for the purpose so ATSDR can have a transcript and a report of your comments so we can deal with them directly after the meeting. There will be a report published of this meeting; not the transcript, but a summary report that will be available to everybody. And we're asking you to silence your cell phones. If you can, just turn them off, which would be our preference. If you have it on vibrate and you're at a microphone, everyone will hear the vibration go off. And for those in the audience, the microphones and the court reporter can pick up your side conversation, even though you're not on mike. So I'll just remind you of that, that it will be picked up.

And with that, that's -- any other questions or housekeeping issues? If not, Dr. Sinks, are you prepared? It's my pleasure to introduce Dr. Tom Sinks, who is our director of science and acting administrator for ATSDR.

DR. SINKS: Thanks, Morris. Well, good morning to all of you. It's a pleasure to be here. As Morris indicated, I'm the acting director for both ATSDR and the National Center for Environmental Health, a title I've been -- I've had for all of three weeks. And as actings go, that may be a record. Who knows? It could be two more days; it could be two more months. But it's actually -- it's been thrilling, embarrassing, exciting. It's been -- it's been a good ride so far in three weeks.

This is a -- this is a great opportunity for us to, I think, do what ATSDR wants to be doing in these very complex sites that we deal with. And the three things, I think, we really want to accomplish here is to make sure that we challenge ourselves to do the best science that we can in what, in this particular example, is a very complex, difficult study that we're trying to conduct.

And in this case, it's the modeling of drinking water supplied to people who were living at Camp Lejeune many,

many years ago and trying to recreate exposure scenarios, which have occurred pretty far in the past; to do it in a scientifically credible way; and make it as valid as we can. And reconstructing these types of scenarios are quite difficult, and we do need help in trying to do that.

So the first thing is the best science. The second thing is trying to do this in a fairly transparent process, to be open to criticism, constructive comments, to let people know what it is that we are trying to accomplish, and to give them that idea upfront so that when we arrive at our conclusions, people have a good understanding of what we were doing and how we were trying to do it. And this panel is helping to play a role for us and when -- to challenge ourselves to the best job that we can.

The panel members here are nationally and internationally recognized experts in the areas of groundwater hydraulics, fate and transport analyses, water-distribution systems, numerical-modeling techniques. And we're delighted to have you-all here.

Again, our objectives are to secure from the panel members, who are not ATSDR employees but are people from outside of ATSDR, your critiques and your approaches and your recommendations for what we're about to do. This information will be made public.

Morris, will we put it on the Web site? Is that -- will the report be on the Web site?

MR. MASLIA: It's our intent to.

DR. SINKS: Okay. So it will also be open to the public just beyond this meeting. And I presume we'll put a response to the recommendations on there as well, how we're going to handle that.

My next challenge is to introduce Dr. Barry Johnson. Barry is sitting at the head of the table. He looks younger every time I see him. I think it's because he doesn't have to be the assistant administrator of ATSDR, and I think a great weight has probably come off of his shoulders. He's smiling. It's the first time I've seen him smiling in years. I tend to be chasing Barry around.

Barry -- I've known of Barry since 1985 when I became an EIS officer assigned to NIOSH. As soon as I arrived to NIOSH, Barry took off. He left NIOSH, and he went to ATSDR where he effectively really became the first assistant administrator of ATSDR, pulling it away from CDC, creating a separate agency and really building it to what it is today. Barry retired in 1986 -- no. That's the wrong date; 1999.

DR. JOHNSON: It depends on how you interpret retirement (laughter).

DR. SINKS: Barry left ATSDR in --

DR. JOHNSON: 1999.

DR. SINKS: -- 1999 and has joined the Rollins School of Public Health over on Clifton Road as an adjunct professor there. He's currently working on a lot of editorial boards. He's writing books. He has one in publication right now, and it's his job to give you-all a charge for this conference and to lead this throughout the next couple of days. I do plan to stop in from time to time during the course of the next two days. I won't be able to attend the entire meeting, but I wish you-all success in a fairly difficult and complex situation.

So thanks a lot and, Barry, I think it's all yours.

DR. JOHNSON: Thank you, Dr. Sinks, for those kind remarks and sage advice to the panel. We have a full agenda ahead of us over the next two days, building upon the direction that Dr. Sinks has provided to us. As you all know, I'm sort of a last-second fill-in for someone else, and I certainly look forward to trying to be as helpful as I can.

When Mr. Maslia called me about a week ago and said he needed a Chair, I listened. And I then reminded him of my retired status, my membership as a senior citizen, and so forth and so on. I said, "Morris, I'm willing to consider this, but there are many personal sacrifices I have to bring to your attention and -- for example, foregoing my morning, afternoon, and early evening naps; my shawl; my warm cocoa; and, of course, the prune juice."

And he said, "Johnson, these sound more like excuses than sacrifices." And with that unassailable logic, I signed on. So I look forward to working with you over the next couple of days. Perhaps, we can get it done in a little bit less time.

The agency has asked me to present both a statement from the Chair as well as the charge to the panel. I'm assuming that you have the charge to the panel, but, I will nonetheless go through it shortly. With regard to the purpose and scope of this expert peer review panel, it is to assess ATSDR's efforts to model groundwater and water-distribution systems at the U.S. Marine Corps Base, Camp Lejeune, North Carolina.

This work includes data-collection activities, field investigations, and water-modeling activities that were performed through -- from March through December 2004. The panel is specifically charged with considering the appropriateness of ATSDR's approach, methods, and time requirements related to water-modeling activities. It is important to understand that the water-modeling activities are in the early stages of analysis; hence, the data and interpretations are subject to modifications based in part on information provided by members of this expert panel.

ATSDR expresses a commitment to weigh questions from the public and to respond to public comments and suggestions in a timely fashion. However, in order for this panel to complete its work, it must focus exclusively on water-modeling issues. Therefore, the panel will address questions and comments that pertain to the water-modeling effort. All other questions and statements will be referred to ATSDR staff for consideration and response.

In particular are -- the ATSDR contact for nonwater-modeling questions is Dr. Frank Bove and -- who will handle questions related in particular to the epidemiological work, and Mr. Morris Maslia and associates will handle the water modeling and other water-related questions.

Any reactions from the panel? Tread on any toes? You okay with that?

(No audible response)

DR. JOHNSON: I think the bottom-line message here is that this is a meeting for the next two days that's going to be focused on the water-modeling activities. I understand there have been other meetings that have focused on other things and so forth. Do you each have a copy of the charge to the panel?

(No audible response)

DR. JOHNSON: I will read most of that for -- just to be sure that it's in the record and it's put before the public and would suggest that you follow along as I go through this.

The Agency for Toxic Substances and Disease Registry, ATSDR, is requesting the panel's opinion with respect to the following questions. ATSDR is seeking a majority opinion with opposing views. First, will ATSDR's approach of using "50-foot cell sizes" for groundwater modeling and all pipes, networks for water-distribution system models provide sufficient detail required by the epidemiological case control study? Should coarser, variable-spacing groundwater-model grids or skeletonized-pipe networks for water-distribution system models be considered in an effort to reduce the length or duration of modeling activities?

Two, is the ATSDR approach of simulating monthly conditions using water-distribution system models sound, or should ATSDR consider using a continuous simulation for the historical period; i.e., 1968 through 1985? If continuous simulation should be used, does this approach, A, increase or decrease the work effort with respect to modeling activities? B, increase or decrease the level of uncertainty and variability of simulated results?

Three, based on information provided by ATSDR to the panel, are there modifications or changes that ATSDR should consider making in its approach to modeling, A, groundwater resources at Camp Lejeune; B, present day; i.e., 2004, and historical reconstruction of water-distribution systems serving Camp Lejeune? If, in the panel's majority opinion, ATSDR should consider changes in its approach, what specific changes does the panel suggest?

And fourth, compared with other publicly documented historical-reconstruction analyses, is the three-year project schedule for completing all historical-reconstruction modeling activities appropriate and realistic for the amount of work and level of detail required by the epi study? If, in the panel's majority opinion, ATSDR should modify the project schedule, what specific actions and activities does the panel suggest ATSDR take to modify the project schedule?

That is the charge to the panel as developed by ATSDR. Any questions or reactions at this time to either the statement or the charge to the panel? It is the Chair's intent on Day 2 to go through each of these four charges, beginning at the "working lunch" on Tuesday. And at minimum, I anticipate providing your reactions, your advice to the first two charges at the working lunch.

If we work in, perhaps, an exceptionally, efficiently way, then we might try to go through Charges 3 and 4. But at least we'll do the first two charges tomorrow at lunch. Charges 3 and 4, if they remain unaddressed, will be subject to our discussion at the 2:30 period.

The take-home message to the expert panel is that we will provide answers to our -- the best of our ability to each of these four charges. Is that okay with the panel?

(No audible response)

DR. JOHNSON: At this time, I'd like to ask each of the panel members -- and as Dr. Sinks said, it's truly an internationally distinguished panel, and we welcome you to Atlanta. Sorry the weather wasn't a bit better, but it's that time of the year, folks, in Atlanta; pop-up storms.

I'd like to ask each of you to introduce yourself, your affiliation, experiences related to this panel's work. And I think I'll ask each of you, as you go through your introductions, to give an initial but pithy, succinct reaction to what you have read, the information that was provided to you. I'm not asking you to pass judgment at this time. That's going to be the product of our deliberations, your deliberations in particular, but just an initial reaction to what you have received. Okay.

Let's start to my right, if we could, with Dr. Walski.

DR. WALSKI: Okay. My name is Tom Walski. I'm with the Haestad Methods Group within Bentley Systems. I've been doing water-distribution analysis work since the seventies and have worked on systems ranging from outhouses at rec areas to the New York City water-supply system. I've done some reconstruction of water quality, in one case with Ben Harding, who's showing up later on. So I have some experience in doing this kind of reconstructive work as well. And my initial pithy reaction is: Gee, I wish I had the budget that these guys had when I was doing my work.

DR. JOHNSON: Thank you. Dr. Singh.

DR. SINGH: Yes. My name is Vijay Singh. I am a faculty member at Louisiana State University. I have been involved for many, many years in hydrologic modeling, both in surface water as well as groundwater modeling. I have also been involved in this kind of analysis as well as stochastic modeling, which has involved some reconstruction work, more specifically in the area of groundwater, particularly the area of surface water as reconstruction codes.

My reaction, based on reading the reams of papers and reports that we were supplied, is a very positive one. I was much impressed with the level of effort and the scientific rigor with which the work has been done.

DR. JOHNSON: Thank you. Please.

DR. POMMERENK: My name is Peter Pommerenk. I'm with

AH Environmental Consultants. We specialize in water resources, water treatment, water distribution. In such, we are involved in water master planning and treatment studies and treatability studies. We also do some water-distribution system modeling, although we don't use Haestad methods at this time.

My particular expertise for this panel is that AH Environmental Consultants has been consulting with Camp Lejeune for several years in the water resources and treatment-distribution system arena. And we have also as such supported the Marine Corps in their efforts to collect data for this ATSDR study.

My initial reaction, when I got first involved in this project -- as I said, this is a huge effort. And what has been collected today is really impressive. Thank you.

DR. JOHNSON: Thank you. Let's just continue.

DR. CLARK: My name's Robert Clark. I spent 41 years with the federal government in the U.S. Public Health Service in the U.S. EPA as a public health service officer for 30 years. And during that time, I was director of the drinking-water research division -- water-resources research division for EPA for about 14 years and then for three years as a senior scientist in the agency and then retired in -- about three to four years ago. And since that time, I've been consulting and am an adjunct professor at the university, which is keeping me busy as well.

Very impressive. I had a chance to work with Morris early on when he was working on the Toms River project. They've come a long ways; very impressive technical effort. I think the questions are even more challenging in terms of how can you extend this now to exposure epidemiology.

DR. DOUGHERTY: My name is Dave Dougherty. I'm from Subterranean Research in Massachusetts. I spent 15 years as a faculty member in civil and environmental engineering in California and Vermont. My background started in groundwater and moved to modeling and moved to optimization and more -- slightly more on the IT side now.

I think the things that I bring to this particular table are the integration of groundwater modeling and optimization kind of activities, experience with a lot of models in the past, and the most interesting connection is when Roger Page and I, in 1985, I think, built the first 3-D model for Toms River; so just trying to connect the loop.

My reaction is there's been a lot of -- there's been a lot of good work here. It is in many ways, in many ways, very far advanced in particular narrow areas for the project. As a whole, I think we have a lot of opportunities to make contributions to the directions that need adjustment, and I'm looking forward to it.

DR. JOHNSON: Thank you.

DR. UBER: My name is Jim Uber. I'm an associate professor at the University of Cincinnati in the department of civil and environmental engineering. I'm an environmental engineer. My research area is water-distribution systems analysis. I've been working in that area for about 15 years and have, kind of like David, focused to some degree on optimization studies and calibration techniques for models, particularly on water-quality models for water-distribution systems and as well as doing some fieldwork and tracer tests.

And my initial reaction is that I thought that the data that was provided was very comprehensive and in particular on the water-distribution systems' side. The -- for example, the fieldwork is certainly very much state of the art in that area, and I think a central question for me is exactly how that fieldwork and those data link back to the needs of the epidemiological study and how they connect up in a logical way with the historic data that is or is not available for what happened some years ago.

DR. JOHNSON: Thank you.

DR. KONIKOW: My name is Lenny Konikow. I'm a research hydrologist with the U.S. Geological Survey. I've worked for them for over 30 years; to a large extent, working on the development and application of solute-transport models, contaminant transport models for groundwater systems. One of the first applications I was involved in was reconstructing the history of groundwater contamination at the Rocky Mountain Arsenal in Colorado, which was kind of the forerunner of the whole installation and restoration program in the Department of Defense.

One of my concerns, reading through all the documentations and thinking about this, is the lack of historical data from the fifties, sixties, on into the seventies. And I see that as presenting a very difficult hurdle to overcome in trying to develop the quantitative models. There's going to be invariably a lot of uncertainty associated with the results of the very quantitative models.

And as Jim said, I'm also a little concerned that I don't have a firm feeling yet -- and I hope I get it today -- for what -- how the models will be put to use. What is needed by the epidemiological studies to come out of the models? And for us to evaluate the models and the approach to modeling, I think we need a clearer -- or at least I need a clearer understanding of how the models are going to be used in terms of the epidemiological studies.

DR. JOHNSON: Thank you. We have two other panelists who will be arriving a little bit later: Mr. Harding and Dr. LaBolle. Did I pronounce that correctly? We look forward to their joining us. Any questions across the table to each other?

(No audible response)

DR. JOHNSON: My hope is that this is truly an interactive panel, and I encourage dialogue, questions back and forth across the table amongst the panelists. And to the extent that I can help clarify, I will try to do that. But this is your panel, and this is your opportunity, as we've already heard, to have some concerns and some really important questions placed on the table already. So keep that up.

I think, at this time, there's going to be an introduction of the epi team and the water-modeling teams, Dr. Bove, and Mr. Maslia.

DR. RUCKART: Good morning. I'm not Dr. Bove, by the way. I'm going to be discussing a summary of ATSDR activities at Camp Lejeune and hopefully answering your question of how the water-modeling component will fit in with epi study.

DR. JOHNSON: Would you introduce yourself, please.

DR. RUCKART: Yep; next slide.

DR. JOHNSON: We'd love to know who you are.

DR. RUCKART: My name's right there. I'm Perri Ruckart. I'm the principal investigator of the epi study, and my other team members include Dr. Frank Bove, Miss Shannon Rossiter, and Dr. Morris Maslia, who I believe everyone knows.

Next slide, please.

The base began operations at Camp Lejeune in the 1940s. Currently, there's a population of about 150,000 living or working on the base, including active military personnel, their dependents, retired population, and civilian employees. Almost two-thirds of the active military personnel and their dependents are under age 25.

Next slide.

Because this is a military base, there has been considerable in-and-out migration. It is estimated that about one-third of the mothers receiving prenatal care at the base hospital during the 1970s and '80s were transferred off base before delivery, and the average duration in base-family housing is two years. There are 15 different base-housing areas. And there are three water-distribution systems serving the base-family housing area: Hadnot Point, Tarawa Terrace, and Holcomb Boulevard. And the dates they were constructed are shown here on this slide.

Underground storage tanks were installed during the 1940s and '50s, which contaminated the Hadnot Point wells, primarily, with TCE. And ABC One-Hour Cleaners began operations on the base in 1954, and the cleaners were near the supply wells for Tarawa Terrace, and that water system was primarily contaminated with PCE.

ATSDR published a public health assessment for Camp Lejeune in 1997. Because of the limited information in the scientific literature on how chlorinated solvents in drinking water might affect a fetus or a child, the public health assessment recommended that we conduct an epidemiologic study to evaluate whether maternal exposure was associated with the higher risk of having an adverse birth outcome or whether maternal or infant exposure was associated with a childhood cancer.

As a first step in following up the public health assessment recommendation, ATSDR published a study in 1998 which evaluated potential maternal exposure to drinking-water contaminants on base and preterm birth, small for gestational age, and mean birth-weight deficit. Only available databases were used, such as electronic birth certificates, which were available beginning in 1968, and base family-housing records.

There was insufficient data available for the 1998 study to evaluate fetal deaths. The study did find an elevated risk for SGA, small for gestational age, only among male infants exposed to Hadnot Point water, which was primarily contaminated with TCE. And the study also found an elevated risk for SGA among infants born to mothers who were greater than 35 years of age and mothers with two or more prior fetal losses who were exposed to Tarawa Terrace water, which is primarily contaminated with PCE.

Because the 1998 study could not evaluate birth defects or childhood cancers, the current study will look at these outcomes, using a case control approach. It is a multistep process, and the first step involved a review of the scientific literature to identify specific birth defects and childhood cancers that were associated with drinking water contaminated with VOCs.

Next slide, please.

And this slide shows the outcome selected for further study based mainly on evidence from the epi studies of VOC-contaminated drinking water.

The second step in this process was to conduct a telephone survey to identify the potential cases of the selected birth defects and childhood cancers occurring to mothers who were pregnant at any time during their pregnancy and living at Camp Lejeune during 1968 to 1985. And the survey needed to address the questions shown here.

Can you go back for a second. Okay.

And as part of the telephone survey, ATSDR surveyed parents of 12,598 children. This is an overall participation rate of approximately 74 to 80 percent. And the survey identified sufficient numbers of neural tube defects, oral clefts, and childhood cancers. 106 cases were reported, including 35 neural tube defects, 42 oral cleft defects, and 29 childhood cancers. And the childhood cancers include leukemia and non-Hodgkin's lymphoma.

Next slide, please.

The third step is to verify the diagnoses of the reported cases. To date, 24 reported cases have been confirmed as not having the condition of interest or being ineligible or refused. That leaves us with 82 children with pending or confirmed conditions. And by pending, I mean we are still looking for evidence to verify they have their condition. That includes, for the neural tube defects, 15 confirmed as having that condition. Thirteen are still pending. For the oral clefts, 20 confirmed as having that condition and 16 still pending. And for the childhood cancers, 14 confirmed as having that condition and four still pending.

The study will include 818 controls, who were sampled from the original survey population. This is a ratio of about ten controls to cases. Interviews will begin in the spring and continue through the summer of this year. And they will be administered to parents of the cases and controls to obtain information on maternal water-consumption habits, residential history, and parental risk factors. We anticipate a 90 percent participation rate based on previous contact with this population and the interest that they've shown in our work.

An important part of the current epi study is the water-modeling component. There's a lack of historical contaminant-specific data at Camp Lejeune. To provide a quantitative estimate of exposure, a historical-reconstruction approach is needed, consisting of modeling the groundwater flow and present-day distribution systems at Camp Lejeune and extrapolating backwards in time. The water-modeling component needs to address the following questions shown on this slide.

Next slide. Oh, go back. Can you go back, please.

DR. KONIKOW: Do you define "exposure" as just being the presence or absence of a contaminant, or are you interested in knowing the concentration of the contaminant?

DR. RUCKART: We would like to know the concentration, and our hope would be to group them into some kind of high, medium, low exposure. But it's going to be dependent on what is available. That's our ultimate goal.

And the goals of the water-modeling component are to determine when the contamination arrived at the wells and the spatial and temporal distribution of the contaminants by housing location. And I'd like to conclude with the study time line.

Are there any questions? We'll be here throughout the panel if things should come up.

DR. JOHNSON: Could you go back, please, to the couple of slides previous; one more; stop. Thank you. No; the one that says "Current ATSDR Epi Study; that one; try again; stop. Thank you.

My question, I guess, is to Mr. Maslia. Are these questions to be addressed in the water-modeling component part of what has been put before this panel? Or are these questions that are, maybe, new?

MR. MASLIA: Part of the -- some of the questions are to be addressed by this panel. We've -- you want me to speak into the microphone, I guess. Let me just come over here and sit down.

Some of the questions have been put forth in the discussion, for example, at Tarawa Terrace where the source is located, the strength of the contaminant source. Others, for example, like at the Hadnot Point, we obviously have not addressed that issue at this point in time. And that's an issue for us to discuss and to address, both with information that we may present or elucidate to the panel now in some of the complexities at Hadnot Point, as opposed to Tarawa Terrace.

Which chemical compounds were supplied? Again, at Tarawa Terrace, it is our intention -- and the data that we have presented has at this point indicated that PCE, PERC, is the primary contaminant, and that's what the modeling to date has been done on. We have not looked at modeling-degradation products, say, TCE to DCE and TCE.

Hadnot Point, again, presents a much more complex issue because, as Perri has alluded to, it's primarily TCE, but there was underground-storage tanks as well. And we just have not -- I'll get into -- actually, when I give an overview of the water-modeling activities as to our rationale for going in one direction right now. But we have not addressed that issue.

How was the contaminated water distributed is a main focus of our investigation. And we start out -- our approach is to try to understand what's going on today simply because of the lack of historical data, and I will get into a little bit later on our approach for deconstructing the system, if that's the way, actually, we proceed. That is, indeed, a required step that we go.

Lenny, did you have a question? Yes.

DR. KONIKOW: In terms of the water distribution and the goals of that modeling, are you aiming to actually get exposure down to the household level?

MR. MASLIA: We're aiming to get it down to the street level. Now, at Camp Lejeune, it so happens -- and we'll get into this -- the distribution is built such that it's a looped system so that each house is serviced by a pipe, as opposed to, say, an area like Dekalb County or even Toms River, where maybe there was a 4-inch main running down the street and we did not model any of the attached or smaller diameter pipes.

But the way the distribution system is constructed at Toms -- I mean, at Camp Lejeune, you really have a 2-inch pipe going from the street to the house. So in essence, by default, you've got houses attached or implied in your distribution-system modeling.

However, I think it's important also to tell the panel as well as the public is -- as with other contamination sites that we have looked at, we are actually blinded to the cases and controls at the site. ATSDR people modeling the groundwater and distribution system, we haven't been provided nor are we asking for any specific information as to who resides, who's included in the cases and controls so that it is our approach that any models that we develop or any analyses -- let's make it more general -- should be robust enough that if you say you want Location XYZ, you should have as much confidence in the results that we give you for Location XYZ as Location ABC. And that is our approach, but we are blinded. So hopefully, that's addressed your question.

DR. BOVE: I just want to say one more thing that one of the questions earlier was: How are we going to categorize exposure? And as it was done in Toms River and Woburn, where they just focused on the percent of the water coming from a contaminated well during a month and then averaging over that for the exposure window, we'll be doing something like that. They had three categories in the Toms River study. Woburn was ever-never, and then they did have three categories, again, of exposure, the high one being the upper tenth percentile, if I remember right.

But the numbers get small when you start doing that. And I have some tables, and we can discuss the impacts of exposure misclassification bias and some of that during the panel discussion at some point during the day, if you want.

DR. JOHNSON: Yes.

DR. WALSKI: I think just to put things in perspective, you said there were about 80-some cases of illnesses that are -- were determined in the study group. About what would the number of illnesses be out of the -- like, an average population? Would it be, like, many times above what we would expect? Or is it only marginally, or what's the perspective?

DR. BOVE: Well, part of the problem here is the way we had to ascertain cases. Ideally, you would like to have a cancer registry, or you would like to do your case ascertainments through hospital records. We had to do it through a survey. So this is not the most optimal way, but it was the only way to do ascertainment of cases. That being said -- and all the comparison data is based on medical records data or cancer registries, like the Sierra Cancer Registry, or birth defect registries, like the one in Atlanta.

It's hard to really compare the two. But if you want, these are -- what we've -- both the reported positive ones that we verified and the ones we're still working on, if you combine those two, we have slight elevations here in the -- I would say the realm of two times what we might expect for some of the end points.

But, again, there are problems with that. Not everybody was exposed at Camp Lejeune either. And the way we ascertained them was different than the databases we would compare them to.

DR. JOHNSON: Other questions? Dr. Singh.

DR. SINGH: So here the assumption was that the increase was attributed to the water contamination?

DR. BOVE: No. We didn't want to do that. We wanted to use the survey to ascertain cases and do the study with the modeling that Morris -- and you're going to be commenting on. We did not want to say straight off whether the -- it was an excess, number one, because we wanted to verify the cases. At the time of the survey, it's only self-reporting -- or parent-reported cases. And so we wanted to verify those cases.

And secondly, because of all the problems with the water information, new information we've been getting over the -- well, not so new actually, over the last few years that things we thought we knew about the water system, information we got about the water system was not quite correct and that, in fact, the study that Perri mentioned that we completed in '98 probably needs to be revisited.

Most definitely, it needs to be revisited because assumptions made in that based on that information at the time, but we find it was incorrect. So we didn't want to do anything until the modeling was done, and we -- and base whatever we do on better information.

DR. CLARK: Are we going to have a chance to look at other compounding effects?

DR. BOVE: We -- well, as Perri pointed out, we're doing an interview of the cases and controls. That's one of the nice things about doing a case-control sample. You have a small enough group so you can do extensive interviewing and go over all the other risk factors that are either suspected or known for these outcomes.

DR. JOHNSON: Do the members know the essentials of a case-control epi study? Are you-all real comfortable with that?

DR. BOVE: Well, we can -- we -- again, that's something we can go into in-depth at any point during the day.

DR. JOHNSON: Could you give us about two minutes now?

DR. BOVE: Okay; two minutes? Okay. Well, I mean, you have -- we're not sure how many pregnancies occurred at the base between 1968 and '85 because many were transferred. We had to guesstimate that about a third of the people who were pregnant there migrated off-site -- transferred basically off-site before they delivered. So we knew how many births on base. That was about 12,400 and some. And we assumed another 3,000 or so were transferred off base and delivered elsewhere, so roughly around 16,000.

Now, you have 16,000. You can't interview them all;

right? That would be an incredible undertaking. That's one approach. Another approach is to take a random sample. But when we have rare diseases, that's not a good approach because you take a random sample and may not get any of the cases in that random sample of 16,000. So the approach you take within a disease that's rare, like this situation, is what we call case-control sample.

DR. JOHNSON: You're speaking of birth defects; correct?

DR. BOVE: We're talking about birth defects. We're talking about, in particular, neural tube defects, which is spina bifida and anencephaly. We're talking about oral clefts, which is cleft lip and cleft pallet. And we're talking about childhood leukemia and childhood non-Hodgkin's lymphoma. And those are all rare events, those diseases that we're focusing on.

And so the approach has been to gather all the cases from that population at Camp Lejeune, keeping in mind that the population at Camp Lejeune of births, both born on site and born off site, some were exposed; some were not exposed; right. That's the question we're going to be asking you is hopefully is will the modeling be able to tell us with some assurance who's exposed at least and who wasn't exposed. If we can get that, that's one step.

And then, of course, we'd like to have -- be able to define it better than that. But that's the first consideration. So we have a population here, some of whom are exposed, some of whom are not exposed during their pregnancy. And we take -- we get all the cases from that population, and then we take a random sample of that population to give us a control series. And that's the case-control series.

Now, in some methodologies, you sample your control series irrespective of whether they were -- what their disease status was. That's one approach. A lot -- most often, though, you sample the nondisease, those people in the population that did not have the case -- the diseases you're focusing on. So that's basically what we're talking about: a case-control sample, the most effective way of doing these kinds of studies. It was also the approach taken in Woburn, the approach taken at Toms River.

DR. SINGH: So why do you have some people not exposed if they were living on Camp Lejeune?

DR. BOVE: Well, we're -- see, that's the question. We -- in the previous study, we thought that about half of the births were unexposed because they were getting water from the Holcomb Boulevard system. And at that time, we assumed that the Holcomb Boulevard system was clean. Okay? So that study, half -- about half the births were unexposed.

Now we're not sure about anything, or at least I'm not. I'm waiting to hear from the discussion. There may be interconnections between Holcomb and Tarawa Terrace. The -- before '73, the people who -- the residences that got Holcomb Boulevard water got Hadnot Point before that. And so we thought that they -- for some reason, we didn't know what their exposure was. We assumed they were unexposed. That was a bad assumption probably.

So we don't know the percent unexposed. I mean, that's what the modeling effort's going to have to tell us. That's why we have to revisit those previous -- that previous study.

DR. RUCKART: There's another piece about those also when during the pregnancy that the mother was exposed. And we're hoping to have that information as well if they were exposed in the first trimester or later. It depends on when they were actually residing at Camp Lejeune.

DR. JOHNSON: David, you had a question.

DR. DOUGHERTY: It actually follows on that one, and it is: You addressed the issue of the spatial resolution desired. What temporal resolution of exposure is desired from these studies?

DR. BOVE: Well, for neural tube defects and oral clefts, the window of exposures is the first trimester.

And actually, for neural tube defects, it's Day 20 to 24, roughly. So we're not asking for day. But we are asking for a trimester with the idea that, you know, that the exposure windows for neural tube defects and oral clefts is quite small. Okay.

Now, childhood leukemia and childhood non-Hodgkin's lymphoma, we are not sure. We -- from the studies I've seen, the initial cause for the disease appears to be prenatal. So again, we're interested in most often -- mostly in prenatal exposures for this study as a whole for all the outcomes.

DR. JOHNSON: Other questions? Yes, please.

DR. UBER: Just to -- I think I know the answer to this, but just to clarify. The study is not concerned with any fetuses that would not have made it to a live birth that might have had a cause from contamination?

DR. RUCKART: Right; because it's difficult to ascertain that. If we could, that would be ideal. But it's just not really possible here.

DR. JOHNSON: Yes.

MR. MASLIA: Just to help everybody get oriented, I think during a subsequent presentation, I've got some maps and some slides, so we're all calling the same parts of the base the same names and things like that. And we'll define that for everybody, so...

DR. JOHNSON: Thank you. Any more questions to Dr. Ruckart or Dr. Bove? I have one last question to PI. This isn't a question but a comment. The question will follow. It looks like these five questions in the main are -- have been in some way put before the panel. Do you feel that that's true? I mean, are you okay?

MR. MASLIA: Absolutely.

DR. JOHNSON: Okay. I would --

DR. RUCKART: We work together.

MR. MASLIA: We even talk with each other.

DR. JOHNSON: Lord, the agency has indeed changed since I left (laughter). I'm so glad I'm sitting down. I would invite the epi team, starting with this principal investigator, to place before this panel at any time questions that you feel have not been addressed or have not been addressed to your satisfaction because this work in terms of the water modeling absolutely has to be vital in support of your work. And now is an excellent time to get things, you know, you always wanted to ask. Put it in front of this group, and you will have profound answers.

Now my question: You mentioned work that's upcoming in the spring of 2005. Has that work begun?

DR. RUCKART: We are actually traveling up to Maryland this weekend to be part of the training for the interviewers, and interviews are scheduled to begin Monday night or Tuesday morning by the latest. That will be next Monday and Tuesday.

DR. JOHNSON: Do you foresee anything that this panel will do over the next two days as having impact for the spring work?

DR. RUCKART: I don't believe so.

DR. JOHNSON: Okay. Well, thank you very much for your presentation. Mr. Maslia, a summary of water-modeling activities.

MR. MASLIA: Let me get the summary of water-modeling activities. Actually -- no. Let's go to project staff first; yes. Thank you. I've got it. I've got it.

DR. JOHNSON: And there are handouts here for the panel.

MR. MASLIA: The panel, yes. Some of the handouts are copies of this slide, and if any of the slides that we show that you would like copies of, please let me know or let Ann Walker know, and we'll try to provide those for you.

DR. JOHNSON: Are these available to the public outside?

MR. MASLIA: Some of them are. The ones that contain actual model simulation and data are not because they have not been cleared by the agency and subject, obviously, to panel deliberations. And so those are not available to the public. But we do have posters and maps, showing some information that everyone's free to look at and peruse, and we'll be pointing to.

Let me officially, I suppose, introduce myself. My name's Morris Maslia. I'm a project officer of the Exposure Dose Reconstruction Program at ATSDR. And I was approached by Dr. Bove and his predecessor to take part in the Camp Lejeune epidemiologic study and looking at some of the techniques that we used for the Dover Township analyses and seeing if those, in fact, could be used or something similar to that could be used.

I've introduced myself. Also from ATSDR is Jason Sautner over here. Jason did the bulk of the modeling work at Dover Township and had his intentions on doing the modeling here. But as things progressed, Jason has really helped us developing some of the field approaches and field protocols for the tracer tests on the water-distribution system modeling and setting those up, setting up the field type of analyses and data gathering. And so he's been more involved in that respect up until this point.

We also have -- we used the Oak Ridge Institute for Science and Education to get postgraduate research fellows to assist us. Claudia Valenzuela has unfortunately been relegated to helping us with logistics on the slide screen back there. I don't mean to point the laser at you, Claudia. It's like *Star Wars*.

But Claudia has really done the lion's share of the water-distribution system analyses that were presented in the notebooks and also has done a tremendous job in investigation in trying to figure out this issue of classification of different types of consumption and demand. We'll get into that. Obviously, being a military reservation, we may not have a simple case of residential, urban, industrial-type classifications.

Also just joining us this past October is Joe Green, and Joe's background is in medical geography. And all of the nice posters and the spatial analysis work, Joe has helped us out. He goes back and forth between the distribution-modeling results and the groundwater-modeling results, helping us put together and pull different aspects of the data.

And as far as groundwater modeling and fate and transport modeling, we have Robert Faye, who is sitting over there. And Bob spent -- and I had my notes. It's probably on another slide here but -- I believe, 27-1/2 years in U.S. Geological Survey; 12-1/2 or so, he was the regional groundwater specialist for the southeast region at USGS. And he has been doing the groundwater -- not only groundwater modeling, but the geohydrologic framework, culling through the data files for the groundwater aspect of the analyses.

And then finally, we also have Dr. Mustafa Aral, who is sitting right at this table. And we have a cooperative agreement with the multimedia environmental simulations lab at Georgia Tech. They assisted us with our Dover Township work and are involved -- I expect to be even more involved when we start tackling this issues of uncertainty modeling, operational cycles, and things of that nature.

And finally, not present -- and I'm not sure why Dr. Grayman decided that he'd rather be on the beach at St. Maarten than here -- but Walter Grayman, whose background is in water-distribution system modeling, has been an advisor to us, helping plan the tracer tests on the water-distribution side as well as water-distribution system modeling. And as I said, he's an advisor to ATSDR.

So that is the project team. I would like to just -- and we can revisit this, but I was -- in going through some of the premeeting comments, which we really do appreciate. It helped us focus more on the direction we needed to go and some of the answers we're going to try to at least provide you in a general sense at this meeting and something to work on, obviously, after the meeting.

But a couple of questions came up with respect to the charge on the work effort. Obviously, everyone's admitted thus far this is not a small undertaking. And so I put together a couple of slides just very quickly, and you have -- there's a -- should be a packet. If not, we can provide you these in your handout.

But this slide sort of shows -- the red bar is the total work effort, the percent of effort. You see, for example, groundwater, we're estimating thus far has taken about 35 percent of the total effort. Water-distribution system modeling is about 40, primarily because of the field and us having to go out in the field and that nature. Data discovery -- this is anything from going through the Marine Corps base facility that they call "the vault" to look through data to other -- finding other sources of information. And then communication, whether that's preparing reports for this meeting, preparing presentations, or ultimately preparing final reports or protocols as to what we did.

And just within each subject I subdivided. For example, in groundwater modeling, you've got a data discovery component and you've got a data-analysis component, which would be both geohydrologic and modeling and so forth.

You can see that in the water-distribution side, we've got an extremely driving up until this part is the, I believe, that's the data discovery. No. That's the spatial analysis. I'm sorry; spatial analysis. And that is the cause of the complexity, both present day as well as historically, of exactly having documentation of where the pipes were, which treatment plants were operating.

A lot of this information originally was on paper copies, and we had to geocode it and all that sort of stuff. Even conducting field tests, locating hydrants, many, if not most, of the hydrants on base are not numbered. And we had to physically send people out there to actually locate and two different people locate two different hydrants and things of that nature. So that's what's driving that.

The final slide is more of a budgeting in terms of staff. If you add up all the red bars, it adds up to about four and a half equivalents, full-time equivalents. And so within that, again, you can see the present day. This refers to the present-day water-distribution system modeling. It is really driving the time-consuming and manpower-intensive aspect of the project. So that's just a very quick overview of our staffing from the water-modeling side.

And I believe that's all the project staff comments I have, unless someone has any specific questions on those. If not, I think next on is a summary of water-modeling activities. Claudia, if you will -- and I think that's number four; number four -- no. It's number five. Yeah, yeah; right there. That's it. Okay.

I'm going to just give a very brief overview of modeling activities, so hopefully you get -- if the written documentation you were providing was confusing enough and voluminous enough to sort of simplify it. And you can go on -- I've got it right here. Okay.

Obviously, we're in coastal North Carolina, and we've got some maps here, some aerial photographs. But as Frank mentioned, there are actually seven water-distribution systems. And historically, there have been eight different water-distribution systems at Camp Lejeune. And we are actually concentrating the discussion today in our charge are the ones down in this area right over here.

So the ones, for example, at the air base, which is over here, and Onslow Beach, while they have and we may have information on them, they are not part of the analysis that we are undertaking. Basically, Perri reported this information; population of active duty, 100,000; and seven water systems supply groundwater at Camp Lejeune.

Here are the names of the different systems, and as I said, we're dealing with the Tarawa Terfrace, Holcomb Boulevard, and Hadnot Point systems. And in the next slide, what I would like to do -- and we have the posters up, that one over there, and I think if you want to move the second poster. Okay.

We have sort of a nomenclature issue. As anybody who's done any groundwater investigation or other investigations, as you get later and later time away from either when the wells were installed or the systems operated, names change.

So this is the nomenclature that we are using for the present discussion and for the present-day system. At present, there are two operating water-treatment plants. Water-treatment plants service areas that we are analyzing. And these are the Hadnot Point, which is down to the south here. And we're referring to that as the Hadnot Point water-treatment plant service area. And then there's the Holcomb Boulevard water-treatment plant service area, which is this area.

Basically, there are two sets of shut-off valves right along the Wallace Creek here that at present day separates the two systems completely. They're shut off. In terms of actual water-distribution systems, there are three water-distribution systems within the two water-treatment plant service areas. Hadnot -- could you back up? Okay.

Hadnot Point happens to service the Hadnot Point water-distribution system area. So it's coincident. The treatment plant services the water-distribution system. However, in this northern area, the Holcomb Boulevard actually services two different distribution systems. One is to the northwest here, the Tarawa Terrace water-distribution system, which presently is combined with service to Camp Johnson.

Historically, there was another treatment plant here, which I'll get to in a minute, and then also the distribution system at Holcomb Boulevard area. There is one pipeline here that, once the water is treated at the treatment plant, sends water to an underground reservoir at Tarawa Terrace and based on demand and tank levels would then distribute water just to the Tarawa Terrace area.

So are there any questions with respect to nomenclature that we're going to use for the balance of the panel meeting at this point?

(No audible response)

MR. MASLIA: I'll get to a very brief chronology. We've got some larger boards here. And as Frank said, this chronology has been sort of at times chasing a moving target. And so it remains sort of changing in flux even as we speak. As we get new information or as we get conflicting information, we start changing.

But very briefly, the Hadnot -- this is actually as

-- I put this together last week, so it's the most current that we have. '43, Hadnot Point was the first distribution system and first treatment plant on base. And then in '51 to '52, the Tarawa Terrace treatment plant was constructed. That's about the time that they also built the housing complex at Tarawa Terrace. And then at '50 -- in '57 was the Montford Point. And the Montford Point actually serviced the Camp Johnson, which is the northwestern-most part of the distribution system.

Then we have a big question, which we have not resolved to date yet. We cannot get a month or year as to when Holcomb Boulevard began operating. They've got a picture on the wall that says '73. You know, one of those architectural pictures that -- and we do have an accounts book that we just received a couple of weeks ago that lists when the information is filed into their system. That sort of lists '73 as well. However, documentation that we have just -- that we've just recently received says '71, and that can be a very critical issue.

So all I can say is I'm at the panel's mercy. That is a major issue, and, in fact, I think -- and I hope the panel doesn't mind me mentioning names, if you've made some comments. But Tom made a comment about putting some effort into data discovery. I'll call it that. And that still is ongoing and needs to be refined. We're planning to do that some more, but we're going to have to obviously get detailed into the files to figure that out. So I'll just put that up there. We're not sure when in that time frame. And obviously, if the epidemiologic study is looking at months, that becomes an issue.

Tarawa Terrace -- when the water-treatment plant was closed, again, we think March. We think 1987. It started back in '85. We just recently obtained some information, a report, that I'm asking for some more background on -- that I've asked the Marine Corps for some background on that was written in '91 that makes a statement in there that, "Two years prior," which would be at -- in '89, "that Tarawa Terrace" -- and I'm quoting --- "supplied water to Holcomb Boulevard." That, again, so -- and that's in a consulting report. There may be other information as well, but that's some of the issues we're still dealing with.

And finally, in '87, again, we have some documentation that says all the remaining wells were closed. So we -- the issue is we are still in the midst of this data discovery and coming up with a finalized or a time line that, if you want to say, is cast in concrete or stone that's fixed. We're not satisfied with some of the components of the time line at this time. Okay.

Goals and objectives of the modeling. These were the goals discussed with the epidemiologists when we first met as to what they needed for the epidemiologic study; arrival of contaminants at the well. And obviously, that also means concentration values or ranges, not just when they first arrived at the wells.

From the distribution side, the distribution of contaminants by housing location. We've sort of -- and housing location is taken to mean, like, Tarawa Terrace, Holcomb Boulevard; not necessarily House, you know, 2103. That's my interpretation, but as I said, the piping-system network does go down to the street level.

And it's always been our intent to address uncertainties. We understand their impact and the impact they can have, especially on interpreting results from the epidemiologic point of view and what sort of confidence. Just as an example, when we were doing our Dover Township work, the epidemiologist came back to us and asked, "Well, now that you've given us that House A receives 10 percent of the water, does that mean it's 10 percent plus or minus 50 percent, or is it 10 percent plus or minus 2 or 3 percent?" We had -- I don't know if it's luxury or opportunity there to tell them, "No. It's 10 percent plus or minus about 3 to 4 percent." We were able to reduce that out by running different scenarios for them.

Whether that proves -- or whether we have the ability to do that here based on data, we're still looking into it. That's what we're looking for some of the input from this panel to tell us. And so -- and we've got the uncertainties on all sides: the groundwater analyses as well as the distribution side.

So to finish up, again, and this, I suppose, is more so for our public that's here but to go over a generalized approach. We've got our site, Camp Lejeune, here. And on the groundwater side, we're using the Modflow or one of its derivatives, which will become eventually coupled with a fate and transport analysis.

You have only been provided -- the panel -- with an advective part up until this point in time. But it's been our intent all along to go to the full-blown look at the dispersive issues as well and then, on the distribution side, an EPANET-type or its equivalent too. Again, we've used EPANET and its equivalent for our present-day analyses; actually to help us, guide us, in preparing some of the field studies.

And I believe that's all on the overview of the -- of the types of models. One point I wanted to make on the report that the panelists were given -- I'm calling it a report, and that's probably a misnomer. It's more probably a collection of data collection efforts and some background information.

And if we -- or if I implied that it was intended as a final or finished product, that was probably a miscommunication on my part. It was really meant to be a working document, hopefully presented in some intelligent form, that you could make sense out of it. So this is not an intent for you necessarily to review that document as a report but as the data contained in it.

And I believe that's it for the overview of the modeling. At this point, Dr. Johnson, we've got two options. I've got a brief overview on the groundwater and then leading into detailed discussions and analyses with Bob Faye. Or we had prepared some general responses to some of the premeeting comments. I didn't know if that was the opportunity -- if this was when you wanted me to just give an overview of those.

DR. JOHNSON: No.

MR. MASLIA: Okay.

DR. JOHNSON: I think it is, though, the time and opportunity to ask questions on what we've heard thus far. Yes.

DR. UBER: Morris, this might not be the best time to ask this question. So I don't -- I cannot speak myself authoritatively at all on chemical or biological processes affecting any of these contaminants, and so this question also maybe then goes to some of the panelists who can.

But do you know: Right now, do any of those potential chemical biological processes act in the distribution system? And if so, are their kinetics effective over residence time scales that are typical of distribution systems?

MR. MASLIA: I have to plead ignorance to that. I don't know if that's a question that Frank -- as far as biologic processes with respect to the epi part of things. I know that question came in other studies of biologic plausibility, the fact that you can make an association, say, between contamination of a water resource and an apparent disease. Is there, in fact, a biologic plausibility for that?

DR. BOVE: Oh, I didn't know -- I thought the question was more on processes.

MR. MASLIA: Oh, was it? Okay. I think I can --

DR. BOVE: Yeah; because I can answer that one.

DR. UBER: I think I can -- I was probably too wordy. I just want -- I'm basically asking: Does the team feel right now that for purposes of transport in the distribution system that they can model these contaminants as tracers?

MR. MASLIA: Based on what we've seen with the responses to the present-day system -- and that's all we have right now -- the answer is yes. In fact, we've made some, I think, some interesting, if not eye-opening, observations based on how the present-day system is operating. And from what we have been told to date, that is a typical operation over the last 20 or 30 years with, of course, obviously, changes in hydraulic and infrastructure, removing treatment plants, starting up the Holcomb Boulevard treatment plant, things of that nature.

But based on the preliminary tests that we've done to date, we have been able to, I believe, do some acceptable -- not maybe final, but acceptable model simulations. And, in fact, it was the model simulations that led us -- and we'll get into this probably later this afternoon and tomorrow -- that led us to suggest to the utilities' folks at Lejeune that they, in fact, perhaps had some closed valves while we were doing it, relying on some -- and it turned out that that was correct.

So I believe -- to answer your question in a short manner, I believe the models will -- based on what we've seen to date will provide us the ability to provide some answers on that. As far as the level of variability or uncertainty, I think that's where we need to get back with the epidemiologists and really sit down and see what level they're willing to accept or can accept for their analysis. And that, I can't answer you at this point in time.

DR. UBER: Oh, okay.

DR. WALSKI: To give you a little answer to your question, Jim, on the processes, most of the things that happen to the VOCs in pipes don't really -- I mean, there's not much that can happen to them. I mean, in pipes, the only place where you could have much of a process affecting them is usually in tanks where you have a free water surface and they can volatize.

But when Ben and I did the work in Phoenix/Scottsdale, we looked at that, then went back to Henry's Law and looked at stuff like that. And we did -- you know, since you don't really -- it's hard to measure these kind of things, and there's not a lot of literature on Henry's Law in a perfectly still tank. Usually, if it's for stripping towers and stuff like that, you have a lot of literature data.

But going back and trying to reconstruct this, we estimated 97 percent of what went into a tank came out. Very little is really lost through the surface, and that's about the only process that you lose VOCs is through the surface of the tank.

So basically, assuming that it's -- what goes in the system goes to the tap is probably, you know, a reasonable assumption if there's not processes occurring. At least, we couldn't figure out any processes that would knock down the concentration significantly.

DR. POMMERENK: Yeah. I have some supporting information on that. Because that question was asked by Camp Lejeune to us as their consultants, we looked into literature and tried to come up with a rough estimate of would there be any removal within the treatment plant. And since, you know, we had to review all of the drawings of the existing plants, we knew the surface areas that are available. We made certain assumptions: You know, is the water quiescent in that tank, or, you know, is there any agitation anywhere?

In all the tanks that we looked in -- and some of the tanks are newer. There's more surface area available today than there used to be early in the seventies. But removal due to volatization was negligible. I mean, it was less than a tenth of percent. The only location where there would be some removal was in the spiractors that were operated in all these Hadnot Point, Holcomb Boulevard, and Tarawa Terrace plants.

And even there, there was a certain uncertainty, depending on they had conditions downstream you would get some agitation at the effluent pipe. So although we said it's probably negligible, and I agree with Tom's number here. At 90 percent, what's going in is coming out on the other end.

One thing that had to be -- we were not able to address. I believe the Hadnot Point plant used to have a carbon dioxide contact basin. We could not find out when this contact basin was operated because, obviously, that process would agitate the water significantly. It was also open to the atmosphere. It was not in a closed building. And there could have been some significant removal, but we were not able to be certain when this -- they ceased the operation of that unit at Hadnot Point a long time ago. And even some of the older operators that we talked to were not able to tell us when that was. But, again, you know, what Tom said is probably accurate, that you can probably use PCE and TCE as a tracer distribution system.

DR. WALSKI: Which leads to the question, though, on the measurements we have. We have only a handful of measurements of VOCs in the system. Were these taken before treatment or after treatment? When were they taken?

MR. MASLIA: There are some -- from the health assessment, there's some tap samples. So that obviously would be after treatment. We've got some groundwater wells with PCE and PCE measurements, so that's obviously before treatment.

DR. CLARK: But there's a third class that's on the schedule that says water-distribution system.

DR. JOHNSON: Step up to the microphone, please.

DR. CLARK: I'm sorry. The time line also has water-distribution systems from neither tap nor well. And that's what, I think, the question is.

MR. MASLIA: It's somewhere -- tap is at the household.

DR. CLARK: No. Let me quote from it. It says, "water-distribution system tested."

MR. MASLIA: Right.

DR. CLARK: Was that -- at which side of the distribution system? I mean, at the tap?

MR. MASLIA: Oh, I see what you're saying.

MR. FAYE: I think that was on the treatment side.

COURT REPORTER: Excuse me. I can't hear you.

MR. FAYE: I believe it was on the treatment side.

DR. CLARK: Post-treatment.

MR. MASLIA: Post-treatment; post-treatment side.

DR. POMMERENK: Can I add to that? Thank you. As far as I'm aware of -- and you, Morris, you probably remember that too. The contamination of the drinking water was first discovered -- there was -- a portion of it was discovered in the early eighties when the -- after the promulgation of the THM rule, the trihalomethane rule. So these samples were taken in the distributions system at consumers' taps, and I think in the course of the analysis, the laboratory that analyzed had problems resolving the peaks from, you know, from the THM compounds because I believe TCE or PCE was masking those other peaks on their chromatograms. So these early data may have been actually tap samples in the distribution system.

MR. MASLIA: Yes. We've actually got documents with the lab notation on there, specifically addressing that particular issue.

DR. JOHNSON: I have a question. With regard to the models, you indicated, I think, that they're both EPA models?

MR. MASLIA: No. No, sir. Modflow was originally developed in the middle to late eighties -- correct me, Lenny, if I'm wrong -- by the U.S. Geological Survey. It's a public-domain model. And now, of course, there are any number of proprietary codes that use it as the engine, more or less, with the data sets. Basically, if they say they're Modflow compatible, then you can run them with a plain vanilla code, which is publicly available from the USGS Web site, and we have done that.

EPANET is the same issue. That was developed by -- can I say this? -- your shop, Bob Clark's shop, when he was at EPA, by Lou Rossman. We've worked with it from Dover Township days, and again, a lot of the commercial codes for the water-distribution models use the EPANET engine. We are actually using both a commercial or proprietary code and EPANET. Some of the commercial codes, as they do have nicer bells and whistles on the front-end to make data input a little easier and things like that. So there are two publicly available model codes that have been vigorously and publicly tested.

DR. JOHNSON: What do we know about their validity?

MR. MASLIA: There -- we're convinced of their validity. There's documentation. In fact, EPA has a documentation ad for specific problems to test for Modflow. And that's, again, available on the EPA Web site, that if you want to -- if you make a modification, if you will -- we have not made any modifications to the models, by the way.

But if you do and you want to test its verification or validity, then you can run those sets of problems. EPANET 2 obviously is a second-generation version of EPA, and it has gone through robust testing. And most of the commercial codes, again, will carry the -- EPANET has a set of problems that you can test your adaptation of it against those benchmark -- if you want to call it those benchmark problems.

DR. JOHNSON: Okay. Thank you. Why don't you continue with the other material, please.

MR. MASLIA: Okay. Thank you. At this point, what I want to do is give a very brief overview, more of a generalized overview, of this morning's -- the rest of this morning's session will be on groundwater. And then throw it over to Bob Faye to really address step-by-step technical issues.

So, Claudia, if you'll get the groundwater slide -- groundwater overview. Okay. There you go. Is that the first slide? No. I need -- back up one. Okay; one more. Okay. I've probably got them X'd out. Okay. I'll make it short and sweet then. Okay. Okay. There you go.

Sources of contamination, we've -- as we spoke about Hadnot Point being the first one leaking underground-storage tanks and spills and other waste disposal and then Tarawa Terrace, which is the dry-cleaning source. And that's really why in discussions with Bob Faye and myself and with some input from the epidemiologic side is where should we attack first.

In other words, we were more sure or more positive of Tarawa Terrace being as close to a single source as possible, an identifiable source. And so we decided from a project-management standpoint as well as initial results to show the applicability of what we were doing to go after Tarawa Terrace. So -- and that just gives you the dates. And the Well 26, which you'll probably hear a lot about and it is on our time chronology, is about 900 feet from the dry cleaners. And that was the well -- one of the wells that became contaminated at Tarawa Terrace.

And so the approach to modeling groundwater was to assess Tarawa Terrace as a single source and a known location, known location for the source and to develop a geohydrologic framework. There have been some previous work done -- Bob Faye will get into the details of that -- both from the U.S. Geological Survey in the middle to late eighties being on site at Camp Lejeune as well as some private consulting firms doing some work; construct the three-dimensional Modflow model; calibrate the model for study state or predevelopment; and then look at transient conditions; and then conduct fate and transport. As of today, we have done all but -- with Tarawa Terrace -- except the fate part. We've done the advective transport.

And that's really all -- I just wanted to give a complete overview from the groundwater side to any members of the public who are here or who want to see the big picture. So that's the big picture on the groundwater side. And at this point, again, I'd like to introduce Bob Faye, who will give you the details of our groundwater-modeling analyses.

DR. JOHNSON: Any questions to Mr. Maslia with regard to the groundwater presentation?

DR. POMMERENK: I have one question.

MR. MASLIA: Oh, sure.

DR. POMMERENK: Morris, don't quote me on this. I don't remember quite -- in one of the public health assessments, I seem to remember there was another dry-cleaning business to the east of ABC. Can you just briefly state why this is not included in your talk?

MR. FAYE: Yeah. Is this on? Peter, I can address that. The initial study that was done in 1985 by Shiver, I think it's called Globa-something or other --

MR. ENSMINGER: Globarama.

MR. FAYE: Globarama; right; Globarama Dry Cleaning. The initial study that was done by NCDEM by Shiver in 1985, he looked at that -- at that facility in detail and decided that not only did their operations -- it was a closed operation, apparently, where they completely recycled their waste and handled their waste in a responsible way by hiring a waste management -- a concern to move the waste away from the site.

Also, there were groundwater samples taken near the site, as I recall, and it showed that there was no real opportunity at that site for groundwater contamination. For example, I think the observation well that they drilled right in front of the ABC facility, the concentration in September of '85 was about 12,000 micrograms per liter of PCE. And the contamination at the Globarama facility was minimal, was no comparison, if any. Did that answer your question?

DR. POMMERENK: Yes.

MR. FAYE: Was that -- okay. And that has been described and discussed in detail, not only in Shivers' report, but also in the EPA Operable Unit 1 and Operable Unit 2 reports that Weston --

DR. POMMERENK: Okay.

MR. FAYE: -- the Weston folks put together back in the early nineties.

DR. POMMERENK: Thank you.

DR. JOHNSON: Okay. Any other questions?

MR. FAYE: Okay. My name is Bob Faye. I'm a contract employee with the Eastern Research Group. And as Morris said, my responsibilities for the most part have been to construct and calibrate the groundwater-flow model to date.

Dr. Johnson, am I allowed to suggest that if the panel members have questions that they could just freely interrupt me at any time?

DR. JOHNSON: Oh, absolutely.

MR. FAYE: Okay; great. Please do.

DR. JOHNSON: About how long is your presentation?

MR. FAYE: I think probably -- well, depending on questions, to complete the framework and the contaminant description as well as the flow-model description, probably on the order of 90 minutes or so.

COURT REPORTER: I'm going to need to take a computer break before then.

DR. JOHNSON: 90 minutes?

MR. FAYE: 90; as in 80, 90, 100.

DR. JOHNSON: Morris, we have a 10:30 panel discussion and answers to questions. This appears -- a 90-minute presentation would appear to be a serious overlap.

MR. MASLIA: Yes. Part of the answer to the question is we were going to direct feedback.

COURT REPORTER: Excuse me. Please get a microphone.

MR. MASLIA: Our intent was, I guess, with direct feedback during Bob's presentation, to start addressing some of those questions and perhaps hopefully -- not eliminate them, but have some discussion on specific -- those specific questions. Unless -- and the other suggestion -- not that that shortens the length, but I didn't know if you wanted to take the 15-minute break now and go through the entire presentation and go forth, rather than breaking it up for the scheduled break.

DR. JOHNSON: What does the panel wish to do? Take a break now?

(Audible responses)

DR. JOHNSON: Okay. We'll take about a 15-minute break and --

MR. FAYE: How do we resolve this, Dr. Johnson? Do you want me to just describe the groundwater-modeling effort? What does the panel -- well, I'm happy to accommodate whatever the wishes are or try to accommodate.

DR. JOHNSON: What I heard Mr. Maslia say that the idea here is to have the panel address some of the, what I call, the eight questions that the agency has put forth on groundwater and to try to integrate those into your presentation. And that leads to them asking questions during your presentation, and that seems to me to be quite a good process. So does that answer your question?

MR. FAYE: Right. Well, I'll just -- then I'll just continue with Plan A, and if somewhere in the interim we need to switch, we'll go to Plan B and Plan C.

DR. JOHNSON: Okay. I will say that 11:45 we're out of here as a stampede toward the lunch. So why don't we take a 15-minute break? Be back at 10:30, please.

(Whereupon, a recess of approximately 17 minutes was taken.)

DR. JOHNSON: Okay. Let's resume.

Let me suggest to the panel that you ask questions during Mr. Faye's presentation, and I think it would be useful if you could relate some of your questions to the questions that have been provided by ATSDR that pertain to groundwater. And specifically, these are some eight questions that were provided to you in advance.

I know you also provided premeeting comments, and at some point, Mr. Maslia is going to provide kind of an overarching response to that. But feel free to blend in your premeeting questions and comments during the presentation here by Mr. Faye.

We will continue the groundwater discussion after lunch to some degree, to the point where we feel satisfied with it. And if we finish a bit early, then I'm going to push up the water-distribution systems questions to later in the day.

So I need, also, as a matter of courtesy and respect to introduce Dr. LaBolle. Would you introduce yourself, your affiliation, and I asked each of the other panelists to give kind of an initial reaction to the materials that you received.

DR. LABOLLE: Yes. I'm Dr. LaBolle from University of California, Davis, department of hydrologic sciences. And my initial reaction: I was quite pleased with the level of detail and work that's being done with the distribution system. My expertise is in groundwater, but I have some experience with distribution-system modeling, in particular, models that are similar in construction with this groundwater linkage to the distribution-system model with the fate and transport involved as well.

And my greater concern is with the variability and uncertainty in the groundwater system, and I'll be posing some questions with regards to that.

DR. JOHNSON: We look forward to those questions.

DR. LABOLLE: Thank you.

DR. JOHNSON: And welcome to the panel. Okay.

MR. FAYE: You ready?

DR. JOHNSON: Yes.

MR. FAYE: Okay. Just to start out, I want to clarify one thing. You may hear me -- and I know in my -- in my papers that I wrote for the document, I use the term "Montford Point," but that's equivalent to Morris' Camp Johnson. Okay? So if I say -- if I slip and say "Montford Point," just think Camp Johnson.

The rest of the areas, he's already talked about: Tarawa Terrace area and the Holcomb Boulevard area. And those are the three areas that feature in the framework discussion. The Tarawa Terrace area features exclusively in the model discussion and in the description of contamination.

The purpose of the framework was to describe and quantify the geometry, hydraulic characteristics, and potentiometric levels of the aquifers and confining units at Tarawa Terrace and vicinity at a scale and level of detail suitable for application to groundwater flow and contaminant fate and transport models.

As far as data are concerned, these -- this is inclusive of the Camp Johnson area, Tarawa Terrace area, and the Holcomb Boulevard area. Elogs, that stands for electric logs. We have a -- we have a poster with the -- with several examples of electric logs for your benefit.

There's two parts to an electric log: the resistivity side, the spontaneous potential side. Both are important and useful in terms of defining the various layers that we -- that we're dealing with in terms of the framework.

There were 100 boring logs that were available to us from a variety of sources. There were -- there are two reports that address -- or three reports, actually, that address the contamination relative to ABC One-Hour Cleaners. There were -- and then -- many, many boring logs associated with those reports. There's also a large number of boring logs associated with RI/FS investigations that are ongoing in the Tarawa Terrace area.

Claudia, could you move back to the previous slide; and the next one, please.

These boring logs, unfortunately, are not spatially well distributed in the study area. The boring logs almost exclusively refer to -- I'm sorry, almost exclusively refer to RI/FS studies that are ongoing in this very southern part of Tarawa Terrace and, of course, in this northern area, just north and south of Lejeune Boulevard, between ABC One-Hour Cleaners and Supply Wells TT-26 and TT-25. And we'll be talking about those in just a second.

That's a picture of a typical Elog that we have to deal with. The spontaneous potential curve, which is the left-hand -- the left-hand curve, is not very useful at Camp Lejeune because it's a -- it's, more or less, an industrial area. You've got a lot of ground currents, a lot of current loss in the subsurface, which causes reversals of the spontaneous potential curve.

Also, you have cycling going on; 60 cycles per second in the subsurface. You have bleeding out of the -- out of the electrical conduits that are buried, which also confuse the resistivity side. But for the most part, all of these analyses were based on areas or zones of low and high resistivity and not related back to the spontaneous potential.

This is typical of a boring log, one of the hundred. I think this extends to a depth of about 20 feet or less. Just a couple of points: This is the detail. These are mostly logs from augering, hollow-stem augering. So you have a lot of smearing in the lithologic descriptions going on, probably plus or minus half of a logger stem, which is typically 5 feet. So any of these depths that you identify as perhaps a top of an aquifer or a top of a confining unit have to be identified in that context, that we're looking at something that might be accurate to only within plus or minus several feet.

A number of the boring logs were created using split-spoon samples at different intervals. Those, of course, are accurate to the identified depth, and they're very accurate. Many of the logs -- many of the boring logs in the Tarawa Terrace area, the northern part of Tarawa Terrace area, the ABC Cleaners' area, identified a feature called "running sands." And this -- this was -- shows universally as the top of the Tarawa Terrace or the -- top of the upper Castle Hayne aquifer. And I can tell you -- I can explain the rationale for that at some time later.

This is typical of the drillers' logs that we had available to us. In fact, that's quite a good one compared to many. That's the kind of detail that we looked at; the lithologic descriptions. Most of the time, I use the drillers' logs just to identify the occurrence of what was called limestone or Copena.

There was a major, major problem in locating accurately the various points of well-data collection, of monitoring wells, particularly for the many RI/FS studies that were -- that were conducted there relative ABC Cleaners and these other places. That was the 100 boring logs that we -- that I discussed.

Virtually, the reports did not -- we used the state plain coordinate system for North Carolina in 1983, 9-AD -- NAD. Virtually, none of the reports use that system, so we had to convert the coordinates that were available to us. Many of the coordinates in the report -- in some of the reports were not correct. They were -- even on their own system -- whatever arbitrary system they devised.

So basically, what we did was just go back to the old-fashioned way of measuring distances on the maps that were provided. And we were able to identify -- you'll see this -- the little building there, TT-47. We would take intersections of roads or identified buildings or whatever and use that as the -- we would find the state plain coordinates for those places and then extrapolate those coordinates to the rest of the map, basically just using hand measurements. So you need to keep that in mind as well as you think about the accuracy of the location data.

Finally, the end product of the geohydrologic framework analysis was the development of 11 or 12 -- actually 11 -- 11 units as part of the framework, aquifers and confining units. Now, as far as the Tarawa Terrace area is concerned, the Brewster Boulevard aquifer and the Brewster Boulevard confining unit do not occur at Tarawa Terrace except perhaps as a -- just a thin mantle of sediments at the surface that are -- that are smeared with every -- with everything else and really not of use to be identified or not even -- they're unsaturated almost always. And they're not dealt with in the Tarawa Terrace area.

I might say two things about the correlation effort. The U.S. Geological Survey produced two reports exclusive to the Marine Corps base Camp Lejeune back in the late eighties. And both of these reports had long, detailed sections, using various Elogs and drillers' logs and whatever; published these sections.

They identified a number of units that they would track on these sections across almost the whole entire base from well to well or Elog to Elog. And essentially, below the Tarawa Terrace confining unit, our geohydrologic framework conforms very, very closely with a few exceptions here and there to the framework analysis that was -- that was performed by the U.S. Geological Survey.

Relative to the Tarawa Terrace aquifer, Tarawa Terrace confining unit, and the Brewster Boulevard and Brewster Boulevard confining unit, we sort of did that on our own. And some of our results at certain places differ from the USGS interpretations regarding these two aquifers.

One thing that I -- one thing that I like to do when I develop a conceptual framework like this is to constrain my results using chronostratigraphic boundaries. That -- that would be like actual geologic unit times. Unfortunately, for this particular study, that type of information was very limited. But I did use the distribution of the top of the Castle Hayne formation, which I identified with the top of what I call the local confining unit. That is the top of the Eocene. And I identified also the top of the Beaufort confining unit, which the US -- USGS has identified as the top of Paleocene.

And what you do essentially is you look at the -- you look at the strike, the distribution of those particular units. That helps you to understand the depositional cycles that occurred, that you're trying to identify as aquifers or confining units. That helps you identify the depositional cycles that occurred within that particular time frame.

And that's important because if you're just correlating a clay to a clay from Well A to Well B, you could just very easily be missing a facies change;

whereas, if you can -- if you can correlate it as well with a chronostratigraphic line, you have some confidence that you're looking at a spatially continuous unit in the subsurface. And we did that. We did that as well as we could with the limited amount of chronostratigraphic information that we had.

And then there's just a whole series of maps that you have in your report. This is the top of the upper Castle Hayne aquifer. This is one of the time units that I just spoke about that I used to sort of keep me on track in terms of the spatial distribution; orientation to the north, south, east, or west; dip and strike that I would apply to units below that and also actually to the River Bend unit, which was above it. And there's the thickness of the upper Castle Hayne.

Almost all of these surfaces that I've identified as either the top of a confining unit or the top of an aquifer are erosional surfaces. Okay? So you would expect some degree of irregularity in the -- in the altitudes at the top as well in the thickness and formation. And I wasn't disappointed at all in that regard.

Another feature of the geohydrologic framework analysis was the -- was the computation, the analysis of aquifer-test data. We probably had -- between Camp

Johnson, Tarawa Terrace, and Holcomb Boulevard areas, we probably had close to five dozen aquifer tests. Almost all of these invariably were single well tests, and almost all of the single well tests were step-drawdown tests.

And what I used -- what I used in for almost all these analysis is the public domain U.S. Geological Survey aquifer test analyses worksheets, Excel worksheets. And the real advantage to those is one -- it has one of the best approaches and methods to analyzing step-drawdown data, which was the majority of my data. And this is just an example of one of the output sheets.

Now, there was a question -- somebody addressed the notion of preferential zones of high permeability within the -- within the various units -- within the various identified aquifer units. We had no opportunity to do that except in the context of the resistivity curves on the electric logs. We could identify, perhaps, where there may have been a relatively thin lensoidal clay within the overall sand that we identified as an aquifer. But there was no way to, in my opinion -- and if folks here on the panel have some suggestions, I'd be happy to hear it. But we did attempt to quantify. That was just strictly a -- that would be strictly just a qualitative analysis, and frankly, it didn't really occur that much.

Another feature of the -- of the geohydrologic framework analysis was the spatial mapping of the horizontal hydraulic-conductivity data that we determined from the aquifer-test analyses. That's the -- such as it is, that's the spatial distribution of the data for wells that were open to the upper and middle Castle Hayne aquifers.

The last thing that we did with respect to the geohydrologic-framework analysis was try to -- try to create a picture of what the prepumping conditions or predevelopment conditions were in the -- in our areas of interest, which were Camp Johnson, Tarawa Terrace, and the Holcomb Boulevard area.

And the way we did this was to identify the -- at a particular well site -- excuse me, was to identify the earliest measurement that we had available to us in terms of a water level. And in particular, in the Holcomb Boulevard area, we were quite fortunate to have a lot of -- quite a good number of measurements that were -- that were obtained in the early 1940s when the first supply wells were drilled.

We either chose the earliest measurement at a site, or we took the highest measurement at a site. If we were fortunate enough in a very few cases to actually have multiple measurements, multiple water level measurements, at a site, it was -- I could probably count those on one hand -- but except for the Tarawa Terrace supply wells. But we chose either the highest measurement or the earliest measurement, and we just spatially plotted those data. And the data almost completely refer to either the upper Castle Hayne aquifer or the -- and the middle Castle Hayne aquifer.

But the notion here was just to look at possible boundaries that might be indicated as a predevelopment condition as well as flow directions. And what we find is that -- what we find is, as expected, Northeast Creek is an obvious boundary at least as far as these aquifers where the water-level information was obtained is concerned. And we have flow directions in Tarawa Terrace, generally either east or south, toward Northeast Creek. And in the Holcomb Boulevard area, we have flow directions north, west, and somewhat northwest, toward Northeast Creek.

And what this tells us is that, at least as far as those upper four aquifers or so are concerned, Northeast Creek is probably a major flow boundary. What this does as well -- and we have one site just north of Wallace Creek, I believe, right in this area here where there is a -- there's one -- there's a cluster site.

There's a series of wells there that are open to several of the units that we identified as aquifers here.

In particular, there's a well open to the Tarawa Terrace aquifer and intermediate to the middle Castle Hayne and also to the lower Castle Hayne. And that's just north of Wallace Creek.

And interestingly there, there's only about a 2-foot head difference between the head in the lower Castle Hayne aquifer and in the -- and the Tarawa Terrace aquifer. And I know that's not a lot to go on, but, as far as the conceptual model, which we'll talk in terms -- we'll talk in a minute about in terms of the model.

The conceptual model that we developed for guiding our approach to the flow-model analysis is that the predevelopment of potentiometric surfaces in all of the aquifers were relatively similar, in fact, very highly similar, so that, as far as the River Bend unit and as far as the lower Castle Hayne aquifer, the flow directions and the distribution of head in the aquifers was highly similar. And that tells us that Northeast Creek, indeed, would have been -- well, it is a boundary for flow for all of the aquifers that we're dealing with.

And I'll just take a minute to explain the reasoning there. You have groundwater flow -- pick your aquifer: River Bend unit or Tarawa Terrace aquifer, whatever. You have groundwater flow heading down gradient toward Northeast Creek from Tarawa Terrace, and that's heading generally south. You have groundwater flow heading east and north in the Holcomb Boulevard -- Holcomb Boulevard area toward Northeast Creek. Well, this flow has to meet in the middle somewhere at Northeast Creek. And at that point, you have vertical upward flow in the vicinity of the creek. And that was the rationale behind us selecting the midline of Northeast Creek -- the midchannel line as a flow boundary -- as a no-flow boundary for the groundwater-flow model.

Also, in these USGS reports that I mentioned earlier, there were some seismic studies that were conducted in the water of New River and Northeast Creek, right around this Paradise Point area. And what they -- what they discovered was that there were buried subsurface channels that were relic -- relic river channels that were now under water. And probably, these relic channels manifest themselves inland as well as zones of relatively high hydraulic conductivity.

But our -- the distribution, the spatial distribution, of our well data are not sufficient that we can actually identify what that old relic channel would have -- where it is and what it would have been. And that may be one of the reasons that we have some irregularities in our -- in our surface well data as well as in our thickness data and also in our hydraulic-conductivity data where, just by chance, one of these wells may have been developed in part or all of an old river channel, which would have been now filled with sand and would be an area of relatively high hydraulic conductivity.

DR. KONIKOW: Bob, what was the -- what's the rationale for the northern limit of your contouring on all of these maps?

MR. FAYE: We have a -- we have digital elevation models, Lenny, of this larger area. Let me show you. We have digital elevation models of this whole large area here. Actually, I think, probably of most of Camp Lejeune, but I was just looking at this. And that is interpolated to 2-foot contour intervals. And so using the -- using that, I identified the divide that ended up as the northern boundary, the no-flow boundary, in the groundwater flow-model.

I identified that as a hydraulic divide that generally sweeps up like this and down like that, and that's a hydraulic -- that's a topographic divide that is translated to a hydraulic divide in the groundwater-flow model. As I said -- and, of course, those are 2-foot contour intervals on the DEM, and they're interpolated as well. But that's the best information that we have. Okay?

DR. KONIKOW: Okay. I was looking at the topo maps.

It looked like there were -- I mean, I couldn't see the divide that close.

MR. FAYE: No, you can't. You can't, Lenny. There's a -- I can show you later, when we get into this, a much larger map specifically of the Tarawa Terrace area. There's -- you might have noticed that just north of this road that runs parallel to Lejeune Boulevard, there's a -- there is a closed 35-foot contour right north of that road, and that sits on that -- that sits on that divide. That is mapped on the topographic map. And that coincides with -- that coincides with that -- with the divide, as recognized on the digital-elevation models.

DR. LABOLLE: Are you going to -- this is Eric LaBolle here. Are you going to get more into the simulation of the predevelopment heads?

MR. FAYE: Yeah.

DR. LABOLLE: Okay.

MR. FAYE: Yes. This is just the framework.

DR. LABOLLE: Okay.

MR. FAYE: It'll show up very well, Morris, in the next couple of slides. Okay. Claudia, let's go to the description of the PCE contamination at Tarawa Terrace. There we go.

Okay. The next major area of responsibility that I had was a description of just what is this PCE contamination at Tarawa Terrace. Where is it relative to the source area? Where is it relative to the supply wells? How deep within the subsurface does it go? What are the quantities; i.e., concentrations in the water? What are the concentrations in the unsaturated materials? So let's try to address that.

The purpose of the study, again, for the record, is describe the occurrence and distribution of PCE and related contaminants within the Tarawa Terrace and upper Castle Hayne aquifers at and in the vicinity of Tarawa Terrace housing area, Marine Corps base, Camp Lejeune.

And a number of comments in the premeeting notes were related to degradation products of PCE, and, yes, to the best of our ability -- and we're severely limited by the data here. But to the best of our ability, we did -- we addressed trichloroethylene, which is the immediate degradation product of PCE, as well as dichloroethylene, the immediate degradation product of TCE, trichloroethylene. We addressed all of that as well as we could, but the data are very limited; very, very limited.

Okay. Here's a map. Maybe we can see that 35-foot contour. There you go. Can you go back, Claudia. There you go, Lenny; right here.

COURT REPORTER: Please get on your microphone.

MR. FAYE: Thank you. There you go, Lenny. That's that -- that's the contour I was talking about right there. And that's right on the line as shown on the DEM and comes down to -- it splits the difference between one of these two little tributaries right in here, I think. I think it's that one. It could be that one.

DR. KONIKOW: You also have a 35-foot contour a little further north.

MR. FAYE: Yeah; right; right. And there are differences between the DEM and the topo map, as you would expect. Actually, some of that is fairly significant, substantial. The differences are somewhat substantial. I can't recall now exactly what -- what's going on up here with respect to the DEM. But I looked for the major divide between here and there, northeast and southwest, and selected it.

Now, that may not be the -- from a groundwater modeling point of view, that may -- and particularly a fate and transport point of view, that may not be the best -- the best boundary. But, really, if we try to extend that north beyond the hydraulic divide, then we're stuck with a general head boundary, probably, for all of the units that we're modeling. And it just seems to me that would introduce more uncertainty into the -- into the analysis than selecting the hydraulic divide as the topographic divide. But let's -- let's -- go ahead.

DR. KONIKOW: I'm not convinced of that. Plus another problem is that during pumping conditions that predevelopment divide -- if that's really where it is and I'm not convinced of that either -- that the divide is going to migrate under pumping conditions.

MR. FAYE: It will. I don't think -- I don't think the -- at least as far as -- we don't really know. We have no data at all, field data, relative to -- relative to any kind of notion of radius of influence of the supply wells; no data whatsoever, so --

DR. KONIKOW: That could be computed --

MR. FAYE: We did.

DR. KONIKOW: -- more accurately than a lot of the other things.

MR. FAYE: Yeah. We looked at that. It just depends on where you want to go with the minimum drawdown out at some radius that you're looking at, whether it's .01 feet or .1 feet or something like that. I mean, that bounces your radius of influence all over the place. And right now, I'm fairly comfortable with the notion of using that hydraulic divide not only as far as the predevelopment situation is concerned, but as far as the transient.

But I would certainly welcome any kind of qualification or criticisms, comments of that notion. I mean, we're open to all that, absolutely. But I wanted you just to be aware of my reasoning, you know, as far as the decision was concerned to identify it as such.

DR. JOHNSON: David, you have a comment?

DR. DOUGHERTY: No. I think we can proceed.

DR. LABOLLE: Well, I have a question here, actually, regarding the -- not the hydraulic divide. But since we're on the subject of boundary conditions here --

MR. FAYE: If we could -- if we could just be patient just for a minute and let me get through the contamination, then we'll be into the heart of the groundwater model. Okay?

DR. LABOLLE: Okay.

MR. FAYE: And that might be the best place to discuss that. I didn't mean to --

DR. LABOLLE: No. That's just fine.

MR. FAYE: Okay.

DR. LABOLLE: That's probably an appropriate opportunity.

MR. FAYE: This slide just identifies all of the Tarawa Terrace supply wells that we know of. There actually may be several more that we don't have knowledge of, but this is all of them from the beginning of time, which is -- it'd be about 1952 up to the time in 1987 when all the wells were shut down. And, of course -- and, of course, some of these were taken out of service long before 1987. And as part of our plans, we have identified various data reports that we plan to produce.

And, of course, in the final report, there will be data reports, and all of these data will be tabulated and identified in terms of well-construction information, when the wells were placed in service and removed from services, et cetera, et cetera. We do have that information for most of these wells. We have good information regarding that, not only from our own data discovery, but the AH people have been very forthcoming and helpful in that regard.

Claudia, I'm going to go one more slide, just to orient myself here; just a second.

All right. Let me talk a little bit -- and I think this is very important to understand. Let me -- even though we're a little pressed for time. But let me talk a little bit about the contaminant data collection at ABC Cleaners and vicinity as well as the Tarawa Terrace supply wells that were affected in terms of timing, in terms of concentrations, in terms of quality of information.

What this slide represents is a summary of several series of data that were collected between 1991 and 1993. And I went into some detail in this in the report, but I want to say it here as well for the record.

The vast majority of these data that you see portrayed here -- summarized here actually -- relate to DPT data, hydrocone data, direct push technologies. We all familiar with that? You know what I'm talking about? Okay. There were probably like 40-some -- almost 50 of these DPT points where data were collected at -- in an upper zone, generally between about 15 and 25 feet, and at the same site in a lower zone, generally between 35 and 45 feet.

And what you see here is a -- is the -- if it happens to be one of those dual sites, this is the highest concentration that occurred at that site, whether it was the upper shell or the lower shell, the upper zone or the lower zone. Several comments about those data: There was an analysis done from a field mass spec operation at the site when the DPT operation was ongoing, and there were results obtained from that.

The -- Weston, the folks that conducted that site, also collected a number of duplicate samples and sent these off to a qualified laboratory for analysis. The end result of that was that there was very poor agreement between the laboratory analyses and the on-site analyses for a particular bore hole or whatever. So we have that particular problem. By the way, the points that were used to construct this map were all the laboratory analyses where they were available. Where they were not, we used the field -- the field site data.

Several -- okay. Let's look at -- here's ABC Cleaners. A point that I'll make later in our advective transport analysis when I describe that -- and, again, I apologize. I'm talking about a model here. But it'll be clear in a minute. The Well TT-26 is right here, and at least as far as our model is concerned now, under normal operation, the operation of TT-26 would capture every bit of the PCE that was introduced into the subsurface and into groundwater at ABC Cleaners.

But we have fairly large concentrations of PCE north and west of ABC Cleaners. And in addition, we have respectable concentrations of PCE south of -- south of the well here, TT-26. And this is near another supply well, TT-23. But as you can see, PCE values or concentrations values at this time, now 1991 to 1993 -- you have to remember this is four to five years after the Tarawa Terrace wells were shut down -- there's zero concentrations here. And these points I'm making now because they'll occur prominently in the discussion of the groundwater-flow model.

Okay. We had these data, as I mentioned, of the PCE concentrations and other contaminant concentrations that we could assign to an upper shell and a lower shell. So given that, we created -- is that it? I'm going to go for this now. We created a map. Thanks, Claudia.

We created an average or a midconcentration map, using the aerial distribution, the spatial distribution from the upper shell and from the lower shell. With that midconcentration shell, we also computed the volume of aquifer material between the two shells. And in doing that, the DPT data we actually used the depth they identified. If it happened to be a well, we used the midpoint of the screen interval to put a limit on the volume -- on the depth.

We computed the area-weighted PCE concentration between the average shell-concentration contours. That, in a sense because it's the midconcentration shell, is the volume-weighted PCE concentration. Once we had that, we multiplied that by the volume adjusted by effective porosity. And we ended up with a PCE mass of about 2500 pounds between those two shells or 185 gallons of PCE. And this analyses, I think, is described in pretty good detail in the report.

DR. KONIKOW: Bob, why do you use effective porosity rather than total porosity?

MR. FAYE: Yeah. Well, if you recall, Lenny, there was a -- there was also a description in the report of the movement of the mass of concentration, the center of mass of the PCE concentration, from the doorstep of ABC

Cleaners, in '85, down to some point midway between ABC Cleaners and TT -- Well TT-26.

Well, the reasoning there was that that movement had to occur through connected interstices in the porous media. And where it ended up in 1991 to '93, the volume that that PCE was occupying was only connected interstices, not the -- not the total interstices in the porous media. So as a consequence, we used effective porosity.

DR. KONIKOW: Well, you know, I think if you have the contaminant in the connected interstices, it's going to be in the -- I don't see any way to have uncontaminated water adjacent to it in the disconnected pores, even if there are. And I find it hard to believe there are disconnected pores there. You used a specific yield value of 20 percent, I believe.

MR. FAYE: In Layer 1 in the Tarawa Terrace aquifer, that's right. The rest of -- the rest of the layers -- like, the River Bend unit is 15 percent, and that's where the vast majority of the contaminant is. Now, we don't have any measurements of effective porosity. We don't have any point measurements.

Two of the studies that -- the Weston study and, I believe, the Bragg's report as well, used effective porosity depending on the on the unit they were -- of 15 percent and 10 percent. And I kind of qualitatively looked at the lithologies and assigned a slightly higher effective porosity to the Tarawa Terrace aquifer.

It looked to me like that was a cleaner, sandier unit. The 15 percent, I accepted for the River Bend unit. And I really couldn't see a whole lot of difference in the lithologies between that unit and the other aquifer, so I assigned a 15 percent effective porosity to the -- to the rest.

But the one point would be that, you know, this is just a preliminary calibration. Okay? We really haven't -- we really haven't had an opportunity to do all of the tests and provide all of the simulation results that we want to, so...

DR. KONIKOW: It's in my comments. But I looked at -- there was one part in your report where you say the center of mass migrated at about .3 feet per day.

MR. FAYE: That would have been an average, yeah, given the distance.

DR. KONIKOW: But if you used that information, together with the other information, you would estimate an effective porosity of about 28 percent.

MR. FAYE: At a retardation factor of one.

DR. KONIKOW: If there's no retardation.

MR. FAYE: Yeah. And if there is retardation, which

I do believe there is, your effective porosity then would -- to maintain that same average velocity, your effective porosity would have to decrease from that number. And really, I think the way to address that, Lenny, is to, you know, take your comment and the notion of the analysis, which I thought was really on target, and just do a range of computations and look at -- look at the various alternatives. And that's what -- we'll definitely do that.

DR. DOUGHERTY: Is there information from the split-spoon samples that you referred to earlier that gives total porosities that would provide some boundary information on where we are with respect to those?

MR. FAYE: You know, I won't say no. If there -- if there are, they would be -- there would be very, very few. And they would be probably only related to the Tarawa Terrace aquifer or the River Bend unit. Okay?

DR. DOUGHERTY: Okay.

MR. FAYE: Okay.

DR. LABOLLE: Can you define how you're using effective porosity in this context?

MR. FAYE: Only in terms of the advective transport.

DR. LABOLLE: That's not what I mean. I mean, are we talking about effective porosity at the pore scale, or are we talking about some macroscopic effective porosity to scale the velocities in the contaminant transport model?

MR. FAYE: Yeah. Well, the correct answer to that is yes (laughter). And I'm not trying to be a smart-ass. I'm just saying that, you know, we're sort of stuck with -- when you do the advective transport modeling, obviously, it's a macro-scale condition. Okay? But if we have any data at all, it would be -- it would be data only on a -- it would be like a laboratory test that you could probably relate to the pore scale itself. Conceptually, we're dealing with the pore-scale concept. Okay? But in practical application, it's a macro scale. Okay?

DR. LABOLLE: Okay.

MR. FAYE: And let me go back now. We'll look at some temporal -- are there any questions at all about the PCE mass? I want to make one other comment about that computation. Pankow and Cherry, not only in their text but also in at least one journal article, they address this particular methodology. And they have some comments about the results.

One comment that they -- that they make is the fact that that particular result of 185 gallons -- actually, they give several examples, like seven or ten examples in their work. It sort of fits midway into their -- into their volumes that they've computed for -- at various -- various places and various studies. Also, they make the point that this is very likely just a very small percentage of the total PCE that's actually out there in residence in the aquifers themselves, and we believe that as well.

MR. MASLIA: Am I on here? I believe -- and Bob brought this to my attention -- there, either through some verbal information or a report that quantified that, they estimated that the ABC Cleaners were using approximately 100 gallons a month of PCE historically in their dry-cleaning process. So again, the 185 is an extremely small --

MR. FAYE: Yeah.

MR. MASLIA: -- percentage of what potentially could be out there.

MR. FAYE: Yeah. I hate to waste 60 seconds on an anecdote, but I am because it gives you a -- just clarifies the kind of things that we're dealing with. Wouldn't you believe that if someone is conducting an RI/FS investigation twice relative to ABC Cleaners that one of the things they would at least do would be to ask those folks how much PCE they're actually using during their operations or did use during their operations? No. Nowhere in the RI/FS reports, the detailed technical investigation reports, nowhere do you find any kind of reference at all as to what was happening at the source in terms of PCE use.

The report Morris referred to is something I ran across fairly recently. It was a report from the National Oceanic and Atmospheric Administration, who were looking at the impact of this PCE loss into the groundwater on wildlife and wildlife habitat in Northeast Creek. And those folks actually had enough sense to go and talk to the ABC Cleaners and ask them, "How much PCE do you folks actually use a month in your operations?" And it turned out to be about 380 liters or 100 gallons a month.

MR. MASLIA: Dr. Johnson, there's a question from the public.

DR. JOHNSON: Please. Go ahead. State your name, please.

MR. ENSMINGER: (Off microphone) My name's Jerry Ensminger. I was a resident there.

COURT REPORTER: Can you state your name again, please.

MR. ENSMINGER: Yes. My name's Jerry Ensminger. I was a resident there. I lost my daughter to leukemia. When you're talking about historical data, and especially ABC Dry Cleaners, there are a lot of variables in that site that need to be considered. And one thing is the historical information: What took place between 1965 and 1970 which involved the Marine Corps and increased the population of the Marine Corps almost two-fold, and that was Vietnam.

From 1965 to 1972, that was the heyday for dry cleaners in Jacksonville. Did anybody get the tax records from these people because PCE would have been an expense which would have shown how much they actually used? And knowing the amount of people -- every Marine that went in the Marine Corps east of the Mississippi River ended up at Camp Lejeune to go to their infantry training school at Camp Geiger.

These dry-cleaning services had trucks that went aboard base, collected these kids' uniforms at the chow halls in the morning and brought them back that night or the next morning. They picked them up. But every Marine east of the Mississippi went through Camp Lejeune. These people made a fortune during those years, and the PCE use was elevated. Thank you.

DR. JOHNSON: Thank you. Thank you for your comment; absolutely.

MR. FAYE: Claudia, could we go back a few slides to the -- there we go. Keep going and maybe one or two more; one more. All right.

These slides represent what we have at the wellheads in terms of contaminant concentration through time. Beginning in late '84 or early '85, these are our data points that we have. This is Well TT-26. This is probably the main culprit in terms of providing PCE to the water-distribution system, far and away, probably. But you can see the poor distribution of data.

Now, enter -- let's go -- let me see what we have here. That was PCE. This is the daughter product, TCE. Virtually, the analyses are for the same time. And you can see there was -- you can make a pretty good case there that biodegradation of the PCE product was going on.

DR. JOHNSON: And what's the source of these data?

MR. FAYE: Who asked that?

MR. MASLIA: Dr. Johnson.

DR. JOHNSON: What's the source of the data?

MR. FAYE: Dr. Johnson, there are a variety of sources. Some of it came from LANTDIV, the Marine -- the Navy lab. Some of it came from EPA. Some of it came from the North Carolina EPA equivalent.

DR. DOUGHERTY: Do we have any information on sampling protocols?

MR. FAYE: Only in the -- only in the latter reports, the latter analyses, which would be in 1991. We think -- have to assume that if NCDEM, North Carolina Department of Environmental Management, did the analyses or the LANTDIV people did the analyses that it probably was a respectable representation of the protocols at that time. And they've changed a lot. The protocols have changed a heck of a lot in the last 20 years, so...

DR. DOUGHERTY: Just to clarify, at that point in time, there were pumps still in these wells?

MR. FAYE: Oh, yeah. Yeah. The wells were actually abandoned formally; and that is, grouted up, pumps removed, everything like that in 1991.

MR. MASLIA: David, I have a document, again, just received. I hate to keep saying "just received," but you know the story. And, in fact, it lists many of the TT wells, and it will say "Well closed but pump still installed in the well," and TT-26, TT-23, and so on. And this is a nine -- I believe it's a '91. I believe I left it on the desk there; a '91, '92 report. It's handwritten notes. It's a document released by the Marine Corps to us. But it does indicate whether the well can be operated and whether it still has a pump or the well does not have a pump and can be operated.

MR. FAYE: You know, and that was a note from the -- from the folks at the facilities -- in charge of facilities at Camp Lejeune to the EPA contractor, who was inquiring whether or not these wells were sampleable. And almost immediately, as far as I can tell, after this contractor obtained those July 1991 analyses, those wells were history. They were grouted up. They were done.

Now, also, recently -- we keep referring to these recent revelations that we get. We have -- actually down to the -- down to report numbers, dates, sample numbers, the whole thing. We have information regarding monthly samples at Well TT-25, which was not -- which was actually right about here. And this -- in July of 1991, there was an indication that Well TT-25 was beginning to show contamination in its discharge.

And North Carolina DEM recommended that monthly samples at TT-25 be collected over the period April -- actually until the well was shut down. But the samples were collected from April of '86 to April of '87. And we're making major, major efforts now to obtain the results of those analyses. The Marine Corps doesn't seem to know anything about them. But we know -- we know the samples were collected. We know the analyses were made. We have sample numbers and report numbers. So we're trying to -- and that will fill in some of that, some of that gap.

Yeah. Also at the -- in the same documents, there were weekly samples taken on the downstream end of the Tarawa Terrace WTP at the same time, which would -- which would help Morris' efforts to -- and the network simulation efforts immensely. Again, we're trying to find those data. We know they exist, but no one seems to know where.

MR. MASLIA: Let me just qualify. Those data were -- there was a panel in September or October, convened by the commandant of the Marine Corps, and it's a published report. It's on the Marine Corps. And in Appendix or Attachment K, they list some of those data. The issue that both Bob and I have with that is that the Marine Corps commandant's panel left out -- and I'm not sure why -- any qualifiers on the data and any of the nondetects based on their interpretation.

I have requested that, and there was a letter from the U.S. Navy to U.S. EPA Region IV, transmitting the data weekly for a various number of wells with these attachments. EPA doesn't have that -- the attachments, and apparently, my last communication with headquarters Marine is they're working on finding the attachments. But that would, again, supply us with what appears to be, on the surface, very needed information because it goes from, I believe, the first week in December of '84 through about '86.

DR. JOHNSON: Bob, if I could go back to your contamination --

MR. FAYE: Oh, yes, sir.

DR. JOHNSON: -- data. I didn't see any error bars for each of the data points. And is that not done for this kind of data? If it were a tox study, you would expect to find it.

MR. FAYE: When you say "error bars," you're --

DR. JOHNSON: Standard errors, standard deviation; some sense of variability at each data point.

MR. FAYE: Well, at the very -- at the very most, Dr. Johnson, except for those supply wells that we have, that I showed you through time, the spatial maps like that at the very, very most, we have only two samples.

DR. JOHNSON: Okay.

MR. FAYE: And those are for different levels. Remember, I talked about the upper shell and the lower shell, and that's all we have there. There were -- we could do some sort of cursory analyses like that for the half a dozen samples that we have at a single site like -- but that's so dynamic, you've got biodegradation going on.

DR. JOHNSON: I understand.

MR. FAYE: I don't know what that would show.

DR. LABOLLE: How do you explain the region between the two plumes with the zero concentration? What's your interpretation of that?

MR. FAYE: That, I'll talk about in the model. Okay?

DR. LABOLLE: Yeah.

MR. FAYE: Yeah. That's after a lot of aspirin, believe me. Okay. We've got a few minutes left to talk about the model. Let's get going. I'm not going deal with the introductory material. Let's do the purpose of study.

Construct and calibrate a groundwater-flow model sufficiently representative of the geohydrologic framework and groundwater-flow conditions at Tarawa Terrace and vicinity to support fate and transport simulations. You've already seen the well locations. You know what the aquifers are and confining units.

Let's describe the model grid very briefly: 270 columns, 200 rows. That's the complete model domain. That's the inactive and active areas, 24,000 active cells. All of the active domains are spatially equivalent. The cell dimensions are 50 feet by 50 feet.

There's nine layers, and they correspond exactly to the geometries of the aquifers and confining units that we've identified. Frenchman's Creek -- could we -- could we go back to that; Frenchman -- Frenchman's Creek is a -- sorry. Frenchman's Creek is a small drain in the western part of Tarawa Terrace, and that's -- that's accommodated in the model as a drain in Layer 1, which is the Tarawa Terrace aquifer.

Northeast Creek, the whole area -- sorry, Claudia. Northeast Creek, this -- the whole area down to the midchannel line, which is our no-flow boundary, is a specified head boundary, zero altitude, in Layer 1. In the other -- in the other eight layers, it's just an active layer or an active part of it -- of the model.

DR. KONIKOW: Is that salt water at Northeast Creek?

MR. FAYE: Yes. Yes. It's not seawater, Lenny, but it's tidal. And it's definitely -- it's definitely -- it's definitely saline. Okay? Whatever that boundary is in terms of TDS or whatever you want to call salt water, I don't think it -- I don't think it quite meets that. But it's definitely saline.

DR. LABOLLE: I had noticed that the previous map you'd put up with hydraulic-head measurements, the hydraulic heads along Northeast Creek that have been measured -- or on boundaries of it --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- range from 14 to about 4 feet. And now you're putting the boundary condition on the creek of a zero head in Layer 1. How -- what kind of correspondence does that have to the elevation mapping along the Northeast Creek as far as the actual heads in -- on the creek itself, and how is that influencing the flow model?

MR. FAYE: Okay. Let me try to understand your question, which I don't completely. Are you asking: Do we actually have measurements within the various aquifers within the Northeast Creek area or on shore at wells that were --

DR. LABOLLE: Either.

MR. FAYE: We don't have any measurements in that -- within the creek area itself.

DR. LABOLLE: I'm referring to a map you showed in the previous presentation where we were looking at hydraulic heads that shows them from --

MR. FAYE: Yeah. The estimated potentiometric surface?

DR. LABOLLE: Exactly.

MR. FAYE: Yeah. Okay.

DR. LABOLLE: And I'm looking at a contour map here in one of the reports that shows a predevelopment simulation, and now I'm hearing you describe this boundary condition of a zero head along the creek. And I'm asking how does that boundary condition influence the model because there appears to be some potential inconsistency there between the 14- to 4-foot head difference along Northeast Creek in the measured potentiometric heads. And I say along Northeast Creek --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- I mean, they're interpolated from measured heads --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- taken at wells, you know --

MR. FAYE: Mm-hmm; right.

DR. LABOLLE: -- in the land nearby and the heads plotted, for example, in the potentiometric contours in one of these predevelopment simulations. And this refers directly to the boundary that you just discussed, the --

MR. FAYE: Right; right.

DR. LABOLLE: -- zero-head boundary.

MR. FAYE: Right. The -- I think the map you're referring to, the actual loop contour is 4-feet upstream of -- that shows flow toward Northeast Creek. The actual loop contour is a 4-foot contour, not a 14-foot contour. And then there's -- you're going to have to remember now, this is an interpolation, so --

DR. LABOLLE: Well, I think it was four on the downstream and then --

MR. FAYE: That's right.

DR. LABOLLE: -- 14 feet if you go up the creek, I think, if you go to the far end of the creek. Is that -- am I correct, or...

MR. FAYE: Well, that -- yeah. That's an interpolation from a point onshore at Tarawa Terrace to a further point, further offshore -- onshore at Holcomb Boulevard. So --

DR. LABOLLE: Okay.

MR. FAYE: -- this is just an estimated -- remember, I said this was a map that we were --
DR. LABOLLE: There we go.
MR. FAYE: -- we would try to put in the highest water level so that we could just kind of define for our own purposes what we thought the major flow directions were in the system as well as what the major boundaries were.
DR. LABOLLE: I can see these Xs on here are -- or the plus signs are the actual data points used in creating --
MR. FAYE: Yes.
DR. LABOLLE: -- this map.
MR. FAYE: Yes.
DR. LABOLLE: So effectively, what I'm hearing is that you don't -- actually, you don't have enough data near the creek to --
MR. FAYE: No.
DR. LABOLLE: -- just to --
MR. FAYE: No. No.
DR. LABOLLE: Okay.
MR. FAYE: This was -- this was a kriging exercise.
DR. LABOLLE: Which explains the inconsistently.
MR. FAYE: Yeah. Yeah.
DR. LABOLLE: Okay. Thank you.

MR. FAYE: We were just there trying to -- well, for example, this shows up very nicely here; this Loop 4, I mean. It definitely shows that you're looking at -- as far as the extant data are concerned and as far as this particular interpolation is concerned, you definitely have, you know, a gaining stream. And you have -- definitely have a flow toward it from the north to the south and the south to the north.

And there's, you know, an inconsistent -- this is -- this shows the inconsistency between -- you know, caused by interpolation very well. You've got, you know, this data point here. Obviously, this contour in the real world doesn't cross the river like that. But this is all of our dirty laundry, you know, that we're laying out there, I mean. And this is just for estimating and interpretive purposes. This is nothing that we would put forth as a real potentiometric surface map.

Okay, Claudia, let's go to the modeling.

DR. JOHNSON: Bob, take about five minutes, and then we will adjourn for lunch and come back and continue with what you are presenting.

MR. FAYE: Okay. I'll try to finish as much of it as I can in that five minutes, Dr. Johnson. Thank you.

That's a picture of our grid. That's the active model domain. This is the now infamous northern boundary that we talked about earlier. This is Layer 1 -- yeah, Layer 1. This is Frenchman's Creek. And that's an old -- this is an old map, by the way. This was before I filled in the rest of Northeast Creek as a -- as a specified head boundary.

There's your -- I forgot I had the map with me here. There you go -- layer tops or cell-by-cell arrays that equate directly to the corresponding geohydrologic unit arrays. And I just showed some examples that we've already seen. We're not going to repeat that.

I did play around with the horizontal hydraulic-conductivity distributions a little bit and try to differentiate a hydraulic-conductivity array for the Tarawa Terrace aquifer and then possibly -- and the River Bend unit and then possibly a different array for the middle Castle Hayne aquifer. But you can -- you can take your pick. It's, basically, I think, if you used all the data and assigned it to all the layers as far as the aquifers were concerned, you probably would not be far off.

Let's see. The horizontal hydraulic conductivity of Layer 9, I reduced strictly to 5 feet per day. And that was just based on a qualitative evaluation of the few descriptions of lithology of that unit that I had. I assigned a hydraulic conductivity of .2 feet per day to all of the confining units, and that was somewhat arbitrary but not completely.

I had a -- I had a -- one aquifer test, a good aquifer test actually using an observation well. Where the observation well was -- actually both the observation and pumping were partly screened across the Tarawa Terrace confining unit. And it came out to be a very low horizontal hydraulic conductivity, and so -- I think of like 2 feet per day. So I just took an order of magnitude less than that and assigned it.

And I want to make a comment, too, about the model that I hope you'll keep in mind through the rest of the discussion. This is just -- this is a preliminary calibration that we got to where we thought we were actually getting some reasonable results.

We haven't really been able to completely test the flow model or for sensitivity or the advection transport model for all the results that were -- that we'd really be interested in. You could look at it on the other side. There's not a lot of sense spending time on that if we have a fatally failed model, so that will -- hopefully, we'll find things like that out from your panel comments.

And I think the vertical anisotropy of -- was 10 percent that I assigned to all layers. The specific yield of the Tarawa Terrace aquifer, I assigned as .2. The rest were -- was point -- well, the rest doesn't -- don't count. That's the only unconfined aquifer.

The storativity of the model, Layers 2 to 9, I assigned as five times ten to the minus four. I have no storage coefficient data for any of the aquifers, okay, with the possible exception of one or two measurements that I kind of wonder about in the Tarawa Terrace aquifer.

But as far as the -- as far as the other layers are concerned, two to nine, the storativity is constant at .0005. The specific storage of all the model layers is simply the thickness determined from the layer geometry divided into that number, and that's our specific storage that we assigned to the model in a cell-by-cell array.

Okay. The calibration strategy. Dr. Johnson, you ready?

DR. JOHNSON: Let's stop right here.

MR. FAYE: Okay.

DR. JOHNSON: And we will resume with your presentation because it's really important that we understand what it is that's been done and what you're proposing to do. Also, Mr. Maslia has prepared some responses to your premeeting comments. And following Bob's presentation, Morris, I'd like for you to put that in front of us.

Following that, we will then begin discussing -- and it may be simply something that reflects my own personality. But they gave us eight questions to answer, and I propose to drag us through one by one because they took the time to prepare them. And they really need your advice and insight on many of those questions, it seems to me.

So that's kind of how I see -- how we proceed after lunch. Does anyone want to do it differently, or...

(No audible response)

DR. JOHNSON: Okay. Well, be back here promptly at one o'clock because that's when we will resume. And, Morris, any questions, any announcement about the lunch arrangements?

MR. MASLIA: Again, if you want to eat at the Century Center motel or hotel where you're staying -- I've eaten there before. It's fine. I'm still around. The bus is there. I would ask that the panel members get the first bus out there because the bus seats 12. We're going to make two trips and then anyone else. Or there are other establishments around here. But we've allotted 11:45 to one -- an hour and 15 minutes or so.

Obviously, I know Dr. Johnson would prefer to get out by five today. Today's not as critical as I'm sure people who are catching a plane tomorrow afternoon, so we'll just play it by ear then. But do try to get back as promptly as we can.

(Whereupon, a recess of approximately 73 minutes was taken.)

MR. FAYE: All right. Let's continue with the discussion where we left it off. Let's talk about the model-calibration strategy, if we could, for just a minute. The first -- the first effort was to develop a conceptual model of groundwater flow. Then we wanted to define a predevelopment condition as well as we could, knowing that it was, at best, an estimate of predevelopment conditions -- and when I say "predevelopment," that's prepumping -- and simulate that as well as we could, but knowing that we would have to iterate back and forth between a transient simulation and a predevelopment simulation in terms of changing arrays and whatever; but any -- to see if the simulations that we -- that we obtained for the prepumping condition would generally support the conceptual model and then attempt to do the same thing basically with transient simulations.

And we would have to choose the period of interest for the transient simulations as a period when we had as many water-level data as we possibly could to give us some insight into how good or how poor our transient simulations were or are. And essentially, that's -- with a few sort of rather cursory advective transport simulations, that's -- that is where we are now in the modeling effort, groundwater-flow modeling effort.

The conceptual model that we came up with -- and I've already alluded to all of -- to most of this. Your groundwater flow occurs as -- groundwater recharge occurs in the highland areas and flows down gradient toward Northeast Creek and Frenchman's Creek and New River. The long-term average annual recharge is 12 inches, and that is -- that's borrowed strictly from several North Carolina State and USGS reports. That seems to be the favorite number that folks -- that folks apply to this part of the North Carolina coastal plain in terms -- could you go back, Claudia -- in terms of recharge to the water table.

The Tarawa Terrace area is not dissected to a large degree with drainage, with streams. Frenchman Creek is essentially the only prominent creek in the area. And my particular feeling is that recharge could probably range from 12 -- net recharge could probably range from 12 to 16 inches per year in that area. If you look at the maps of long-term average annual rainfall and potential evapotranspiration for this part of Onslow County in North Carolina, you're looking at a difference between the two numbers of about 16 inches.

So somewhere between 12 and 16 inches per year is the number that we'll probably end up with as an estimate of long-term average annual recharge, and that's one of the things that we want to continue to -- one of the issues that we need to continue to address in the modeling that we haven't done yet.

And the other third element of the conceptual model is -- and I've already suggested that previously -- that the potentiometric surfaces in all of the aquifers are relatively similar. And if you'll recall, that large area map that I showed earlier that we had some discussion about here, if we just take the piece out of that that reflects Tarawa Terrace, you can see the data points. You can see the contours, and now these represent -- these are data points that represent the highest water levels at a particular point or the oldest. And for the most part, they're the highest.

Okay. All of these points here in the western part of the study area, these relate to us; fairly coarse and crude studies of underground-storage tank removals. And we selected these water levels regardless of season, regardless of -- regardless of season. There's probably some fairly inherent inaccuracies in there because of the lack of data that we had at a particular point. But to be honest with you, I was just so happy to have a data point in a particular place, I just -- I selected it and just kept in mind the caveats regarding the accuracy of the point.

But that's the map in detail for Tarawa Terrace that we generated, our estimate of the prepumping potentiometric surface. And if you recall, I mentioned earlier in the context of the framework discussion, that the monitor wells and bore hole logs that we had were concentrated in the southern part of the Tarawa Terrace area. That's actually in a shopping center area there where there's a -- probably a half a dozen or so RI/FS operations going on. And then here, of course, are the monitor-well data and -- related to the ABC problem.

So that's our conceptual model, the hydraulic characteristic data that we described earlier, and the arrays and whatever. We applied that to Modflow, Modflow 2000. We have the drain -- is that the upper Castle Hayne? That is -- that's either -- well, that could be the River Bend unit or the lower unit. It's probably the River Bend unit. There's our simulation. You'll recall now that -- darn it. Claudia, can we go back, please; forward one. There we go.

Recall that in the uppermost layer that Northeast Creek out to the midchannel section is all a specified head of zero elevation. You can see that, for the most part, at 12 inches a year recharge, with Frenchman's Creek in there as a drain -- and this is -- this is three or four layers below the Layer 1. You can see that the discharge to Frenchman Creek is still occurring. It's well defined. You can see that the -- that the head declines from the highland areas toward Northeast Creek and toward New River, toward Frenchman's Creek.

The flow lines are just as we had hoped in the conceptual model down toward the southeast and the south toward Northeast Creek. So for all intents and purposes, given the sort of cursory data and approach that we used, the simulation of the prepumping conditions, I think, supported our conceptual model quite well, and we were satisfied with that.

So let's take another look. No. That's the simulated potentiometric surface in the lower Castle Hayne aquifer. So we've essentially gone from Layer 1 to Layer 9. And as you can see, just as the conceptual model indicated, we're dealing with a very similar -- very similar directions in terms of flow lines and a relatively similar potentiometric contours and slightly higher heads; slightly lower heads in the highland areas; slightly higher heads in the discharge areas.

This is a scatter diagram of those data points that I just told you about, wherein -- which we used to construct our prepumping surface. This is just a direct one-to-one comparison between the simulated head and the observed head with -- and the observed heads, as I said, they have some bit of baggage associated with them. But it's not -- I think that's quite good actually. The variance on this, I think, was slightly less than one; the comparison between the observed and the simulated heads, .96.

There we are. Okay. There's our simulated predevelopment budget, the recharge -- Claudia, please. Thank you. She's getting used to me.

The recharge was 1.9 CFS, and if you want to distribute that to the 1400 acres for a year, you'll find that you've got 12 inches a year. Discharge to Frenchman -- we want to distribute that then as discharge. Discharge to Frenchman's Creek was .6 CFS, and discharge to Northeast Creek was 1.3 CFS. And this is nice and easy in the model. It tells you what you're discharging to drains, and it tells you what you're discharging to specified heads. So it's sort of a no-brainer after the computation is done.

All right. We'll talk about the transient simulation. I went into some discussion in the report regarding the quality of head data that we were dealing with, with respect to creating a transient simulation, developing a transient simulation. The vast, vast, vast majority of those head data occur between 1978 and 1985. And as best as I can understand it -- and I would be the first to admit I don't completely understand where the head data come from or how they were measured, I guess, is a better way to say it -- these are air line measurements.

And there was apparently a monthly requirement at Camp Lejeune to obtain what they called a static level and a pumping level at each of their supply wells. And we have data, as I said, from Tarawa -- for Tarawa Terrace for almost all of the supply wells. There's data gaps, but all of the supply wells are in the mix from January of 1978 to about April of 1986.

And -- so we used the static-water levels as a calibration standard, and we didn't try to adjust them. We just took them as they were. And you'll see in a slide here that, basically, these levels -- you know, for static levels, they're sort of all over the landscape. We don't have any notion of the accuracy of the gauges that they used. I made some -- I made some estimates of that in the report. We don't have any notion of the accuracy of the gauges that were used to obtain these measurements.

We do know that the gauges were calibrated to the depth of the air line in the well. We don't know if there was a standard. For example, when you obtain a water-level measurement, you repeat the measurement until you get a consistent result within some predetermined error. We don't know if that was done. We don't know whether this measurement was just a one-time shot. We don't know how much time elapsed between turning. If it was indeed a static measurement, we don't know how much time elapsed between terminating the pumping at the well and collecting the so-called static level. We don't know any of this.

We're on track to answer some of those questions when we have some discussions with the folks at Camp Lejeune. But I just want to outline the uncertainties related to these data. So -- and we selected -- because Morris and Mr. Bove are -- you've already heard this morning of the time reference that they're interested in, we selected one-month periods as stress periods.

So between -- and we extended the transient simulation through 1994 because, in '91, '92, '93, and '94, we had several dozen accurate water-level measurements that were obtained throughout the Tarawa Terrace area in various monitoring wells that were related to several RI/FS investigations, ongoing investigations. So rather than stop the transient analysis at, like, when the wells shut down in 1987, we extended the analysis without pumping at Tarawa Terrace up through the end of 1994 to take advantage of those additional measurements.

Let's go through a number of details. So that results in 204 monthly stress periods. Because I think the 12-inch standard -- the recharge of 12 inches per year is somewhat on the low side -- I had some difficulties with cells drying up in the upper two layers of the model, and this caused some convergence problems during the transient simulations.

So I just tweaked the recharge for that particular stress period; just would start it at 12, and I'd increase it to 13 inches a year, maybe 14 inches a year to maintain a continuance convergence for each stress period. And I had, ultimately, a range of recharge rates between 12 and 16 inches per year that I ended up using for a month. Those were monthly rates. I think the average recharge that I ended up with between -- for the period January '78 to March -- or December of '86 was like 12.7 inches per year.

We had data from a consultant's report that listed the well capacities, the active supply wells, in 1979. And those are the capacities that we identified and used throughout the transient analysis. We also had annual -- annual average daily pumpage rates. Actually, these were -- these were treated-water rates from the Tarawa Terrace WTP on an annual basis, so -- that were reported by the USGS in one of their reports.

So, for example, in 1982, for example, we would -- we had a number of, like -- I don't know. I'll shoot at it -- maybe, like .93 MGD. So for the whole year, 1982, the average pumping rate was like .92, .93 MGD. So we had that number, and we had well capacities.

We also had a crude idea of how Tarawa Terrace operates their well systems. It's called a rotating system. They would -- at a particular well, they might pump for eight hours a day, and the well then would be on standby for like 16 hours a day. And they would rotate that type of a schedule through their whole active supply well network. And, of course, we don't have -- we have no data indicating the period of pumping for any particular well for any particular day.

So -- but I did know -- I did -- unless these operational records that had -- that we have copies of that include these static water-level measurements. Unless they indicated that, say, for example, Well TT-26 pumped all month or Well TT-52 was down for two months for maintenance or something like that, I made sure that the actual rate that I used for simulation in the model was less than the capacity and also that all of the wells pumped for a particular stress period for a particular year equaled the rate -- the average daily rate reported by the USGS. Those were the only two constraints that I had.

And a secondary constraint were the operational records. So if a -- if the records told me that a particular well did not pump for a certain three months in 1984, I honored that. I took that pump off-line. I didn't -- that well off-line. There was no water discharge for that.

So those are basically the three constraints that I used to put together a pumping schedule for 1978 through 1986. And then, of course, when the wells were all shut down in March of '87, then all the wells were turned off. And the Tarawa Terrace -- then the aquifer basically recovered to pretty much its simulated predevelopment condition in a very short period of time.

Okay. I think that covers that all.

DR. WALSKI: I have a question.

MR. FAYE: Sure.

DR. WALSKI: On the monthly recharge rates, did you take into account anything about whether it was a wet month? dry month? Like, some --

MR. FAYE: No.

DR. WALSKI: -- months you had hurricanes hitting with --

MR. FAYE: No.

DR. WALSKI: -- huge flows --

MR. FAYE: No.

DR. WALSKI: -- and some with none.

MR. FAYE: That's a great question, Tom. No. We haven't had time to do that. We're in the process of having discussions, actually. And that's something that we would very much like to hear from you -- from you-all, from the panel. What we have in terms of meteorological data: We have pan evaporation data so -- and on a monthly basis. We have rainfall data on a monthly basis for our whole period of interest, basically from 1950 to 1995, something like that, as much as we want. Okay?

So we have that all on a monthly basis. And once we can make a decision about a long-term average rainfall -- rather long-term average recharge, whether it's 14 inches or 13-1/2 or 15 or whatever it is, we're trying to devise a scheme to use this meteorologic record to adjust our recharge on a monthly basis. That's clearly, clearly on the radar screen, but as I said earlier, these simulations were pretty basic. I mean, we're just trying to get a handle on things, and we haven't done that. Okay?

And that's kind of why I felt free to just kind of tweak recharge during a stress period when I had a convergence problem, just boost it a little bit to a particular higher rate -- a little higher rate and achieve convergence and go on because I wanted to see what the end product was. Okay?

DR. KONIKOW: Did you give any thought to the possibility that recharge may be greater than the natural recharge in urban areas where you have lawn watering and --

MR. FAYE: Yeah.

DR. KONIKOW: -- leaks and --

MR. FAYE: Leaky pipes --

DR. KONIKOW: -- car washing and --

MR. FAYE: Yeah, we have; we have. And any comments that you-all have about how to deal with that -- there's a really good paper -- I can't quote it right now to you -- that really goes into a tremendous amount of detail on this and using GIS to look at the lawn areas and the paved areas and everything else and --

DR. KONIKOW: Are they on septic tanks, all the houses --

MR. FAYE: They were.

DR. KONIKOW: -- housing developments?

MR. FAYE: They were originally on septic tanks.

DR. KONIKOW: That's a source of recharge.

MR. FAYE: Oh, absolutely; for quite a while. And they're on a collection system now, but for --

DR. KONIKOW: A leaky collection system, no doubt.

MR. FAYE: Probably; yeah. And the water supply, the pressurized pipes are probably leaking as well in different places. Yeah. Yeah. Yeah. We've thought about all of that. We haven't really acted on it. We're in the process of trying to find -- figure out how to act on it.

DR. KONIKOW: Now, you have a lot of cells going dry, I saw, in your simulation --

MR. FAYE: In the -- in the -- yeah --

DR. KONIKOW: -- if you're concerned about that.

MR. FAYE: In the -- in Layer 1 and Layer 2 in the highland areas; yes. And that -- and I know for a fact that that actually is true in the real world. These -- those cells would only be wet, seasonally wet. Okay?

DR. KONIKOW: Yeah.

MR. FAYE: The water table --

DR. KONIKOW: Did you -- did you run Modflow with the rewetting?

MR. FAYE: I did, and it just caused a tremendous amount of convergence problems. I'm going to revisit that again.

DR. KONIKOW: Have you thought -- you were using monthly stress periods, but I believe you're also using monthly time steps. Have you thought of cranking down your time-step size?

MR. FAYE: Oh, to a smaller size?

DR. KONIKOW: Yeah. In other words --

MR. FAYE: Yeah.

DR. KONIKOW: -- you could have monthly stress periods but --

MR. FAYE: I did that. I did that. I did that when I rewet it, when I played around with the rewetting feature. And it just -- I was not -- I spent a lot of time. I was not successful. I'm hoping -- I'm hoping -- well, I very strongly believe that the baseline recharge that we come up with, this long-term average annual, is going to be somewhere probably around 14 inches or so. I'm hoping that when we're dealing with that extra recharge plus, you know, we'll be starting out as a prepumping condition. So we'll have antecedent conditions taken care of pretty well, right from the get-go, in early 1950s.

I am hoping that we -- we're still going to have dry cells. I'm hoping it's not going to be a big issue. And I hope, maybe, we can try to do some rewetting in that context, but the rewetting was not at all successful, not at all.

DR. KONIKOW: Maybe, with smaller time steps, it would work better.

MR. FAYE: It could. It may. I definitely did try that, but I'll definitely try it again.

DR. KONIKOW: Yeah.

MR. FAYE: I'm open for any -- I'd like to have that rewetted. I really would.

DR. LABOLLE: My experience has been, like Lenny's suggesting, decreasing the time step --

MR. FAYE: Right.

DR. LABOLLE: -- but you can also -- if you want to get that to converge, another helpful item is to use a solver with a dual-convergence criteria. So in other words, you'll have convergence criteria for the outer, nonlinear loop, in which things are --

MR. FAYE: That's the PCG solver.

DR. LABOLLE: -- which you can -- which you can -- no; not the PCG. It will be the -- actually, it will be one of the latest solvers that Mary Hill released. I forgot which one it was. It's the only one with the dual-convergence criteria.

MR. FAYE: Okay.

DR. LABOLLE: I can send you one for the PCG if you want. I have one.

MR. FAYE: Oh, that'd be great.

DR. LABOLLE: But the nonlinear loop, you set its loose convergence criteria, and you can set the linear solver. You know, it's a very strict convergence criteria, and the combination of the two allows you to --

MR. FAYE: To rewet?

DR. LABOLLE: No. What it allows you to do is to solve a confined flow problem as an approximation essentially is what you end up doing because really you're solving a confined flow problem --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- at some point in time. And you're looping nonlinearly, but you --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- at every point, you're making a confined approximation, essentially. Anyway, that allows you to converge. That's one issue. And another comment I have is on your calibration, recognizing that it's preliminary, but I noticed that if I were to probably fit a line through the scatter points there that it would probably have showed less of a gradient. And I think that --

MR. FAYE: You mean the scatter line?

DR. LABOLLE: Yeah; exactly --

MR. FAYE: Yeah.

DR. LABOLLE: -- and then the one-to-one.

MR. FAYE: It would --

DR. LABOLLE: And so the implication being that your heads up here --

MR. FAYE: Mm-hmm -- are too low?

DR. LABOLLE: -- out in front are lower than --

MR. FAYE: Yeah.

DR. LABOLLE: -- you expect, and --

MR. FAYE: Yeah; yeah.

DR. LABOLLE: -- bringing them up --

MR. FAYE: Yeah.

DR. LABOLLE: -- relates to this --

MR. FAYE: And that's the --

DR. LABOLLE: -- wetting and drying --

MR. FAYE: And that's the recharge problem too.

DR. LABOLLE: Exactly.

MR. FAYE: That -- I know that, and I'm hoping, again, like I say, that the baseline recharge, whatever we actually end up with is going to be more than 12. And it'll take -- and you'll see on the -- you'll see on the scatter diagram for the transient analysis the same kind of thing, I believe, although it's only the latter part of it up toward the top where we have some really decent data that it shows up. But I'll point that out.

Here's the capacity data that we used. This is from the consultant's report, that I mentioned, in 1979. And I violated this with respect to one well. After like 1980 or something like that, I violated that with respect to TT-53 or 52, I believe -- it's in the report -- just because I couldn't find any water anywhere else. I needed water to match the USGS criteria.

It was one of those several periods -- several month periods where several well -- two wells were down. And I just needed that extra water to match that annual rate, and so I violated that criteria at that time for Well TT-53, I believe it was, or 52. But that was the only time.

All the other times, those capacities were honored to the limit. In other words, unless I had a note that the well was being pumped for 24 hours, all of the capacities that I used in the model to pump were less than those recorded there and in many cases substantially less.

DR. POMMERENK: Bob?

MR. FAYE: Yes.

DR. POMMERENK: The map shows a lot more wells than you indicate here.

MR. FAYE: Yes.

DR. POMMERENK: Do you have the data for the other wells as well?

MR. FAYE: A lot of them we do, Peter.

Can we go back to that one, Claudia. Is it in -- is it in this module where I showed the -- yes. Keep going. There it is.

Yeah. Yes. Yes, Peter. These TT-45, TT-29, TT-28, 2-A, TT-55, TT-27 were all out of the -- out of operation by 1978. Okay? These are some of the original wells along with TT-26 that originally supplied the Tarawa Terrace network water supply treatment plant: TT-27, TT-55, 2-A, 28, 29, and 45. And in the very beginning of Tarawa Terrace, from about 1952 to 1961, there were actually two wells, and Tarawa Terrace call -- or Camp Lejeune called them six and seven that were off the reservation. They were off-campus. They were about a mile and a half or so up Bell Forks [sic] Road.

And what the operation was there, I have no idea how the water was actually connected to the network at Tarawa Terrace. I don't know. But they're officially listed as Tarawa Terrace supply wells in the records, numbers six and seven. And they're actually located on Bell Forks Road, and I have a crude map showing where they were located.

So there's another actual two wells that actually don't show up here for the very early supplies. Now, you have to remember those -- all of these wells were off -- out of the system by about 1961 -- those ones. Except for TT-26, all of those wells were out of the system by 1961 or '62. Okay?

DR. KONIKOW: Why were they out of the system?

MR. FAYE: Pardon?

DR. KONIKOW: Why were they taken out?

MR. FAYE: The early wells, Lenny, the way they were constructed had a tendency to sand up. The maintenance was a horrible situation. They had that, plus, I believe, there were some network problems because of the lack of proximity to the wells, to the WTP. The WTP is located about right there.

And so they just -- they took those wells out of the system. They were low producers. I have records in 1959, indicating that they were very low producers and -- except for TT-26. And so in '61, they came in and put in a number of additional supply wells and took those all off-line, abandoned them.

Thank you, Claudia.

DR. POMMERENK: I have another question on that table that you showed earlier.

MR. FAYE: The Von Oesen table?

DR. POMMERENK: No; the capacity table.

MR. FAYE: Yeah. Could you go back.

DR. POMMERENK: According to those numbers, they would have to meet their one MGD daily demand to operate --

MR. FAYE: Easily; easily.

DR. POMMERENK: -- three wells for 24 hours?

MR. FAYE: Mm-hmm; easy.

DR. POMMERENK: Or let's say six wells for 12 hours --

MR. FAYE: Yeah.

DR. POMMERENK: -- because the state of North

Carolina doesn't allow you to run your --

MR. FAYE: Right.

DR. POMMERENK: -- wells 24 hours a day.

MR. FAYE: Right. Well --

DR. POMMERENK: So how did you determine in your model which out of those seven wells -- did you just have them all run at a, you know, prorated capacity?

MR. FAYE: No. What we had, Peter -- we actually had copies of tables from Camp Lejeune of their operational records. Okay? And the various columns of these records would show a pumping level, a static level, a pumping rate, operational notes about the well, whether the well was down, whether the well was -- where the pump was being replaced, things like that. And we have those on a monthly basis from January '78 through March of 19 -- or April of 1986.

So the pumping schedule that is used in the model for each of the 204 stress periods honors those operational records 100 percent in terms of what wells were operating, what wells were not. I could see that what I just said is bothering you. What is that?

DR. POMMERENK: No. I'm just wondering. So that's in the simulation. And I'm not a groundwater modeling person, but the simulations of those wells that you determined according to that operating schedules were operated --

MR. FAYE: Mm-hmm; at that month.

DR. POMMERENK: -- for the whole month.

MR. FAYE: Yeah. I had to. Yeah.

DR. POMMERENK: Okay.

MR. FAYE: That's our -- that's our minimum --

DR. POMMERENK: And at that capacity?

MR. FAYE: No, no, no, no; because, I just said, the wells rotated. They were, like, on-line eight hours a day and off like 16. So if you -- if you use that capacity --

DR. POMMERENK: You were just --

MR. FAYE: -- you're assuming a 24-hour pumping period.

DR. POMMERENK: No. It's understood. Thank you.

MR. FAYE: Okay. Okay. So that's what I said. The pumping schedules in the model honor those capacities, such that the rate was always less --

DR. POMMERENK: Okay.

MR. FAYE: -- than that capacity.

DR. POMMERENK: It's understood. Thank you.

MR. FAYE: Okay. And I mentioned that the USGS gave us average daily rates for various years. And the -- our -- the pumping schedule, Peter, also honors those rates from 1978 to '86. And then '87, you know, everything went to hell, and they shut it down.

And I mentioned the static water-level data. This is -- this is Well TT-26. This is what these data look like. These are the static measurements, unvarnished. That's what they are, and that's typical of all of the so-called static measurements for all of the supply wells.

Okay. Given the schedules, given the data that I've talked about, that's the scatter diagram for the transient analysis. And these data here -- oh, why do I do that? Thank you, Claudia.

These data here are -- for the most part, a lot of these or the majority of these are the monitor-well data that we had for the early nineties in various parts of the -- of Tarawa Terrace. Almost -- and these are all of these so-called static water levels that we just discussed.

These are the accurate measurements here. And we have a situation where, for example -- and I don't understand this at all. Like, for example, like, at TT-30, which is near TT-26 and TT-25, all of a sudden in, like, about 1980, the static water levels just go up and stay there. And the well is running. The well is operating, and I don't know what happens. Then it just -- water levels rise, and it stays there. Not only is that pump -- is that well operating, but it's near two other operating wells. And yet -- but those numbers are in there. We didn't -- I didn't selectively disregard any of the data at all. It's all there.

DR. JOHNSON: Bob, you need to kind of wrap this up, please.

MR. FAYE: Okay. We're almost done. And I'll just show you a couple of the results. This is TT-26. That's the observed -- so-called observed static and the simulated. There's TT-31, -52, -67. And there's the stress period '84, when TT-23 was operating and just very rapidly that -- and we've just done some very preliminary advective transport simulations. And let me go through that.

There's our water budget for the stress period '84. There's our recharge. It was 12.8 inches a year, what went into storage. That's induced recharge from Northeast Creek, which would have been brackish water; our well pumpage, and that honors the USGS rate for 1984; the discharge of Northeast Creek; discharge of Frenchman's Creek; and change in storage.

Advective transport, I just basically did several things. We -- I seeded the cells or one or two cells right next to ABC One-Hour Cleaners to see where they would end up. Because of the -- because of the contaminant extent that went north and west of ABC Cleaners that we saw on the maps before lunch, I put particles in 600 feet west of ABC Cleaners along Lejeune Boulevard. That's State Route 24, and I looked at the time of travel to the Tarawa Terrace supply wells of interest. And I came up with an explanation for the occurrence of PCE at Well TT-23, which is that isolated section to the south that we looked at in the maps earlier.

When we seeded the particles right in the immediate vicinity of Tarawa Terrace -- of the ABC One-Hour Cleaners, all of them were captured at TT-26; everything. The -- none of the other supply wells captured anything for this particular stress period '84, which relates to December of 1984. When we went a little bit west of ABC One-Hour Cleaners -- and this is after 10,000 days, by the way -- indeed, TT-23 captured particles that were seeded west of the ABC Cleaners.

DR. LABOLLE: Bob, are you running the hydraulic static then? Because you keep mentioning the stress period in '84, but then you run it for 10,000 days.

MR. FAYE: Yeah.

DR. LABOLLE: Can you elaborate? So steady-state hydraulics, transient?

MR. FAYE: The gradients, velocities, and whatever relate to that one stress period, stress period '84.

DR. LABOLLE: That would explain probably the sole capture of contaminants in a single well.

MR. FAYE: Well, actually --

DR. LABOLLE: If you consider all the pumpage, you tend to have things --

MR. FAYE: Yeah. It could bounce around. Yes, it could; in reality, yeah. I also did it for other stress periods, but I came up with slightly different configurations in terms of drawdown from the, you know, in the system. And TT-26 captured everything, always captured everything when -- but, again, that's a simulated of continuous pumping. But it captured everything that I put in right in the immediate vicinity of ABC Cleaners. It captured everything. It always went there.

DR. DOUGHERTY: Were these all seeded in the top layer?

MR. FAYE: Some of them were. One experiment seeded Layer 3, which is the River Bend unit. And that's where a lot of the contaminant was -- has been observed. And I also seeded Layer 5, which is the lower unit of the upper Castle Hayne aquifer. And there was a little bit of contamination observed in that layer as well from the field data. So I seeded both layers.

DR. KONIKOW: Why didn't you seed layer -- the top of Layer 1? That's where the contaminants reached the water table.

MR. FAYE: Yeah. The -- that's a good question. The -- at that time, the Tarawa Terrace, when the data were collected, all of the -- all of the contaminant was below that particular layer. And that was -- that was when I was having problems with the cells drying out too, Lenny, in Layer 1. And that's up in the highland areas with Layer 1 and Layer 2. So I ended up -- I ended up seeding Layer 3.

DR. WALSKI: The fraction of the time was 26 on? Is it run like 80 percent of the time, or did it run 70 percent of time on average?

MR. FAYE: That, I really don't know, Tom. All I know that it probably rotated --

DR. WALSKI: Okay. So --

MR. FAYE: And so didn't run 100 percent of the time.

DR. WALSKI: So therefore, you can explain possibly some of this water getting past it by the fact that, if you took real, like, hourly time steps for a change, the hydraulics would then shoot past it and --

MR. FAYE: And that's right; that's right. That's right. And there's even a better explanation, I think. Okay? And that's this right here. If you seed -- there's another well down here, TT-54, right here. And TT-23 is actually right here, and if you look at the capture zones of TT-26 and TT-54, you can see right in this area that they're very close to one another. So when the well -- when TT-26 is shut down for any reasonable period of time, probably the capture zone for TT-54 moves over into part of the capture zone for TT-26.

Also, this is a highly contaminated area right in here. This is a much less contaminated area here. So even if this situation here persisted through time constantly, I think you may also have had some exchange of mass along concentration gradients from the highly contaminated area to a lesser contaminated area. And it would end up in the capture zone of TT-54.

Now, you say, how did well -- well, this -- you have to understand that TT-23, at best, only operated for about a year. And TT-23 is right here. And in the DPT analyses that we have, there was a low-level PCE contamination throughout all of this area here.

So my conclusion was that one possible explanation for the occurrence of PCE at TT-23 was not that TT-23 pumped for six months and was able to capture PCE that was in the general vicinity of ABC Cleaners, but rather over a period of time -- TT-54 began operation in 1961. But rather over a period of time, you had intermittent capture of PCE by TT-54 that ended up creating this low-level contamination in this particular area of the Tarawa Terrace campus or housing area.

And then in 1984 when TT-23 was actually turned on for a short period of time, there was a resident PCE in the aquifer that was induced into the well. That's one -- that's my explanation, and I'm sure there's others. But that's my explanation for the occurrence of PCE in Well TT-23.

DR. DOUGHERTY: Quick question. In terms of -- I want to connect this one to the pumping capacity chart from Van Oesen. Looking at those capacities for the late seventies, it appeared that if I summed up the capacities for the TT-26 area, there are the three wells up there --

MR. FAYE: Mm-hmm.

DR. DOUGHERTY: -- and then for the cluster that's down in the development that there was a significantly larger net capacity for the southern cluster than the northern cluster --

MR. FAYE: No.

DR. DOUGHERTY: -- is that accurate? I mean, it was a partial record.

MR. FAYE: It's as accurate as I know it.

DR. DOUGHERTY: No. What I'm saying is my assessment, since I only saw this table rather than the entire simulation set of data. In terms of what you simulated, did you actually have twice as much pumping from the southern cluster of wells than from the northern cluster? Is that roughly the division?

MR. FAYE: Oh, I see; because of the -- because of variations that I made in the pumping schedule to honor those two criteria that we talked about; yeah.

DR. DOUGHERTY: Because of capacity --

MR. FAYE: Yeah. Mm-hmm. And -- but, again, now, Dave, you have to understand that there would be months when these -- some wells were out of --

DR. DOUGHERTY: Sure.

MR. FAYE: -- operation. So I had to increase the pumpage at other wells to make sure I could maintain that rate.

DR. DOUGHERTY: No. I understand. I've got that right. I got how it worked.

MR. FAYE: Great; okay.

DR. DOUGHERTY: But I'm just trying to get a sense for -- a simplified sense because there's an awful lot of material here.

MR. FAYE: Okay.

DR. DOUGHERTY: Basically, you're pumping twice as much down here, generally speaking --

MR. FAYE: Right.

DR. DOUGHERTY: -- than up there?

MR. FAYE: Right. But if you -- and I -- what I also looked at the simulated capture zones for all of those wells. And they're all deflected up to the northwest except for TT-54. Okay? These wells down in this, they're all deflected up here --

DR. DOUGHERTY: Mm-hmm.

MR. FAYE: -- rather than giving any competition to TT-54 or TT-26 up there.

DR. DOUGHERTY: Mm-hmm.

DR. LABOLLE: Did you look at the sensitivity of the simulated capture to vertical hydraulic conductivity at all?

MR. FAYE: No; haven't done that at all. It's on the radar screen; just there's all kinds of sensitivities that we need to deal with.

DR. LABOLLE: Yeah. It's been my experience in situations like this that it tends to be highly sensitive because what will happen is that if your source is seeded in Layer 1 and your vertical hydraulic conductivity is decreased, then the contaminant's going to migrate along more -- not in the ambient gradient, but more of an ambient gradient --

MR. FAYE: Right.

DR. LABOLLE: -- than is affected by the --

MR. FAYE: Right.

DR. LABOLLE: -- by the actual pumpage in the deeper layers, assuming these wells are screening deeper.

MR. FAYE: Right. Well, also, too, we're dealing with, in the real world, a heck of a contrast in densities. I mean, 1 to 1.6 and that -- none of this shows up in any of that simulation there. I mean, that's just strictly advective transport.

Thank you very much. And I'm sorry that -- oh. Okay.

DR. KONIKOW: When you talk about a density contrast, you're talking about --

COURT REPORTER: Please get on your mike.

DR. KONIKOW: When you're talking about a density contrast, you're talking about pure phase?

MR. FAYE: Yeah; absolutely; yeah.

DR. KONIKOW: But we're not looking at the movement of the pure phase, are we?

MR. FAYE: No. No. But, I mean, that's just -- I know it's a DNAPL. Okay? And that's what -- that's what the -- that's what it is: 1.6 in the laboratory.

DR. LABOLLE: But not at these concentrations.

MR. FAYE: No.

DR. DOUGHERTY: I wonder if the hydrodynamics will drive it.

DR. LABOLLE: Only near the source --

MR. FAYE: Right.

DR. LABOLLE: -- might we have some kind of density effects.

MR. FAYE: And most of that is actually in the -- I mean, there is no -- the almost free product stuff is in the unsaturated zone at the source. And there's a map in your report that shows that.

DR. JOHNSON: Well, thank you very much for your presentation, and --

MR. FAYE: Well, thanks for your forbearance.

DR. JOHNSON: -- also thanks to the questions from the panel. Let's proceed. Morris, you had prepared some responses. Yes, please.

DR. CLARK: I had one question.

DR. JOHNSON: Of course.

DR. CLARK: We had a side conversation before, earlier today, about the other sources of groundwater contamination that existed in the Camp Lejeune area, and I thought it might be useful for the panel to hear about some of that.

MR. FAYE: You mean, like, in the Hadnot Point area?

DR. CLARK: Well, in the Hadnot Point area.

MR. FAYE: Am I going to steal your thunder on that, Morris?

MR. MASLIA: No; no.

MR. FAYE: Okay. Yeah. I'd be happy to as long as -- the -- as Morris mentioned this morning when we first started the program, we deliberately chose Tarawa Terrace because, believe it or not, it's the simplest system that we had to deal. Okay? As he said, there's one source, and it's an identified source as far as the contamination of the groundwater is concerned.

If you go south to the Hadnot Point area, you're dealing with dozens and dozens of sources of contamination, some relatively small, some off the radar screen, that have contaminated groundwater in a big way. A number of these sites have RI/FS operations ongoing right now in terms of remediation. We're looking at a lot of TCE, a lot of BTEX. It's kind of a mess. Okay? You're looking at -- you're looking at surface sources. You're looking at buried sources.

You face the possibility of -- you face the possibility of a particular supply well capture zone collecting contaminants from several sources very easily. So that's an exceedingly complex condition to try to do what we're trying to do. And you sort of have to crawl before you can walk. And our thought was if we can be reasonably successful, create a technically defensive -- defensible product at -- ah, a Freudian slip -- product for Tarawa Terrace, then we may have a shot at doing something similar for the Hadnot Point area. Does that -- does that cover --

DR. CLARK: But the chances of actually being able to do that, I gather, are marginal at best; right?

MR. FAYE: I really -- I don't know one way or the other on that. I would just -- in fact, I don't even know how we would approach that, maybe just a single supply well at a time. Okay? I don't know. It's just -- we're just going to have to deal with that when the time comes.

MR. MASLIA: Let me, if I might, qualify that because when Bob and I got together, again, we made the decision based on, you know, consulting work, the USGS work, and all that, that we had the best chance from -- for developing a framework and either before you even get to the modeling at Tarawa Terrace. And so that's some of the -- I guess one of the questions we've posed is: Do we extend that? And, again, it means going back to developing the geohydrologic framework again for Hadnot Point, which we -- I don't believe we've done at this point --

MR. FAYE: No; just for Holcomb Boulevard.

MR. MASLIA: -- at this point yet. And so that's one of the issues we really want to discuss. Or is it just going to be so completely uncertain and variable that we may not be able to narrow any of the uncertainties, stuff like that? So Tarawa Terrace, we felt, was our best shot, given the time frame, given agency constraints, budgets, and time lines for the epi study. Dr. Bove can address the study time frame and some of the pressures associated with that to try to get some answers in a reasonable amount of time.

Am I on?

DR. JOHNSON: Yes, you are.

MR. MASLIA: Okay. Okay. I'm a little shorter than Bob. It's happened all my life. I even have to look up to my son, so...

In reviewing the premeeting comments and, of course, I've had a few days to look through them and hit more of the salient points. And they do bring up some gaps, if you will, that we need to address. But I wanted to give the panel a sort of a feeling that, again, we take these very seriously. Some of them may, in fact, change our approach or change our direction.

So I wanted to try to see what general areas the comments from the panel got into and, you know, what our response -- obviously, in a generalized, given the time frame that we've put these in. So I will go through here, and I'm not sure if I've included that in your handouts or not, in your packets. If not, we can get the panel a copy of our generalized responses.

But from the groundwater side, and, Doctor, did you just want me to end on the -- for the groundwater for this morning and then --

DR. JOHNSON: Yes.

MR. MASLIA: -- tomorrow we can or --

DR. JOHNSON: Yes.

MR. MASLIA: Okay. On the groundwater, a lot of comments resided in the area of uncertainty of geologic and aquifer parameters as we've discussed thus far and what -- it looks like some mention of probabilistic methods, such as Monte Carlo, looking at realizations. And I know Dr. LaBolle has a lot of expertise in that area and has worked on some sites for ATSDR in that area.

And that is something, I think, would be the next step. The question, I think, for the panel would be: In taking that as the next step, should that be the next step prior to doing any more refinement of the Tarawa Terrace model? Should we jump into probabilistic uncertainty methods now, rather than doing any more refinement on the Tarawa Terrace model?

Secondly, some parameter estimation methods to look at sensitivities like vertical hydraulic conductivity relative to other parameters. Again, that is a direction we definitely need to go in and anticipate going in. As far as modeling boundaries and sources, source conditions, I think the best way may be to look at use of sensitivity analysis to assess the nearness or the impact of moving that northern boundary further away from the source and seeing how much change it provides to the model, adjusting the boundary.

Again, we have the contradiction, if you will, that you've got the DEM that I didn't get to mention. The DEM data that was contoured for us -- actually, North Carolina district office is who we sent it up to, to pull it off the DEM site and provided us with the 2-foot contours, but, again, based on that and the topo maps. But I think that would be an area of -- that we could at least try to address and looking at the sensitivity of the northern boundary with relation to what impact it may provide on the model.

And the one question is: Would we see a bigger impact or a more pronounced impact if we go to the full fate and transport as opposed to just looking at the advective flow, which we're doing right now? In other words, you may find a changed impact when you go to the full fate and transport where you're looking at dispersive properties and start moving boundaries away from the ABC Cleaners' source.

The other approach -- and I think this comes into if you want to put in the area of sensitivity analysis -- is we do have techniques. Actually, there have been some papers on that, developed out of the multienvironmental media simulations lab at Georgia Tech, but they -- where they have taken observed concentration values and backed out source locations through use of genetic algorithms.

And that's, again, maybe an avenue to explore, taking some of the observed values that we have, historical in nature, and seeing if, in fact, it backs out the source location that we are assuming to ABC Cleaners. And I don't know -- I don't want to put Dr. Aral on the spot there. But we've had some preliminary discussions on that. And as I said, that's another area that we may -- that perhaps, we should explore is using the observed data --

(Projection screens withdrew to the ceiling.)

MR. MASLIA: I didn't -- is it time? You may have to touch the touch screen, Claudia. The touch screen may have timed out (laughter). Either that, or it didn't like the answer I gave. Okay. I don't know. Okay. You may have to hit "dual projector" to do that. And if not, I don't know if Ann Walker or somebody out in the hallway can hear us. They may have to call somebody to come get us. But I'll proceed in talking as we go on.

So those two areas of doing -- I'm not sure -- inverse modeling is not the correct nomenclature, but reverse modeling of going from the source, observed source, backing out. And that may also give us an indication if, in fact, that source -- where we think ABC is too close to a boundary.

The next groundwater, I've got fate and transport issues. And I know, Lenny, you brought that out that we mentioned fate and transport only provided advective, and it's been our intent all along to do a full fate and transport. And again, in the Tarawa Terrace area being PCE is the only known source that would give us a single constituent model. So we are -- definitely, that's on the plans. That's always been on the plans to do that.

One of the issues I want to bring up -- and Bob mentioned -- some of the data that we get in pieces as far as production and things like that, although we've been at this for over a year, I think, more or less. For example, last week, I just got a pile of information: month-by-month, raw water, finished water, production data from Camp Lejeune from 19 -- what was it?

MR. ASHTON: 1980.

MR. MASLIA: 1980 through 1986.

MR. ASHTON: '84.

MR. MASLIA: '84; month by month. And, of course, we've been asking for all data, so I'm saying it's slowly filtering in. It may take a more direct involvement of, you know, giving ATSDR staff or whatever to going into the vault, locating contract numbers, and things like that.

But this is new data that we just were provided with from the folks at Camp Lejeune. So again, that's in that critical period. What we really still need is the prior to the '78 information; '68 to '78. We're still looking for that.

Let's see. So again, the advective transport were viewed as preliminary estimates; get the model working; any issues with -- as far as not model code, but implementation of the code that we could take care of at this end and then taking comments, feedback, from the panel. Again, at least we've got some basic parameters and basic numbers to then go into uncertainty areas, go into other more refinements of the model.

So that's really the groundwater issues; a quick preliminary perusal from your comments that I saw, and that's the direction we're going in. And we will try to answer, you know, anything else.

DR. JOHNSON: Did anything you just heard raise concerns, or is there anything that you heard for which you would give a strong endorsement? What I've heard from Mr. Maslia is a series of considerations, and all that's good. But is it something that really that you've heard you'd say, "This really ought to be something you pursue," based upon his responses?

DR. DOUGHERTY: I think you should move the northern boundary and skip the sensitivity.

MR. MASLIA: Okay.

DR. DOUGHERTY: Just do it. Topography does not define hydraulics, unfortunately.

MR. MASLIA: And would you then just use a generalized, head-type boundary or inflow boundary since --

DR. DOUGHERTY: I'd have to look further north than the maps that I have here show me --

MR. MASLIA: Okay.

DR. DOUGHERTY: -- so I can't answer it really.

MR. MASLIA: Okay.

DR. WALSKI: Are there municipal wells, other things up north?

MR. MASLIA: Oh, yeah. There's the city of Jacksonville is, you know, pumps the wazoo out of groundwater. And I think we uncovered some -- did we not uncover some documents when we first went to Raleigh about discussions back and forth between Camp Lejeune and the city of Jacksonville about --

MR. FAYE: For the period of time that we're interested in, the pumping at the city of Jacksonville is not an issue. They have for decades pumped from the Cretaceous aquifer system, which is well below the Castle Hayne units that we're talking about here and with no effect on the Castle Hayne.

Just most recently, they've applied for permits within the last year or so to develop wells in the Castle Hayne. But for the period of time we're involved in, Jacksonville pumping would not be an issue.

What would be an issue would be a lot of older subdivisions and industrial areas and business areas north of there that back in the fifties and sixties and seventies, the period of time that we're interested in, would have been self-supplied. And I don't -- it would be just -- we could certainly look, but I wouldn't be too hopeful of determining or of finding out what kind of -- we would know less about those situations than we would about the Camp Lejeune pumpage.

So that's the situation there in terms of the -- and that self-supplied pumping was almost invariably from the same aquifers that we're dealing with because they were shallower and they were good. They yielded good water to wells, and, of course, the businesses and the residences and everything loved that because it was much cheaper than going deeper. So that's what we're dealing with.

MR. MASLIA: I've got half a screen -- half a room screen working, and we've got a number for the room operator. So we're trying to...

DR. JOHNSON: Based on what's on the screen, we've had one comment from David in terms of his view and strong recommendation. Does the panel have other recommendations based on what's on the screen or what you have heard?

DR. KONIKOW: Well, I would look again closer at the vertical hydraulic conductivity, its relation to the horizontal, and also the hydraulic conductivity of the clay layers of the confining units. The values that you or Bob gave earlier just seem a little too high, relative -- you were talking about .2 feet per day, as opposed to, you know, maybe 10 or 15 in the aquifer.

That -- for a clay confining layer, that just seems too high. And one of the things that might -- what you might find is that, as you make the vertical hydraulic conductivity lower and the hydraulic conductivity of the confining layers lower, your cell drying problem may go away.

MR. FAYE: Yeah. That's a good point, and you easily could be right. But the fly in the ointment there, Lenny, two things: The, admittedly, very limited lithologic -- good lithologic descriptions that we have of these confining units, yeah. They're clay, but they are very, very sandy. They are definitely sandy. And they're not real competent clays there, texturally.

I mean, when you look at the drilling times and the drilling records, pha-phooonk, I mean, it's -- you know, there's no -- there's no slowing down at one -- at a clay. So they're leaky. They are very definitely leaky. We haven't done any kind of sensitivity analysis at all on the anisotropy or the horizontal hydraulic conductivity. But this is not, you know, this is not a -- these are not real competent confining units at all. Okay?

MR. MASLIA: I, actually -- and this is part of our question, so I don't know if you want me to pose that now. Dr. Johnson, I'll let you go down the list. But I'll just throw it out there, and then you can decide. I'm not usurping your power as the Chair.

DR. JOHNSON: I have no power as the Chair, nor do I want any. But I am fully committed at some point today to start down this list of questions, and we will do that in the not-too-distant future. Are there any other points here of emphasis from the panel on Morris' presentation? Yes, Vijay.

DR. SINGH: I think it was pointed in prepanel meeting discussion as well as during the presentation. I think that there has to be a better accounting of recharge, especially when you are doing the transient groundwater modeling because recharge constitutes the input. And if your input is not properly accounted for, I don't think -- I don't think you will be able to do as good a job in groundwater modeling. And I think that may also partly explain the problems that you're encountering in the convergence.

Dr. FAYE: You're exactly right. I mean, we have recognized that, and I know it sounds kind of lame. But the actual truth is that we just haven't had a chance to really address that issue in a lot of detail, but I fully agree with you. And hopefully, that will solve a lot of these problems.

DR. SINGH: And the other point that I think it will be important to also evaluate the reliability of the model results, and this is particularly useful from the standpoint of giving the information to the public.

MR. FAYE: The reliability of what, sir?

DR. SINGH: The reliability of your model result, how -- what level of credence can you really put, given all the uncertainty associated with your hydrogeologic description, your parameter estimation, you know, groundwater conceptual assumptions, and a whole host of other things. I think it's very important to --

MR. FAYE: To qualify.

DR. SINGH: -- give the level of confidence --

MR. FAYE: Right.

DR. SINGH: -- or the confidence bends to the model results so that -- so that the public can have some confidence --

MR. FAYE: Absolutely.

DR. SINGH: -- in the results that you are giving.

MR. FAYE: And that should not be a qualitative assessment. That should be a quantitative assessment as much as we can do, and I fully agree with you.

DR. JOHNSON: In that same vein, I asked a question earlier about validity of the EPA models, and to my knowledge, they're quite good. So I'm not -- I don't have any agenda here other than the fact to say to you that the National Academy of Sciences has begun a very serious study of the EPA system of modeling and validity of specific models. Now, I do not know how far into that study they have gotten, but I surely do know that they are doing that at the request of EPA, which is quite commendable.

MR. FAYE: Well, let me just say that, first of all, the USGS, the mother and daughter of Modflow here, which is our simulator, they have exceedingly rigorous standards for qualifying their codes, number one. And typically, Dr. Johnson, the way this is done, they -- you recognize a standard groundwater problem that can be solved analytically. And then you pose that problem to the numerical code and see -- and compare that result against the analytical results. And I can tell you that that was done with a great deal of rigor by the USGS, and the results were highly successful.

DR. JOHNSON: I have a couple of administrative questions, Morris.

MR. MASLIA: Yes.

DR. JOHNSON: The panelists have provided a set of written comments, premeeting comments. My question is: Will these be made part of the public record?

MR. MASLIA: They will be in the -- in a refined -- and when I say "refined" -- grammar and otherwise --- as part of the report -- the report about the meeting summary. Our past experience has been, like in Dover Township, they were included as an appendix to the report.

DR. JOHNSON: This is going back to Dr. Singh's comment this morning about the transparency of all of this effort. It would seem quite meritorious to have these part of the public record, whether it's the record of this meeting or some other source. Does any panelist object to having his comments made part of that record? Do you want time to "correct your premeeting comments," knowing now that it looks like they'll be in the public record? You should be given that privilege.

DR. DOUGHERTY: I'd like the opportunity to go back and just check. I don't have a problem with the principle.

DR. JOHNSON: Okay.

MR. MASLIA: Well, what will happen, based on our modus operandi from the past is that a draft meeting summary report will come out with your comments in the appendix. And each panelist will be given a copy of that draft meeting summary to correct their comments, see if it's misquoted, or anything else through our contractor, Eastern Research Group. And then once they hear back from you -- yea or nay or change page so-and-so -- then that will become a final meeting summary report. And that will be published and, as Dr. Singh's asked, put on the Web as well.

DR. JOHNSON: Does ATSDR plan to provide an answer to each of these questions?

MR. MASLIA: As closely as we can. In other words, some of the questions were -- the same questions were asked by multiple panelists. That's what I'm trying to say. I have not thought out yet -- if you're asking me going down each comment, you know, Panelist No. 1, you know, has ten questions. Do we answer those specifically, then go to Panelist No. 2, even though there's a repetition -- may be a repetition.

DR. JOHNSON: All right. That's just an administrative detail, you know. It's called "ditto" or something like that.

MR. MASLIA: Right.

DR. JOHNSON: But do the panelists feel the need for having an agency response to what would strike me as rather seriously thought-through questions? What are your expectations? I don't want to push something forward that's not palpable.

DR. POMMERENK: For me, personally, if I see that my comment has been addressed in a follow-up report -- you know, this is obviously a draft. If the final has those questions addressed because, you know, some of the questions were simply due because I could not find the answer immediately. If they were addressed now, for example, that would be fine, but if it's something else, or...

DR. JOHNSON: But there's another group of people who might profit from a reply, and that's the public.

DR. POMMERENK: Yeah.

DR. JOHNSON: I mean, here's a serious question from Dr. Clark. Number 5, what kind of errors might be inherent in these assumptions? Should that be answered and made part of the public record?

DR. WALSKI: I think that as long as they have addressed the substance of the comments, I don't think it's really a good use of resources to be going through question by question. It seems like that's excessive. As long as they substantially respond, I think, and incorporate it in the report, that would be satisfying to me.

DR. JOHNSON: Okay.

DR. DOUGHERTY: For myself, they weren't -- were not prepared for the expectation of a point-by-point response because they were prepared to inform the agency about some of the issues that were on my mind that would be useful to hear about here. They were to prompt discussion as opposed to elicit responses. There are some that, certainly, are in that other category, but I think we've heard many responses; not all, but many.

DR. JOHNSON: I would offer the opportunity at 2:30 when the public addresses us to make comments on that same subject. But I think you have a sense from the panel that it might be -- it might be an overreach to provide a kind of point-by-point response to their premeeting questions.

MR. MASLIA: I thank the panel for clarifying that. Tom, your point is well taken about agency resources in general, but I think there are some points specific, like the boundary issue. I think that's a specific answer or approach that we've discussed here. But others will be generalized, and as Peter said, if he sees it in the final report --

DR. POMMERENK: Yeah. I'll --

MR. MASLIA: That's sort of the approach that we used in Dover Township. We used a similar set-up with several panels. And the final report did either allude directly to some issues that were brought up.

DR. POMMERENK: Yeah. Many of my questions were -- they're clarifications questions --

MR. MASLIA: Right.

DR. POMMERENK: -- where I was not clear --

MR. MASLIA: Right.

DR. POMMERENK: -- and you --

MR. MASLIA: We appreciate -- I appreciate another set of eyes or ten sets of eyes looking over our shoulders to help us see the light of day.

DR. JOHNSON: Well, thank you. Let's take a 15-minute break, and when we return, we will start with the specific issues and questions for discussion.

(Whereupon, a recess of approximately 11 minutes was taken.)

MR. MASLIA: One issue: For our working lunch tomorrow and -- we're going to this place called -- or not going to, but we're going to order several platters of Roly Poly sandwiches, which include anything from monster veggie, California turkey, roast chicken, and all that sort of stuff; a variety of that. And so what the ladies up -- well, there's Ann right there -- need to know by the end of this afternoon is how many people want to participate in that. It's a volume thing. And the price is based on the volume of whatever we order so -- and then they'll -- based on that, then tomorrow morning, they'll pass around envelopes to everybody, and you can put your, you know, five or six bucks in there.

DR. DOUGHERTY: When we do that, do you want us to raise our -- just raise our hands and get a head count now?

MR. MASLIA: Well, this afternoon, maybe, sometimes -- I don't know if we're taking another quickie break or whatever at some point. Ann.

MISS WALKER: Tell me if you're not going to do it.

MR. MASLIA: Oh, well, that's -- who doesn't want to do it? And that includes any people in the audience and public as well.

DR. JOHNSON: Thank you.

MR. MASLIA: Okay?

MISS WALKER: Okay.

MR. MASLIA: Okay.

MISS WALKER: I don't see any no's, so we'll just count. And then tomorrow morning, you can see Joann and give her some money.

MR. MASLIA: Okay. It's all yours, Dr. Johnson.

DR. JOHNSON: Well, let's turn to the questions that the agency posed that are specific to the groundwater presentation. As I count them, there are eight questions, and there may be others that arise during the course of a discussion.

First of all, based on groundwater-modeling results presented, what modifications, if any, should ATSDR make? Who wants to take the lead on answering that, as I look around the panel? Let me warn you, I teach, so I know how to pick them (laughter).

DR. DOUGHERTY: I'm in the front row.

DR. JOHNSON: I know when I see people hunkering over. Robert.

DR. CLARK: Okay. I guess one of the -- one of the questions I had goes back to the relative importance of the work that's being done now versus the other contamination sources in the system. And would it be better to devote some resources to understand the relative impact of that, particularly on the epidemiologic results, as opposed to spending a lot more resources in refining the existing model? And I'm not clear on that. I don't have a clear feeling. It's a very impressive technical effort, but I'm not sure that it gets us very far as far as understanding what the other sources might be and what the impact might be.

DR. JOHNSON: Eric.

DR. LABOLLE: Yeah. I would like to add to that.

it's not clear to me yet the role of the groundwater model in the whole simulation process. And what I mean by that is some of the discussions we've been having over lunch and such and looking at this time-line chronology that's presented here and I'm looking at when the Tarawa Terrace wastewater treatment plant came on-line and when it was closed down.

And it looks like, you know, the contamination from the various wells is mixed at a single point, and it would be useful, actually, to have some kind of discussion at some point -- maybe perhaps tomorrow or something -- on the ranges of concentrations within these different wells and how much we really gain with additional detail in the groundwater model.

So I think -- I think any recommendations should be preceded with some further understanding of its role and how much is going to be garnered from additional work in that regard.

DR. CLARK: Another variation on that, too, is the amount of resources that are available to do the study and how does it take away from other type -- other parts of the study, which might actually have more impact, more importance.

DR. JOHNSON: Morris; Bob; whomever.

MR. FAYE: The objective of the groundwater model --

flow model is to form the basis of a fate and transport analysis using numerical models that will ultimately result in a monthly value of concentration of contaminant; i.e., PCE at certain wellheads. I mean, that's from -- for the period -- was it 1968 to '85? That's the objective. I think that was clearly stated several times. Now, if that's not a tenable objective, it would be nice to know that in your opinion. But that is the objective.

DR. KONIKOW: Based on your groundwater modeling so far, you're really starting in 1978 or '79 --

MR. FAYE: Right.

DR. KONIKOW: -- and so what's -- how do you hope to cover the period back through 1968 or so --

MR. FAYE: Good --

DR. KONIKOW: -- when the epidemiological data is starting?

MR. FAYE: Good question. The reason we did the '78 to '94, as I said, was because that's when we had some water-level data that we could actually pay attention to. Probably between 1952 and 1978, we may have a grand total of two or three dozen water-level measurements in comparison. Okay?

We also only have discrete -- a discrete window for about, oh, six or seven years, periodic nonconsecutive years; a discrete window in terms of a published value of the -- of the quantity of water, the total quantity of water treated. We have another half a dozen references for different years in that interim, relating to well capacities and what wells were operational. The well capacities do change with time.

The flip side of that is that for most of that period -- and certainly the USGS data there for the -- for the pumping information from '75 to '86 indicate that within plus or minus 10 percent of about -- of .95 MGD that the average annual rate doesn't change that much. And that's because Tarawa Terrace, the housing units, were occupied just about 100 percent all of the time, 90 to 100 percent all the time. So we shouldn't be looking for a lot of variation.

We do have enough data now with the additional information that Morris discussed a few minutes ago. We do have enough data now, I believe, to make some sense out of monthly variations and pumping over a long period. And we can apply that information backwards in time as well. And that's kind of the summary of the suite of information that we have available to us, Lenny.

DR. KONIKOW: As far as exposure goes, though, there's no --

MR. FAYE: No. That -- that's historical reconstruction. I mean, that's -- we do know -- we do know the -- within a year of the beginning of operations of ABC Cleaners, we know that they used only PCE during their whole period of operation. That's it.

MR. MASLIA: Based on suggestions also -- and this gets into, I think, Bob's question about resources and staffing. But, actually, I think another part of our effort or a more intense effort will be on data discovery. That appears to be a key factor, and I think going back to, like, tax records, maybe trying to refine the actual use of the PCE at ABC Cleaners.

And that calls into, as far as an answer in terms of agency resources, that's a two-part answer, and I think you can appreciate this being a former government employee yourself. As far as the, how shall I say, funding-part issue, I believe the funds are there. Okay. They've been there this past year while we've been doing fieldwork and that. The other side of the equation is the staff of personnel. That is not there. Issues of do we have enough staff -- and let me get into that.

As we discussed at lunch, unlike with other state programs that ATSDR has, we have no cooperative agreement with the state of North Carolina. We used that very heavily in Dover Township, New Jersey being a state. So that alleviated the need if we needed people to go and do some historical record search or do some detailed sitting on site, so to speak. We actually had a field office over there.

So that assisted us. We don't have that option in this situation. So that means if I want to spend the next month, which maybe I'm just taking a month out of my hat, and doing "data discovery," going into the files at Camp Lejeune or something, somehow our project has to come up with a warm body to do that.

So while the funding may be there, the people are not there. And that's a consideration, I think, with recommendations, obviously, from the technical staff that management may need to look at that. If we say it appears to be a consensus of the panel -- I haven't taken a vote. That's -- Dr. Johnson probably will try to do that later on.

But if data discovery, refining our chronology, our operational history, and things of that nature to pinpoint specific lack of information that we have now is a -- should be a focus of our continued effort, then that's something we have to address, I think, as a division, as an agency. So hopefully, that's addressed your question. Is there a follow-up, or is there...

DR. JOHNSON: Well, what I hear is a strong commitment on the part of the agency to continue the groundwater modeling and activities associated with that effort. I also am hearing from the panel some concern as to whether that, perhaps, the depth of that should be pursued. Am I misstating the case here? Please, Tom.

DR. WALSKI: What I would want to do as a starting point would just sort of do an overall classification of which areas we know were contaminated with this chemical, which ones we know were safe, and then which ones were -- and those you just sort of say, you know, these people were exposed, period, and these people were not exposed, and concentrate the modeling on areas that we're gray on. Do we have a marker for this easel here?

MR. MASLIA: I've got -- these are drawing markers, but you can --

DR. WALSKI: Here. Oh, here's one. Okay. How am I going to operate this thing? Okay. There we go.

(Drawing) It's sort of a thing like this with, you know, Terrace, Hadnot, Holcomb, 1952, 1972. You know, I have separate rows. 1971, 1987, and just draw these in. This one here is a -- this area where we know was bad here, we know it's cleaned up here because they shut the plant down, and we know that ABC Cleaners wasn't in existence before some date, possibly. So this we know, and we just want to focus the modeling in here to areas we're not sure.

And like, Holcomb, we knew was pretty good most of its life, but there are some periods where we were uncertain of. And this might be where you'd look at some modeling where it was unsure. And Hadnot, we know was pretty bad throughout all time and you know, until they went to some type of -- what ended the -- they put some more treatment in, right, some pump and treat?

MR. FAYE: No, they didn't. They just took the wells off-line.

DR. WALSKI: They took the bad wells off-line at some point. So we know that after this point you're okay. But here we were in pretty bad shape. And then just focus in on the places where the models could tell you, you know, where it's critical because here you knew there was exposure. So you might want to do some kind of matrix like this as the next step before you got into, you know, doing -- just trying to model every single month of this thing where you know there's contamination in some of these areas. So why bother beating that when -- or you know that some of these weren't contaminated at that time, so why bother modeling those periods?

MR. MASLIA: My -- I guess, at least, my experience and knowledge would be in a numerical model, such as Modflow or any of its varieties. We have to step through time. So we're going to have to time step whether we -- whether we use the information or not, we're still going to have to time step it to get to the period of interest. Is that --

MR. FAYE: And also, in terms of the periods of time when no exposure was occurring, your point's well taken. But it would be so much more convenient -- say, for example, we know that Tarawa Terrace -- I mean, the ABC Cleaners, for example, they probably started operations around 1955. We know that. And the Tarawa Terrace wells went on-line in 1952. From a modeling standpoint, it would be so much better to start your -- to start your simulation in 1952 because you're starting out from a prepumping condition, rather than begin things in 1955 and try to guess at what the antecedent conditions were.

So, you know, that's a decent trade-off. Three years is not a big deal. And we wouldn't have to do that, say, for example, on a monthly basis; those three years. So I think -- in certain context, I think your comments have a lot of merit. In that particular case, I'm not sure.

DR. UBER: I think that I'm taking Tom's comments as more metaphorically, maybe, not exactly literally, on that -- on that matrix. Just to -- what I hear some of the panel saying is that we might like to hear the objectives of the groundwater modeling explained more in the context of the ultimate goal of the investigation, meaning the epidemiological study and the needs for that.

So, for example, if you knew that these nine wells -- I'm not saying this is the case. But if you knew that these nine wells were all blended together and served Tarawa Terrace residents during a certain period, then that means that the groundwater model is really predicting the blended sum of those waters from those nine wells. And the -- and if you do sensitivity analysis, such that it doesn't really affect very much the blended water over time from those wells, then you -- you know, if that's the case, if that's insensitive to those assumptions, then those assumptions are not necessary to nail down any further.

Whereas, those same assumptions might have impacted significantly the individual arrival times at certain wells or individual captures zones. So, I mean, that's just an example. I'm not saying -- you don't need to comment on that particularly. But if that were the case, then that would be one example of making the objectives of the groundwater modeling, in my mind, closer to the needs of the epidemiological study because it brings it into the context of the exposure. Does that make any sense? I'm thinking not.

MR. FAYE: Yes, it does. The fly -- well, yes, your comments do make a lot of sense. The situation as it exists is that the results of the groundwater-flow model, which would provide monthly concentrations at the wellheads -- those are one step removed from the exposure at a street or a house in the -- in Tarawa Terrace because that -- those results are linked to the network, to EPANET, to the network model, which provide the exposures at the individual residences or streets or whatever.

DR. UBER: Mm-hmm.

MR. FAYE: So the results of the groundwater flow model are one step removed from where you're getting to. But that's the linkage that the network -- the network analysis is the linkage.

DR. LABOLLE: So expanding on that -- Eric LaBolle here -- if one looks at the groundwater model and its results today, even though they're still in preliminary stages, can you make an assessment that some of these wells saw contamination for all time, for all the entire study period?

MR. FAYE: That's a really good point, and I was hoping somebody would ask that. My gut feeling right now -- and I could be wrong. But my gut feeling right now is that TT-26 is the major player in the whole -- in the whole event from the time that there was a breakthrough at TT-26 of the PCE from ABC Cleaners until the times that the wells were shut down. I think most of the PCE produced at ABC was captured at -- only at TT-26 with maybe some residual amounts at TT-25.

There were -- we have that migration to the northwest. That was probably caused by local pumping there that we know nothing about as well as dispersion. But for all intents and purposes, the capture of PCE occurred at TT-26, and I think, you know, that that's going to be the end result.

DR. LABOLLE: And is it -- can you state an opinion at this point in time as to a range of times that you think the contamination might have arrived at TT-26? Not to pin you down, but my point here is this. My point is: If you're dealing with a study period in which TT-26 saw contamination during the whole time, that might change the role of the groundwater model versus a study period in which the groundwater model is expected to predict an arrival curve to TT-26. The level of detail necessary to predict an arrival curve would be significantly different than one needed to predict, say, maybe just a boundary range of concentrations --

MR. FAYE: Yep.

DR. LABOLLE: -- in which assumes --

MR. FAYE: Yes. That's good.

DR. LABOLLE: -- inherent uncertainty.

MR. FAYE: Yeah. That's very good. You have -- you have several issues to address, okay, in that whole context. If you have the arrival time -- I made an estimate with the advective transport simulation. It occurred about -- in about three years. Okay. So if we assume that PCE entered the -- got -- was actually being discharged to the septic tank at ABC Cleaners some time in 1955, probably made it to the water table maybe a few months or a year later, you're looking at something around 1959 when PCE started to -- and that's not accounting for dispersion. It might have gotten there earlier when dispersion effects are taken into account.

Now, having said that, you have these other issues of retardation, biodegradation, and whatever that are going on in that interim -- in that whole period of time, say, from 1959 or whenever up to 1985 when that particular well was shut down and taken off the -- taken out of the network.

So what the model would be attempting to do, okay, would be to address those issues of retardation, dispersion, biodegradation, whatever, decay; and in that interim period of time for that particular -- for that interval.

DR. LABOLLE: The sense that I'm getting then is that the 15 years roughly -- or, say, 10 to 15 years that have elapsed there between the introduction of a source to the system and/or probable introduction of a source to the system and the beginning of the study period sounds like sufficient time for the contamination to have arrived --

MR. FAYE: Oh, yeah.

DR. LABOLLE: -- at TT-26.

MR. FAYE: Oh, yeah; absolutely; absolutely. We would not begin -- or at least I would not think it would be appropriate to begin the model simulation -- the groundwater flow and fate and transport simulations in 1965, which is the beginning of the period of interest to the epi study. We would want to be there before. We would be simulating conditions before that and then all the way through it.

MR. MASLIA: One other issue because Bob and I have discussed this, and that's the issue of Well TT-23. And that, again, I think this is where the model can help refine our understanding. Well TT-23 was drilled after the shutdown or in anticipation of the shutdown of TT-26.

MR. FAYE: No. It was '84. Well TT -- we have a -- we have an actual step-drawdown test for TT-23. I think it was in March of '83. So TT-23 was sitting there available. That was part of Tarawa Terrace's routine operation of bringing a new well on-line and probably taking an older well that had reduced yield off of line.

And then all of a sudden, when they did the sampling while TT -- there was PCE that showed up in TT-23. So PCE

-- TT-23 never got a chance to be in operation probably for more than a year. But -- and frankly, I don't know how much importance the contribution of TT-23 had to the -- to exposure because it was only operated for such a short period of time.

But I will say that it's been on everybody's radar screen as a point of interest, and I do believe that the only way you're really going to understand whatever the contribution was from TT-23, if it remains a major point of interest as it seems to be, would be through a -- through numerical simulation.

DR. JOHNSON: Well, I think we've had a good discussion and some suggestions as to how the modeling work might be modified. It's certainly for the agency's consideration and final determination. But some interesting ideas were placed on the table, and we would ask that they be seriously considered by the agency.

As an aside, I have not forgotten about the public session, and I plan to do that at 3:30. So those of you who wish to speak at 3:30, be prepared to do so. We will need your name, et cetera. To the extent possible, focus on what we're discussing today: the water-modeling issues. But anyway, at 3:30, we will do that.

Let's continue on to Question 2, and, again, we can come back to any of these questions. I'm just trying to get us through these series of significant issues. Number 2: Should ATSDR use the same level of detail; i.e., 50-foot cells and expand the groundwater model to include the Holcomb Boulevard and the Hadnot Point areas? If so, what level of increase in effort does the panel envision for this effort? Lenny, please.

DR. KONIKOW: Well, a 50-foot grid spacing seems, you know, reasonable, but I think the approach that, you know, I would recommend and probably other people would recommend is do some grid-sensitivity testing. I heard someone mention that this morning. Try a 100-foot cell, and see if there's any difference. Try a 25-foot cell spacing, and see if there's any difference. If it doesn't make any difference, stick with the 100 foot.

UNIDENTIFIED SPEAKER: Right.

DR. KONIKOW: If it makes a difference, depending on the nature of the difference, you probably want to go to the finer grid spacing. So it's hard to say if 50-foot spacing is the right one without looking at some sensitivity tests. So somewhere along the line -- and, again, this is one of the nice things about a graphical preprocessor based on a GIS-type system is that you can very easily change your grid spacing. And that's one of the things we'd certainly recommend doing.

As far as expanding it to the Holcomb Boulevard and

Hadnot Point areas, I think it depends do you want to apply a transport model there or not. Do you want to, you know, look at the -- I mean, you're starting in just the Tarawa Terrace because that's simpler. So if you can't succeed there, then maybe there's no point going to the other systems.

MR. FAYE: And that's -- that was the whole idea.

DR. KONIKOW: Yeah. So I think you have to kind of see what the results are after a little more time.

MR. FAYE: Good. Thank you.

DR. JOHNSON: Other comments on this question? Vijay.

DR. SINGH: I think you may also want to look at variable grid size. You may want to consider finer grids near the source and coarser away from the source.

MR. FAYE: Yeah. That's clearly -- that's clearly something that we intend to do. And as Lenny said, when you're using a GIS conditioner for your input arrays, why, it's really easy to do. It's not a problem, and that's something that we very definitely would look at or intend to look at.

DR. JOHNSON: Any sense on what extra level of effort would be required?

MR. FAYE: Not a whole lot.

DR. JOHNSON: I'm not sure -- I'm not sure that's the kind of thing a panel is equipped to come to grips with, but I speak only for myself. I haven't a clue as to how efficiently you work and other -- what equipment you have.

MR. FAYE: My response was just to the specific notion of changing the grid dimensions. Okay? I mean, I didn't know you were touching on the overall issue.

DR. JOHNSON: It's part of the question.

MR. MASLIA: Let me just address this. The reason that question came up is looking at the, I guess, experience and expertise and different type of analyses that some of the panel members have been involved, I suppose we were looking at it based on their experience of saying, "Oh, no. That's going to take a completely separate project team. You know, that's going to take another three years, five years, or whatever based on our experience."

And that's something -- an input that we need and to discuss with the epidemiologists as whether that increase in effort is warranted for the type of results that we may obtain. It clearly has been referred to on a number of occasions now. If, in fact, we're having some difficulty, although maybe success, in Tarawa Terrace in this level of effort now, expanding that difficulty at least an order of magnitude because of uncertainty and unknown in Hadnot Point and the variety of nonpoint specific sources, that may be an area that we may say that the level of effort will not warrant the refinement in the answers that we need for Hadnot Point area. And that's really why that was posed, not looking for a specific person number or hour -- labor hours or anything like that.

MR. FAYE: Could I say something?

MR. MASLIA: Yes.

MR. FAYE: With regard to the additional complexity that we're fairly certain that we would see at Hadnot Point, perhaps, an intermediate step or even a final step to simulating various concentrations at a great number of wells with numerous source areas would be analytical, rather than numerical, which would greatly simplify the situation in terms of analysis. But what would also be somewhat limiting in terms of the results that we would provide -- be able to provide for the epidemiological study. But it may be a very useful intermediate step.

DR. JOHNSON: Yes.

DR. CLARK: The answer -- it seems like the answer to this question somewhat answers the concerns I had on the first question. In effect, what you're doing with Tarawa Terrace, that's basically a pilot study to validate, develop groundwater-transport model; right?

MR. FAYE: It's -- I would say it's perhaps a little further than a pilot study. We know that these things have been done before. There's not a lot of mystery about it. More the issue is, yeah, we can do it, and we can give you an answer, but just how damn good is the answer? Okay?

DR. CLARK: And so if you have success at Tarawa Terrace, then the potential for applying it to other areas increases, I suppose, significantly.

MR. FAYE: Yes; sure.

DR. CLARK: And so that basically is kind of the reason that you're taking that approach on the project.

DR. JOHNSON: Yes, please.

DR. UBER: Could I just follow up on that real quick? Could you clarify for me: Is the proposal -- I know we're talking about just the groundwater analysis now. But is the proposal to use Tarawa Terrace really, truly as an advanced pilot study but moving it from the groundwater to the water distribution through to the epidemiological conclusions prior to moving significantly or changing directions drastically for some of the other areas?

MR. FAYE: That's yours, Ace.

MR. MASLIA: That is -- our intent is to hopefully -- I don't want to say wrap it up -- but put some finality on our state of knowledge and conclusions we can make from the effort at Tarawa Terrace in terms of the groundwater fate and transport and the distribution side. That is the

-- as we've alluded to, we know we've got one primary well, TT-26. We've got some data gaps in historical or chronology.

But as far as the hydrogeologic framework, we've defined that as far as modeling. When I say "boundaries," not the physical model of the boundaries, but where we should start our timing, stuff like that. We've got -- we're getting more well-production records. As I said, we just got some more in the middle eighties to fill in some gaps. So that's pretty much further along. I can't speak as far as the cases and controls. Dr. Bove can probably speak more on that if he thinks it's appropriate to discuss that issue.

MR. FAYE: And there's also another major issue implicit in that -- in that question. And that is the actual linkage between the models. The results of the groundwater flow model I used as input into EPANET or some similar thing. And we want that to be as transparent and as fluid as -- no pun intended -- as fluid as possible. We don't want that to be a stop-and-start, really hard-nose mechanical-type of operation. And so there's some issues there to be dealt with in terms of refining that.

DR. UBER: So that's good. That actually reinforces the point, perhaps, of making a decision to try to do it all with Tarawa Terrace. It sounds to me like maybe the team is not quite committed to doing that because there's some, maybe, uncertainty, reasonably, about the time frames of the, you know, getting all the control group together and doing all of that work.

But I -- personally, I would be very much in favor of that approach, if it is feasible at all, because I think, you know, well, you always learn from doing it. And I think bringing this -- bringing that study to the end conclusion, even on a first-order basis -- end, meaning to some kind of integration with the epidemiological conclusions -- would be a good thing to add going into the other areas.

MR. MASLIA: The other thing, if I might just jump the gun for either this afternoon or tomorrow's presentation on the water-distribution side, I alluded to earlier in my opening remarks that we do have an analysis. Claudia did a very good analysis on building use and building type and, you know, whether it's residential, family housing, industrial, car wash, and so on. And I'll show that later on either tomorrow or this afternoon, depending on the time.

But what you will notice is obviously Tarawa Terrace is 90-plus percent family housing. Holcomb Boulevard is 90-plus percent family housing with elementary schools and high schools. When you get down to Hadnot Point, it's just the opposite. It's 90 percent plus industrial and other things and bachelor housing with maybe 5 percent family housing. Would that be about right, Claudia, somewhere around that?

MISS VALENZUELA: Yeah.

MR. MASLIA: Yeah; about like that. So that's the other -- we haven't gotten into that, but you'll see some maps on that. So that's the other consideration really from our standpoint.

DR. WALSKI: When the distribution system measurements for PCE were made in Tarawa Terrace, what was the range of values at the tap?

MR. MASLIA: PCE or TCE?

DR. WALSKI: PCE at Tarawa Terrace, like, the range. Was it a huge range? Did it show tremendous variability, or was it basically, once you got it, you got it?

MR. MASLIA: We've got a map with the chronology on them.

MR. FAYE: Yeah.

MR. MASLIA: Here. We've got a chronology here. Here we go. Actually --

MR. FAYE: The concentrations at the tap were probably somewhat less to greatly less variable than the concentrations that we observed at the wellheads.

DR. WALSKI: Because everything gets blended, and so --

MR. FAYE: Right.

DR. WALSKI: -- it seems like, basically, once the system gets contaminated water in it, the people get contaminated water, and, you know, the amount that the model is going to tell you is, well, maybe they got 52 instead of 54. But the fact is that once the plume hits the wells and they use the wells, everybody got the same thing in that system. That, you know, I'm just questioning how much more you're going to get by really refining the models.

MR. FAYE: Don't know; don't know. I can't -- I couldn't -- I know that the concentrations at the wellheads vary by orders of -- by an order of magnitude at least. And I'm not -- I'm not sure that I'd be comfortable in going into detail even about a cause and effect of that. I don't know that. I haven't reasoned that out that well. I just -- that's it. I -- you know, that's the extent of the information.

DR. LABOLLE: Particularly with regards to the distribution system model, I think that what's been raised here is quite important. If you're putting in a source and everybody has to drink that water because there's only one source in the system, which is the wastewater treatment plant, at least during a significant portion of the time, if not all the time in the study period, then how does refining the model increase one's information on exposure?

MR. FAYE: Well, for one thing, when we -- when we finally get to the point where we're able to deal with monthly recharge and we have some decent confidence that we're doing a good job there, you're looking at -- you're looking at orders of magnitude change and recharge from month to month. Okay?

DR. LABOLLE: My question was with regards to the distribution-system model though.

MR. FAYE: Oh, I'm sorry.

DR. LABOLLE: But I have one for the groundwater too.

MR. MASLIA: Let me -- if we assume that you've got several wells and they're all blended in at the treatment plant and then they go out into the distribution system and are up in the tanks and equally mixed and all that, then your point is everybody gets the same blended concentration of water; no question about that.

We found a couple of things, and again, this is probably something we'll get into tomorrow or this afternoon. But we are finding, at least in the storage tanks, that it's not a complete mixed situation. This is based on some field testing that we did this past year.

We're not sure if you're seeing last-in/first-out or a compartmental-type issue in the tanks. We're testing that out, doing some sensitivity runs right now, so that, if you had in one given month one well running more than the other, either contaminated or not contaminated, and pushing that out through the treatment plant and then stored up in the tanks or whatever, you may not necessarily see that water coming out into the distribution, depending what's going on in the mixing in the tanks.

DR. LABOLLE: Then in that case then, the study, you know, the detail would then focus on a very restricted portion of the system, that being the tank and one of the sources --

MR. MASLIA: Mm-hmm.

DR. LABOLLE: -- which wells the sources were coming from?

MR. MASLIA: That's correct.

DR. LABOLLE: But then the rest of the distribution system, the detail and the level of analysis would have little effect then on exposure. Am I missing something in that?

MR. MASLIA: Well, the only thing we're -- or we're trying to understand right now is we're still in the process, at least for present-day, trying to understand exactly how the tanks are mixing. We've instrumented some tanks, and it's raised some additional questions. And I really can't, at this point, answer: Can we make some either simplifying assumptions or assume, given a certain input from the treatment plant, that this portion of the system received this slug of water or not?

I think, perhaps, maybe the panel will see some insights from some of the data, more detail that we'll present either this afternoon or later tomorrow. Those are some good issues to bring up.

DR. CLARK: Depending upon the variability on the input side, you could get blending in the system that would cause different levels of exposure to individual households too. So I guess it's those issues that you have to resolve.

DR. LABOLLE: Yeah. Particularly if the treatment plant doesn't. You know, the treatment plant is delivering water out into various pipes into the system at that point, then the detail -- I could see the distribution system would become important.

MR. FAYE: On the groundwater side, you would have an expectation of variability. We don't know how much. Depending on your rainfall, which would translate -- the way we're looking at recharge now would translate directly to recharge. You would have periods of time when you'd virtually have no recharge, probably extended periods of time. And then you'd have other times when you would have just an excess of recharge.

How this affects the -- would affect the variability of concentrations at the wellhead, we just don't know. And it -- is that the reason of the order of magnitude change in contaminant concentrations at the various wells? We don't know. But we do know that there is a great deal of variability in concentrations at the wellhead, just based on observations.

DR. DOUGHERTY: I have one question for -- actually your comment and Eric's. Since you're preparing, planning to perform a fate and transport model --

MR. FAYE: Ultimately.

DR. DOUGHERTY: -- ultimately. And this is a question about your preliminary thinking, and so it's subject to draft and revision and all these things as the project evolves. But the question is: How do you think you're going to handle the source? How is it going to be represented?

MR. FAYE: Well, as Morris said, one thing that we have in the works is to use Dr. Aral's expertise at Georgia Tech. Are you familiar with CXTFIT?

DR. DOUGHERTY: Sure.

MR. FAYE: Okay. It's kind of a simplistic notion, but, you know, it's the same idea where you would actually look at your observed concentrations in a "plume" and then be able to compute backwards and estimate a source concentration for a limited period of time relative to those observed conditions.

We have data in 1985 that probably -- early 1985, that probably represents, goodness, for want of a better term, routine operating conditions, okay, at the -- at ABC Cleaners. And we're looking at 12,000 micrograms per liter there. The gentleman earlier made the point that there may have been a greatly increased rate of input into the system during Vietnam.

And hopefully, hopefully, through the data discovery that Morris was talking about with the tax returns and whatever, we can get something of a handle on that. Obviously, it goes without saying, I mean, the source term is the -- is -- it's not all the eggs in the basket, but it's a good number of them.

DR. DOUGHERTY: My question in particular was: Is it going to be treated as a specified concentration, or is there going to be -- or are you anticipating a process model for --

MR. FAYE: No.

DR. DOUGHERTY: -- some dissolution process?

MR. FAYE: I -- that, we haven't thought of yet. My -- right now, my thinking would be basically just a rate at a -- at some concentration. Okay?

DR. DOUGHERTY: Some of mass loadings?

MR. FAYE: Yeah; right.

DR. JOHNSON: Okay. Let's stop at that point. I think we've -- the panel's given you some excellent advice and some perhaps new directions to consider: grid sensitivity, testing, et cetera, other ideas. Again, we can always come back to any one of these questions.

The third question, before we have the questions from the public: Rather than developing three distinct groundwater-flow models, should ATSDR considering -- should consider developing one model?

DR. CLARK: It sounds like the answer to that has to be no, given the complexity of trying to do that.

DR. JOHNSON: The answer is no.

UNIDENTIFIED SPEAKERS: It may be later.

DR. DOUGHERTY: And then you have the choice of whether you do two and three or whether you expand one and two or incorporate two and three or whether it's a similar approach at that point.

DR. LABOLLE: Where does the third one come in? That's actually where I'm confused. We have Tarawa Terrace. We have Hadnot Point. It's my understanding that the community in the middle wasn't receiving much contamination; is that correct?

MR. MASLIA: Actually, correct, unless we find any other information to the contrary. That was probably a rush to write questions down, but I suppose one -- when I was thinking also of three models, one way I was thinking back to my USGS days is where you have an overall model and -- one model for the whole area, which may be a coarser grid, or define some boundary flows or whatever and then you have the two refined areas.

But from what our discussion this morning and this afternoon is going is, I believe, we'll be doing good to get at narrowing uncertainty or addressing uncertainty with the Tarawa Terrace area. I mean, I think there's some issues there that may, in fact, tell us, you know, don't go down the direction of the numerical model to Hadnot Point.

MR. FAYE: Accept no.

MR. MASLIA: What?

MR. FAYE: Accept no.

DR. JOHNSON: Okay. I think you got a clear answer on that one. We need to take about a five-minute pause or so, so that our recorder can recalibrate her recording equipment. And then after that, we look forward to comments from the public, and then we'll resume with the rest of the questions. So take a brief break of about five to ten minutes.

(Whereupon, a recess of approximately seven minutes was taken.)

DR. JOHNSON: We are at the point where we would be pleased to hear comments or observations from the public, and please come forward to the dais. Tell us your name. To the extent possible, we would ask that you summarize the significant points that you wish us to hear.

MR. ENSMINGER: Good afternoon.

DR. JOHNSON: Good afternoon.

MR. ENSMINGER: My name's Jerry Ensminger. I told you who I was earlier. I lost a child due to this contamination, and I have been deeply involved in this since 1997. Likewise, a retired major, Thomas Townsend, who I work very closely with and have worked with him for many years on this, and this following statement is a -- and questions is a combined effort between Mr. Townsend and I. And without further ado:

Construction of the Tarawa Terrace housing area commenced in 1952 and, at that time, was owned by Spangler Real Estate Company. My family lived at Tarawa Terrace, 3442 Hagaru Drive, from January 1955 to May of 1956, as cited in CLW-2982. In 1958, TT-26, the first of eight water supply wells, was constructed in Tarawa Terrace. The year 1961 saw the construction of an additional three wells: TT-52, 53, 54. Wells 27, 31, and 25 were constructed in 1972, 1973, and 1980, respectively.

Well 23 was constructed in 1984. However, this well was never put on-line or in -- never put into production, as PCE was discovered immediately following construction. This well is also described as TT-NEW WELL in the same documents.

I provided you with a list of the supporting documents that support this statement. TT tap water was tested 27 May 1982 from seven wells less TT-23. PCE was found at 80 parts per billion and on 27 and 28 July '82 retested with PCE at 76 parts per billion, 82 parts per billion, and 104 parts per billion. TT wells were sampled in July of 1984; TT-23 at 37 parts per billion; TT-25, trace amounts; and TT-26 had 3.9 parts per billion. No TCE was detected.

Tap water in Tarawa Terrace was tested again on 5 February of 1985. The analysis indicated PCE at 80 parts per billion, TCE at 8.1 parts per billion, and DCE at 12 parts per billion. All Tarawa Terrace wells were disconnected from the water-distribution system on 8 February 1985, and Wells TT-23 and 26 were closed.

Four days later, on 12 February 1985, and again on 19 February of 1985, water from the TT system was tested and determined to contain no VOCs. Unable to meet the increasing water demand without these wells, the Tarawa

Terrace water-distribution system was supposedly closed. None of the TT well data, installation or operational date, and contamination testing results can be confirmed by this reporter since Marine Corps base Camp Lejeune has not provided same after many FOIA requests submitted; no responsive documents.

Question: If the TT water-distribution system was closed in February of 1985, where did the potable water to support some 1843 housing units and commercial establishments come from to fill that void?

DR. POMMERENK: Can I answer that question? I believe, in 1984, there was a pipeline constructed from the Holcomb Boulevard treatment plant, and that pipeline connected directly to the raw-water tank. So you received treated water from the Holcomb Boulevard area.

MR. ENSMINGER: In 1984?

DR. POMMERENK: I believe so. I would have to check the numbers, but that's the approximate time frame that I recall from the...

DR. JOHNSON: Come to a microphone, please.

MR. FAYE: The records that I'm familiar with that we've obtained from Camp Lejeune and other sources indicate that only Wells TT-23 and TT-26 were taken off-line in February of '85, that the other wells in the system at that time continued to operate, probably, through all of '85. We know for sure that the water-treatment plant was operating and processing water at least up to March of 19 -- 1987. There's a real question about 1986. My gut feeling is that the ex-TT-23 and ex-TT-26 at the Tarawa Terrace wells probably operated all through 1986 as well.

Just with some corrections here to what this gentleman has said about TT-26, we have copies of notes from Mr. - a Mr. R. E. Peterson, who was an employee of the Lejeune facilities at that time in May of 1951, where he describes the construction and -- the drilling and construction of Well TT-26, TT-27 and 2-A. At that time, they were called Number 1 and Number 2-A and 2-B; 2-B was TT-27. So that's just a few comments there.

Thank you.

MR. ENSMINGER: And if you would, in your supporting documentation that I've provided you, CLW No. 1129 through 1131 was an action brief prepared by the Chief of Staff of Marine Corps base and is dated 1 March of 1985. That's Colonel M. G. Lilley, who I have spoken with personally. And he gave a -- his action brief was -- the subject was "Alternatives for Providing Water to Tarawa Terrace Area." So if a pipeline was installed in '84, why are they having an action brief in '85?

DR. POMMERENK: That's a good question. I was just aware of the construction date of that pipeline. Obviously, my conclusion was that there was water supplied which may have not been started at that point.

MR. ENSMINGER: Well, while we're speaking about that, the next part of the question: Action brief for the commanding general of 1 March 1985, which I just referred you to, had seven alternatives, ranging from hauling water in tankers or construct a new 8-inch line from the Holcomb Boulevard water-treatment plant, which was being upgraded from 2 million gallons to a 5 million gallon per day capacity, or turn on the contaminated wells that have been shut down if required to maintain adequate water levels; estimated cost: none. New water -- new line was installed, temporary auxiliary line, in June of 1985 from Holcomb Boulevard water-treatment plant to the TT distribution center.

Question: Definitive criteria for describing -- describing operation of well status at Marine Corps base is confusing by using active, inactive, closed, abandoned, on-line, off-line, et cetera. CLW-2963, which you have there in your references, wells are taken off-line or out of service for short periods for maintenance; pumps are replaced; screens are cleaned; new data loggers installed.

Too many reports from Marine Corps base will show X-well closed in 1965, then in operation again in 1967, shut down in 1968, operational in 1969. Having run water systems, I consider a sequential pattern: One, electricity turned off, pump in well, et cetera, et cetera.

Wells are either on-line or off-line; active or inactive; temporary nonfunctioning for service or long-term nonfunctioning, which can show as permanent non-serviceable; to be abandoned. Is there a sanctioned set of rules -- state, federal, American Water Works -- that can demystify this melange of terms, which are chaotic, at Marine Corps base?

DR. JOHNSON: Does anyone know?

(No audible response)

DR. WALSKI: Well, unfortunately, I think the terminology is whatever the person who wrote it down felt like writing that day. That's unfortunately the case.

MR. ENSMINGER: And another thing is, especially over in the Hadnot Point system, when you look at the Marine Corps' chronology, you would find wells that were taken off-line for contamination. And later on in the events, you'll see that it was taken off-line again for contamination, which tells me it was back on-line.

DR. POMMERENK: I guess the only state regulation, current state regulation, in North Carolina that I recall that would relate to that is that you have to, I think, file a record of abandoning a well if you take it completely out of service. But otherwise, I wouldn't know of any, you know, regulatory issues regarding this terminology.

The other issue that you just addressed, and I'm just -- one problem could be -- and we have observed it in Camp Lejeune -- that sometimes a new well is drilled and it receives the same well number as the old well. That may have not happened in Tarawa Terrace, but I'm just throwing this out as a thought.

MR. ENSMINGER: You said at Lejeune there were wells -- new wells that were drilled that had the same number as the old one?

DR. POMMERENK: Yes. This has happened.

MR. ENSMINGER: Where?

DR. POMMERENK: I can't cite the exact numbers.

MR. ENSMINGER: Which well numbers?

MR. FAYE: Peter, I think, you know, your statement may be only partially correct. What happens in the -- when the contract -- at least as far as the documents that we have, when Lejeune turns loose of a contract, either for bidding or whatever, they'll -- there's a note on that "Well Replaced." Okay? And the old well number goes in there because there is no new well yet. Okay?

And so what happens then is the driller comes along and creates that suite of documents, like the drillers' log or Elog or whatever. And they'll put in new HP-645 or something like that or new HP-647, which is what you're referring to. But that number, in my experience -- and I've looked through dozens of these records -- that number doesn't actually stay in the system. Okay? That new something or other gets a new number. Okay? Ultimately, as far as I can tell from the Camp Lejeune records, that well gets a new number. It doesn't -- it doesn't stay the old number very long.

DR. POMMERENK: Okay.

MR. FAYE: Okay?

DR. JOHNSON: Please proceed.

MR. ENSMINGER: When were the wells or the eight wells at Tarawa Terrace taken 100 percent out of service and abandoned? When were they taken out? When were they absolutely abandoned, closed, pumps pulled?

MR. FAYE: May I address that?

DR. JOHNSON: Would you stay up there, please.

MR. FAYE: I think that's a really critical, critical, critical question. The only -- what I can say with relative certainty is that TT-26 and TT-23 were removed completely from service in February of 1985. We have records in January and February and March of 1987 that indicate that the Tarawa Terrace -- and also, I think if you look at the plant capacities, you would really have some bit of difficulty believing that Holcomb Boulevard could supply all of its needs, its original service area needs, and Tarawa Terrace needs during 1985 and 1986. Okay?

Maybe it could, but I think there would be some real serious operational difficulties. Unfortunately, the records that we have, like, for example, for monthly discharge -- monthly water-treatment plant operational records that give flows for a particular month that are exceedingly complete from 1980 to 1984 and then again exceedingly complete from 1987 to 1989. For some reason, these records for 1985 and '86 have just up and disappeared. No one seems to know what happened to them, but I believe they certainly existed.

My own feeling, as I expressed a few minutes ago, is that ex-TT-23 and ex-TT-26, the remaining wells at Tarawa Terrace that were operational in 1984, probably continued -- most of them -- in operation in 1985 and 1986. But we really -- and we do know that something was going on at the WTP in early 1987. But we really cannot say what was going on with the wells, what the well operations were in '85 or '86. The records for that period of time have just fallen into a black hole somewhere.

DR. JOHNSON: Okay. Let's continue. I'm going to ask ATSDR to provide answers expressly to each of these questions. I don't think that's an imposition on the agency. To the extent that we can provide some feedback today, we will try to do that. But if you're looking for complete, satisfying answers, this isn't -- this isn't the forum for that. But please continue.

MR. ENSMINGER: Well, in response to what Mr. Faye just said, you have there in your package CLW-1914, which is a handwritten memorandum and it's dated in 1991. And it stated in this handwritten memorandum that TT-23, TT-25, and 26 has pump, will run. However, the well was closed. I mean, they weren't 100 percent decapacitated.

MR. FAYE: That's a note from, I believe, Daniel Sharp, from the facilities branch at Camp Lejeune. And that was written in a -- in specific -- as a specific response -- as a request from either EPA or Weston Engineers as they were preparing the Operational Unit 1 project to study the contamination caused by ABC Cleaners. That was a note to Camp Lejeune and a response, asking which wells were operational so that they could prepare to sample them.

MR. ENSMINGER: Well, there are means of pulling the pumps and putting a -- and still taking samples.

UNIDENTIFIED SPEAKER: But it may be more convenient.

MR. ENSMINGER: Okay. All right. If the TT well fields were not incapacitated in 1985 and an auxiliary line to Tarawa Terrace, back and forth from Tarawa Terrace to Holcomb Boulevard, was in place in June of 1985, how do we know if Holcomb Boulevard water-treatment plant did not receive raw water from the Tarawa Terrace well fields?

MR. FAYE: We don't, and we actually have just the opposite information, a report from Geophex -- was it 1991, Morris? There is a -- there is a consultant's report that we have that we've recently referenced from a firm called Geophex out of Raleigh, North Carolina, that indicates just what Mr. Ensminger has said, that indeed, perhaps in 1989, the Tarawa Terrace wells were used to supplement the water supply to the Holcomb Boulevard water-treatment plant and perhaps for even an extended period of time in that -- within that year or maybe several years.

DR. DOUGHERTY: Did you say '89?

MR. FAYE: Yeah.

DR. WALSKI: But wouldn't they have to construct another line to go across, then, a raw-water line because you can't send the raw water over and treated water back in the same pipes. So they had to put in another line, so there'd be some record of that.

MR. FAYE: Yeah. One of those -- the report continues to say that whatever those operations were, Tom, that they ended when the -- when a freeze occurred and the pipe collapsed into Northeast Creek. So whatever was happening there, it ended when the pipe collapsed. Okay? But I agree with you, and perhaps, there were dual pipes there. But we don't have the details.

MR. MASLIA: Let me just, if I may, qualify that again in terms of data discovery and all that. We just came across this report, actually, a couple of weeks ago, maybe less than that. It's a report that's dated 199 -- March of 1991. And on page 23 it makes the specific -- apparently the author of the report, who we're trying to find out still who the author is, makes the statement going over historical issues with different well fields, and it talks about the Tarawa Terrace well field.

And it says two years ago, which would make it '89, that the Tarawa Terrace wells supplied Holcomb Boulevard with water. That's almost a verbatim quote. I've got the report with me. I have called the Geophex office in Raleigh. They are no longer doing environmental report, and I'm on my third contact, trying to actually pinpoint -- if I can pinpoint the author of the report, as well as we've asked -- we do have a contract number, Camp Lejeune contract number, for that particular report. And we have asked and I think the folks from Camp Lejeune are preparing some documents for us on the entire contract that generated that report. So we may find out more details, but that's what we have that's come to our attention within the last couple of weeks.

MR. ENSMINGER: If you'll take a look at the 1 March 1985 action brief by the Chief of Staff, Colonel Lilley, go to the last page, which is 1131. Please note under advantages, Item No. 5: Potential future use to return raw water from Tarawa Terrace wells. And I'd like you to look at Number 2 as well: Availability of water. Can draw from Holcomb Boulevard and Hadnot Point system, which leads me to believe that that interconnecting valve between the Holcomb Boulevard system and the Hadnot Point system was being opened, just by that statement in Item No. 2.

DR. JOHNSON: Any reaction, Bob or Morris?

MR. FAYE: That could easily be a --

MR. MASLIA: I'll only address one of the issues that has been brought to our attention previously, and this is by a different -- a congressionally mandated panel that occurred what? In February, Frank? Yeah, in February.

And we were repeatedly -- I was repeatedly asked the question: Would we and could we model the interconnection? Because, again, the understanding or the statements have been made previous to our investigation that the interconnection was only for emergency purposes, meaning, you know, neither short supply and by definition emergency -- and we've had this discussion with the present-day operators of Camp Lejeune -- would be, you know, a day -- maybe a day or two if either something broke or needed extra supply of water.

That panel specifically wanted to know if we could model, you know, several weeks to several months at a time of interconnection on that. And my answer to them, just to complete the answer, would be that's where we would need distribution-system models to model that interconnection.

DR. CLARK: It sounds like Tom's point --

COURT REPORTER: Microphone, please.

DR. JOHNSON: Use the microphone, please.

DR. CLARK: I'm sorry. Could we turn -- it sounds like this pipe was designed to do both things: potentially, to return raw water from Tarawa Terrace as well as provide treated water from Holcomb Boulevard and Hadnot, which is very unusual to do that.

MR. FAYE: Don't forget now, you're dealing with two pipes, okay, one connecting Tarawa Terrace and Holcomb Boulevard and the other connecting Holcomb Boulevard and Hadnot Point.

DR. CLARK: Yeah. But this talks out -- oh, I'm sorry. Yeah. This talks about one pipe: construct 8-inch line from Brewster Boulevard to Tarawa Terrace. And then it has advantages, and I assume that refers to the --

MR. FAYE: That's --

DR. CLARK: -- 8-inch line.

MR. FAYE: That's the one from -- that's the one that apparently froze up and fell into Northeast Creek.

DR. CLARK: Okay.

MR. FAYE: If they actually built it, which we don't know.

DR. CLARK: But they're talking about a potential use of both supplying raw water as well as --

MR. FAYE: That refers to what Tom was talking about.

DR. CLARK: That was Tom's point.

COURT REPORTER: You need to be at the microphone.

UNIDENTIFIED SPEAKER: Sorry.

DR. JOHNSON: Okay. Shall we move along?

MR. ENSMINGER: All right. How do historical water-system operations, assession, monitoring, treating, and distribution at Camp Lejeune relate to systems of comparable size of population served during the same general time frame from 1950 to 1985 in the United States' civilian world? In other words, how does -- did the operation of Camp Lejeune and presently how does it stack up against its civilian counterparts?

MR. MASLIA: Could I give you a brief answer now, and then, since we haven't got into the distribution side of things, give you a more detailed answer tomorrow? Because I do want to answer that, so -- but I didn't want to go off on a --

MR. ENSMINGER: No.

MR. MASLIA: -- tangent right now, if that's okay with the Chair.

Briefly, based on our experience, it's -- and I'm talking about Camp Lejeune, not other military installations, but it's night and day. There's almost basically an intent to make it demand independent; in other words, so they maintain constant pressure, constant level in the tanks.

They don't empty the tanks out, as opposed to, say, our work where we saw in Dover Township where there's more of a sinusoidal, a filling of a tank during periods of low demand, you know, midnight through four a.m. and then using that supply of water in the tanks and draining it out as people take showers or restaurants come on.

At Camp Lejeune -- and I'll admit our understanding still is not complete as total operation -- even for present day, we still have questions. They basically almost maintain a constant pressure, maintain a constant level in the tanks with the exception of one controlling tank per service area. And based on the water level in that controlling tank, which, based on our present-day information, may only fluctuate from a -- from half a foot to maybe 6 feet at most. It's in a paper we prepared. That's the maximum fluctuation we have -- we have seen based on data for present day.

Then trigger high-lift pumps to turn on, say, at Tarawa Terrace to push water through the system. So it is a totally different way of operating, and that's one of the lacking pieces of information is specific diurnal demand. You know, the military personnel, enlisted people, you know, may get up at four or three a.m., and that's when, maybe, your maximum use may be. And then it may trail off six, seven a.m.; whereas in a more urban setting, like Dover Township, you may not see a peak in demand until eight -- seven or eight o'clock in the morning. And then it levels off, and then another peak at six p.m. when people come home. And we're still trying to understand it, but typically it's a vastly different way of operating.

DR. CLARK: But they do -- they do meet the requirements of the Safe Drinking Water Act. I think that's a commitment on the part of the military to do that.

MR. MASLIA: Oh, I wasn't referring to Safe Drinking Water Act.

DR. CLARK: But in terms of treating water, they meet the requirements of the Safe Drinking Water Act.

MR. MASLIA: Right.

DR. WALSKI: Yeah. I wouldn't say "night and day" either. I mean, there's a wide range in the way systems are operated around the country, and they're somewhere in the band. You know, they're more conservative though. From what I've been reading here, they're more conservative. Like, they try to keep raw water in storage for fires and emergencies than the average system, which allows more fluctuation.

MR. MASLIA: Yes.

DR. WALSKI: But it's -- so they're a little more on that side of the curve. But there's a wide range of operations. If you go -- every time I say I've seen it all, I go to the next water system. I see something totally different.

DR. CLARK: That includes civilian water systems too; right?

DR. WALSKI: Yeah; civilian and military.

MR. FAYE: I don't -- I don't mean to belabor the situation, but it is really important. Going back to the use of the wells at Tarawa Terrace during 1985 and '86, we do know that from Naval records that water samples, specifically to identify any contaminants, were collected at the water-treatment plant at Tarawa Terrace weekly from March 1986 to March 1987, which certainly lends [sic] me to believe that -- that the wells were operating during that period.

And monthly samples were collected at TT-25 during that same period, so there was this continuing concern on the -- and these -- this sampling program was recommended by North Carolina DEM and, I believe, implemented by the Navy, by the Marine Corps.

So it just seems rather incongruous, if the wells were not operating and if there was still a not a concern about contamination, that none of this sampling program would have been implemented. And that's the main reason that I believe that the Tarawa Terrace supply Wells ex-TT-23 and ex-TT-26 were operating during 1985 and 1986.

MR. ENSMINGER: I know that flow meters have been installed during the conduct of this study. It's been published in the newspapers down at Camp Lejeune. What results can be made public at this time, and do they -- do they match your expectations?

MR. MASLIA: Again, we'll get into the specifics this afternoon and tomorrow, but basically, flow meters were recommended -- or requested to be installed by ATSDR because we could not just, based on system records available to us, get a handle on flow to different areas and trying to establish a diurnal and demand pattern.

We located 16 areas -- or 16 points, not areas, 16 points where we wanted the flow meters installed. This discussion took place initially with representatives from environmental management division from headquarters, Marine Corps and Camp Lejeune staff in July 28th -- on a July 28th meeting at Camp Lejeune. And headquarters said to proceed with that.

As of -- in January, towards the end of January, all the flow meters were installed. It was ATSDR's technical staff, meaning myself and my staff, that a performance-based contract be used to install those; that is, install one and see any issues that may arise with it, how useful it may be. And then proceed to the next one or not proceed, as the case may be.

We were in a position that to let a contract of that size -- for ATSDR to let a contract would have required us to, at the minimum, advertise in the *Business Commerce Daily*, and you would have seen that taking six months or longer -- eight months. So at the time, it was decided that the Marine Corps would handle the procurement.

Apparently, they had a contract in place that would not require such a long time to get the flow meters installed for procurement. That was already in place, whereas ATSDR would've had to advertise to the world basically on a size of that, 16 meters -- a contract containing 16 meters.

So that's why. The Marine Corps offered, and we accepted their offer for them to do the procurement and installation. So we were in the recommendation stage. We did recommend that it be performance based. All 16 were purchased, and all 16 were installed.

As of this past March, while they are operating, they are not calibrated. And we're still working on that. We have submitted a report, a detailed report, on every flow meter on what needs to be done to calibrate the flow meters so we can get reliable information. So the short answer to your question is: We have not obtained any reliable or useful information to date from the flow meters.

MR. ENSMINGER: What's the holdup with the calibration?

MR. MASLIA: Some technical issues. Number one, in the calibration process, certain valves have to be shut off to zero the meters out. And on the other side is ATSDR not having -- or I not having staff to actually -- as I alluded to, we don't have a field office there. So when questions need to be answered, we are not on site to specifically direct the work to do that.

We are not on site there full-time, and so it's a combination of installing field equipment and so us making trips back and forth. We have been told on a number of occasions that the flow meters have been calibrated. We have made trips up there, and when we try to QAQC them, they're not calibrated.

DR. JOHNSON: Let me digress and ask if anyone else from the public plans to make a statement.

(No audible response)

DR. JOHNSON: Seeing no hands raised, please, continue.

MR. ENSMINGER: Historical documentation: pumping records as to quantity, quality, distribution-system problems, well-field problems, infrastructure data on well construction, depth output, locations are by necessity to be furnished by the environmental management division of Marine Corps base Camp Lejeune or by their utility section.

Has ATSDR received all the materials it has specified that it would require? And if not, what is the explanation? And has ATSDR brought this matter of lack of cooperation to a -- to the attention of anybody else, such as headquarters of the Marine Corps?

MR. FAYE: Well, first of all, let's not make the presumption that there's been a lack of cooperation because I wouldn't go that far. In a number of areas that are very critical, the Marine Corps has been extremely forthcoming and provided very useful information.

As far as the well data are concerned, between the information that we have obtained from the Marine Corps and from the U.S. Geological Survey, who, as I mentioned earlier, did two very comprehensive studies there in the late 1980s, we've got a -- we have -- ATSDR has a very -- what I would say a very substantially complete record of all of the wells that have been drilled at either Holcomb Boulevard, Hadnot Point, or Tarawa Terrace, or Camp Johnson, starting back in the early 1940s up to about 1987 or '88.

We do have additional -- well, several additional well records that have been completed at Camp Lejeune; very extensive records with contract numbers and whatever. Now, we have asked Camp Lejeune if -- we've asked them for some location data and other information about these wells that they've not provided yet. But in that regard, you know, that's only a half a dozen records.

Another thing I'd like to point out is the records provided to us relative to RI/FS studies and underground-storage tank removal studies at Tarawa Terrace have been very, very useful. And as far as I can tell, the records provided by Camp Lejeune, which are in the dozens -- dozens of reports, are complete.

We would really like to have a similar contribution of those RI/FS and underground-storage tank removal reports, et cetera, from the -- for the Holcomb Boulevard area and the Hadnot Point area, and we've asked for that. But that's a large volume of information, and we haven't received it yet. But we hope we will in the future. In fact, very soon, I hope.

But as far as the well data are concerned, specifically, I think we have a very substantially complete record of what's available, of the data available.

MR. ENSMINGER: Listening earlier --

MR. FAYE: No. That doesn't -- that includes the well data in terms of, like, construction. That does not include operational information.

MR. ENSMINGER: Yeah. That's what I was just going to ask because earlier you stated that you didn't have near the information for, say, Hadnot Point that you did for Tarawa Terrace. I mean, that's the same organization. The same outfit that's running Tarawa Terrace is running Hadnot Point. So if they had good records for Tarawa Terrace, they should have good records for Hadnot Point water system as well.

MR. ASHTON: I'd like to --

COURT REPORTER: I need you to get to a microphone. Please identify yourself.

MR. ASHTON: I'm Brynn Ashton, and I've been really spearheading the effort from our environmental management division to provide the information. And in all cases, I think we've given -- we tried to provide you whatever we have. Recordkeeping is not consistent across Camp Lejeune. And there's been times where we might have some information in certain plants. We might not have as good information or organized as well in other plants.

So what we've tried to do is provide whatever we have, and, you know, the Commandant has made it very clear to us that we shall provide you with whatever information we have in as timely a manner as possible. If, at any time, it appears that we are not providing that information, it's just because it's not available or it's not organized. Or in some cases, we've scoured our records. We've found records that we did not realize were in existence. So in summary, we have the charge, we have the mission, to provide as much information as you ask in as timely a manner as possible.

MR. ENSMINGER: I have another question for you while you're up here. If that's the case, the plant account records --

MR. ASHTON: Yes.

MR. ENSMINGER: -- I know that EMD has a listing of all and has pulled all the well data and all of the water-system data off the plant account records, all the historical data. I know it exists because I used to call Rick Raines and get certain information from him when he was here. Why hasn't that been provided to them?

MR. ASHTON: Now, I think -- I think they will verify that we've provided them what we have. The plant account data is very minimal. It -- what it has is it has square footage of the buildings. It has years of construction. It has, you know, numbers of the facilities. It has certain category codes, and that -- you now, that is available through our plant account organization.

MR. ENSMINGER: I know.

MR. ASHTON: Some of it was not computerized. Some of it's in hard copy.

MR. ENSMINGER: I know.

MR. ASHTON: I think we've provided you what you've asked for on the plant account. And we've -- we actually have a point of contact that runs that section, and what we've done is we've provided the point of contact so you can get whatever information they have.

Again, you know, I'm not always proud of their -- the level of recordkeeping that we've done in the past. You know, we've already alluded to some gaps in the knowledge. Whatever we have, whatever we can locate, we provide. And, you know, that's our charter. That's our charge from the highest level, from the Commandant, is that we be fully cooperative, that we provide whatever information we have. And we're routinely -- we're going through records as we speak. We've got volumes of records.

Morris will verify to the facts that we have this vault with, probably, 70,000 different drawings in it. And the vault dates back from the forties because, for example, Tarawa Terrace was built by a private contractor --

MR. ENSMINGER: Mm-hmm.

MR. ASHTON: -- the records are very spotty because we -- they weren't government records when the development was initially constructed. The air station, for example -- this isn't part of this study. But, you know, we had virtually no construction drawings from the early fifties from the air station. It was just discarded by somebody. That's the unfortunate environment that we're working with. But the one thing that, I guess, I'm here to say is that whatever support we can provide, whatever information we can provide, we try to provide that as soon as -- in as timely a manner as possible.

MR. ENSMINGER: Thank you.

DR. JOHNSON: Well, thank you for your comments. Do you have one more question, Mr. Ensminger?

MR. ENSMINGER: No. I have some -- I have some statements. The reason I am a bit skeptical of the Marine Corps or their personnel, as far as their involvement in this thing -- and you have to admit, Camp Lejeune, that -- or the people that represent Camp Lejeune now, today, what was done in the past at Lejeune regarding this situation, there's -- there have been some real atrocities committed down there by some people that provided ATSDR with incorrect water-system data, purposely. And when they were told to correct it, they did not do it.

And there was a repeated request by headquarters Marine Corps for you to correct it -- or not you, but your predecessors: Mr. Neil Paul to be exact. And he did nothing. And ATSDR went from 1993 to 2003 under the assumption that the Holcomb Boulevard water system provided water for all those housing areas on the main part of the base for the entire study period, which was '68 through '85 when, in fact, Hadnot Point provided that water up until 1973, August of '73. And that's by statement from Carl Baker from the plant account records.

So can you understand my skepticism? And you've got to understand that I lost a child. And I wish -- there's no way that I can relay to you what I feel and what my daughter went through. And damn it, I want to know, and there's a lot of other people out there that want to know what happened to their kids. I want to know why my daughter went through the hell she went through. And if there's anybody that's withholding information or not providing correct information, I swear to God, if I find out about it, I'll do everything that is possible to make sure that they are dealt with.

DR. JOHNSON: We appreciate your comments, and we offer, certainly, our condolences in the loss of a child. We cannot fully appreciate your feelings, but we certainly commiserate with you and offer you our sympathies.

I have asked your comments and those from Mr. Townsend might be made part of this public meeting's record. I have suggested, Dr. Cibulas, that the agency provide a response to what are serious and important questions. And I hope that you feel that you've had a fair hearing and response to your questions today.

MR. ENSMINGER: Well, we'll see by the end of tomorrow.

DR. JOHNSON: Okay.

MR. ENSMINGER: Thank you.

DR. JOHNSON: Thank you again. I'd like to return to these eight questions and ask first of all, Mr. Maslia, we've got four through eight. Is there any priority here in these -- priority of importance in these questions that remain?

MR. MASLIA: Okay. Let me reorient myself here; not really. They're of equal importance.

DR. JOHNSON: Okay. Let's turn to Question 4: Should ATSDR consider using a parameter estimation approach to assess parameter sensitivity? And I suggest that you -- that we ignore the second part of that question: when such a process should begin. Anyone want to take a bite on parameter estimation? Eric.

DR. LABOLLE: Are we referring to the distribution system model or the groundwater model at this point?

DR. JOHNSON: Groundwater.

MR. MASLIA: Groundwater.

DR. LABOLLE: Well, my primary concern would be with dealing with the uncertainty and variability in the subsurface with regards to parameter estimation. At this point in time, there is some preliminary characterization done and a model constructed. And the construction of the model -- and I think I voiced some of this in my premeeting comments -- kind of constrains one's characterization of the subsurface, which is considerably more variable. And the uncertainty in that is great. We have samples at locations, wells, borings, and such, but no information between other than what we know of the geology.

And so the parameter estimation that you do is going to allow you to vary these parameters within the cells based upon the constraints of the model. And my concern -- not -- that's not a bad idea, but my concern would be that the model response is still constrained by the characterization that's in place and that there potentially be, in addition to, depending on the role of the groundwater model, of course, and the level of detail that it requires in order to improve the answer.

But my concern would be that not only there would be some parameter estimation, but also a way of addressing the uncertainty and variability in the subsurface beyond the constraints imposed by the current characterization, if necessary.

And that's going to be driven by the epi model, whether or not one needs to essentially get at multiple exposure scenarios in order to tease out the dose response. So if the epi model is very weak in a sense in terms of its correlation, the actual dose response, then one might need multiple exposure scenarios in order to find that. There's my primary concern. But, certainly, parameter estimation, I think, is a necessary step if, indeed, one needs to refine the arrival curves to these wells.

MR. FAYE: I have no argument or really even any comment to say except that I agree with you, and we've always planned to use parameter estimation to the greatest extent that we possibly could. We've only done it recently -- or not recently. But with respect to the prepumping model, I spent quite a bit of time using PEST and UCODE to estimate -- to estimate that recharge rate. And frankly, I didn't get any better answers than just using the estimate that's published in several -- several papers. So -- but it's something that we definitely plan to deal with in the future.

DR. LABOLLE: There is one additional concern actually with regards to parameter estimation that I've been meaning to touch on at some point here which is: What data do you calibrate to? And I've noted from some of the slides you had up there that parameter estimation or the focus on the calibration has been on the hydraulic model, and that's used in the transport model. Now, to the extent that the parameter estimation could be used in combination for both the hydraulic and the transport model, I think that's quite important.

And the more recent data that's available on concentrations, unfortunately, probably doesn't overlap with the time frame of interest and the time frame in which the model's been developed.

But if there was any plan to extend the model period forward over the later periods over which you have better information, there may be something to be gained from calibrating the transport model to probably the better data on concentrations in later time periods.

MR. FAYE: Oh, yeah. We would definitely be remiss if we ended our calibration in 1985. We would extend the calibration for the fate and transport to 1991, which is the last period that we actually have contaminant information at several supply wells. That's always been on the books to do that. I had another comment. It slipped my mind.

DR. LABOLLE: Is there --

MR. FAYE: The -- pardon?

DR. LABOLLE: Is there additional data after '91 also?

MR. FAYE: No; no; no. As Mr. Ensminger said and as I reiterated later in some of my comments, apparently, right after the wells were sampled during Operable Unit 1, the Operable Unit 1 study at ABC Cleaners, the Marine Corps destroyed the wells, literally. It grouted them up, took the hardware out, pumps, and grouted them up.

DR. LABOLLE: And there's no monitoring at the monitoring wells after that time period? Or is there?

MR. FAYE: No; no. I think actually the monitoring wells are gone as well.

DR. LABOLLE: Okay.

DR FAYE: Except for the immediate vicinity of ABC Cleaners because they have to -- they have to have some means of determining the efficiency of their remediation activity there at ABC Cleaners. So that's pretty much it. The -- as you saw, we would -- in order to -- in order to do some parameter estimation during this transient period, we would probably do some additional refinement on those so-called static water levels.

You saw the shotgun scatter diagram there, so that makes -- that makes the notion of parameter estimation a little -- a little difficult when you're trying to match that number of water levels plus that type of variability in the water levels. But it's definitely something that we -- that we'll deal with. And that was a good comment. Thank you.

DR. JOHNSON: Any further comments on that question?

DR. CLARK: One comment.

DR. JOHNSON: Yes; please, Bob.

DR. CLARK: It seems to me that, in addition to having data for parameter estimation, it would be nice to be able to create an independent data set for validation of predictions. And I think that would be an essential part of the protocol for doing the regression estimations.

MR. FAYE: The only -- the only way we could do that would basically to be randomly select data from the -- from the -- from the total population of the database that we've got. We could do that.

DR. SINGH: I would like -- since it says no linear regression approach, you know, I think you should consider using more efficient and powerful parameter estimation techniques, such as GLUE, and especially in conjunction with the generic programming, your load times. I think that would be a better approach than only the regression approach, especially when you have such limited data.

MR. FAYE: Thank you.

DR. DOUGHERTY: One other comment is that, at least the way the language is usually used, parameter estimation assumes a model. And it seems to me that the model estimation, at least the submodel for source terms -- and getting ahead of our current topic -- tanks is perhaps more significant than some of the parameters that one might first think of going off and estimating. And my initial reaction is that the model estimation process, particularly at the source term, is more significant.

DR. JOHNSON: Okay. Let's move on to the next question. Should ATSDR consider using probabilistic analyses to assess the variability and uncertainty of model parameters and variability and uncertainty of contaminant concentrations at public supply wells? Are there public domain codes available that the panel would recommend using? Anyone want to bite on that one? Please.

DR. CLARK: I'll take a shot at it. Yeah. I think the idea of using probabilistic analysis and so forth is a good idea, but I'm wondering: You're having enough trouble dealing with just the -- with the deterministic model you're working with is -- wouldn't that add a level of complexity that goes way beyond where you could possibly go at this point?

MR. FAYE: That was your question, Morris. You answer it.

MR. MASLIA: Yes. Yes. That was a question posed in the early stages of the formulation of this panel, and we were trying to consider any and all topics that might be brought to the table. And obviously, the panel has sort of narrowed our focus into certain areas. And it may be just more than we can bite off at the present time. And I think, as David already appropriately pointed out, we may be talking more into model estimation as opposed to parameter estimation, given the limited data that is available, and really find out how our model -- the effect on the performance of our model.

If I could just go back for a second when -- Eric, you were speaking about calibration for -- from the water-quality standpoint or from the transport standpoint in addition to the hydraulic. And I think we've taken -- and this gets into the distribution side.

But we've taken that approach, and that's one of the ideas that has driven us on the water-distribution side -- once we saw some of the hydraulic parameters of the distribution side -- to do tracer tests, realizing that if we were going to ever calibrate a distribution model that we would have to calibrate it to water-quality parameters, rather than just on the hydraulic side.

We would probably end up, at best, with a nonunique hydraulic solution; at the very best if we did not. So we are aware of that. Your point is well taken. We're probably at that step on the distribution side, and that's a step we need to look at from the groundwater side.

DR. LABOLLE: I think it might be important here to define what we mean by calibration to some extent because the previous question was with regards to parameter estimation for calibration. But in my mind, when I speak of calibration, I think we're talking the big picture, including the source term, as David brought up, then including the recharge and everything else --

MR. MASLIA: Oh, absolutely.

DR. LABOLLE: -- that comes into play here, so...

And with regards to the use of specific models, I'm reluctant to advise ATSDR to necessarily embark on, for example, a geostatistical approach to -- although that's kind of what I was implying by my previous answer. I'm reluctant to specifically recommend that at this point in time until I understand more the role of the tanks, the mixing, and the distribution-system model, the time frame at which we know contamination was present at some of the wells relative to, you know, some of the uncertainty, and how much uncertainty can be tolerated in the epi model. I think that's going to become apparent over the next day and a half.

DR. WALSKI: Instead of using the word "probabilistic" analysis, I would just think in -- more in terms of sensitivity analysis. Find out what is the model sensitive to and focus on that parameter and not try to figure out every cell's hydraulic conductivity or anything like that. And you know, focus on the one or two things that really make a difference. And it's probably going to be source.

DR. DOUGHERTY: And the answer is -- focusing on the last part of the question, rather than the first part, the answer is yes. You should you use some probabilistic analysis for the impact at the -- it's not clear yet whether it's the individual wells or the blended well concentrations but on that metric. Yes.

DR. LABOLLE: Yeah. The answer -- if I can elaborate on what I said -- I was reluctant to provide recommendations for using geostatistics but certainly some sort of probabilistic analysis is going to have to be employed to consider the uncertainty in these arrival curves to the wells regardless of how well you know the source because although the source terms -- and the uncertainty in that is going to, you know, directly affect the arrival to these wells and the concentrations at which the PCE arrives.

The hydrogeologic uncertainty is an additional component that will make that highly uncertain as well and possibly on the order of a magnitude, an order of magnitude or more, maybe even two orders of magnitude, uncertainty in concentrations that arrive to these wells, even from the hydrogeologic uncertainty. And so constraining that, to the extent that you can, from the models, I think, is important.

DR. JOHNSON: Okay; moving on. How should ATSDR address the issue of lack of observed water-level data prior to 1974, reminding us that the epi study is from 1968 -- or covers 1968 through 1985?

MR. MASLIA: That should have been from '78. If you've been following the discussion all day, we don't have the data prior to '78.

MR. FAYE: Very few.

DR. JOHNSON: So that becomes a moot question.

MR. FAYE: No. But I think we've already addressed it in terms of the uncertainty discussions and the parameter estimation discussions. I think we just sort -- it would be a lot of repetition in response to that question, but that's no reason not to respond.

DR. JOHNSON: If you're happy, I'm happy. Any comments on --

MR. FAYE: Okay. I'm happy.

MR. MASLIA: The only comment I will -- I will make and I've had this initial discussion with Frank Bove, and he's actually prepared some, I guess, iterations or some initial analyses. And the discussion went along the line is: How much uncertainty or variability could the epi study tolerate in terms of if our arrival times are plus or minus a couple of months versus plus or minus six months versus plus or minus a couple of years?

And that's an issue. As I said, he's just prepared some preliminary analysis on, but that's something we need to sit down and discuss with them. That's the exact issue. So the fact that we don't have very many data prior to '78 brings that again to the forefront since they're starting the study in '68.

DR. KONIKOW: Do you have pumpage data from prior to 1978?

MR. FAYE: Yeah, we do, Lenny. We have periodic information for, perhaps -- well, not perhaps, for a particular year. Maybe, I think we have data for '71. We have data for '62. And, of course, the USGS, their data go to '75. I think we also have some '68 data, but these are just, you know, snapshots.

And -- but the point is -- and I think I made it earlier -- that because of the -- because of the utility of Tarawa Terrace, the housing was occupied 90 percent to 100 percent all the time. And that's borne out in the USGS data as well. I mean, we're looking at point -- averages of .95 MGD plus or minus 10 percent for, you know, well over a decade. And I think that was probably the case, you know, from the get go.

DR. KONIKOW: So really what you're saying is that if you can calibrate the model adequately for the times when you have water-level data --

MR. FAYE: Right. That's --
DR. KONIKOW: -- you could then run the model --
MR. FAYE: That's the whole plan.
DR. KONIKOW: -- impose the stresses --
MR. FAYE: Yep.
DR. KONIKOW: -- for the earlier time.
MR. FAYE: Right. That's the plan.
DR. KONIKOW: -- and that still leaves you with the issue of concentrations though.
MR. FAYE: Exactly; exactly. And the thing that we hope to be able to do is to have some good estimate of mass loading through time. It should be fairly constant except for the periods there that, like Mr. Ensminger was discussing during Vietnam, when there was -- when it was probably somewhat to greatly accelerated, the activities at ABC Cleaners.
But for all intents and purposes, it is a single source, and hopefully, maybe, perhaps from these tax records or other information that we'll be able to discover in the reasonably near future. We should be able to -- or we'll hopefully be able to get or to obtain some notion of the use at the source. That still doesn't really address what the loss -- what the percentage of loss was from their actual total use. So we'll just have to start out, make some estimates, do alternative

simulations, and hopefully arrive at a defensible, reasonable answer.

DR. KONIKOW: Well, I think what you're going to come up with is that there was some contamination there from the beginning of this --

MR. FAYE: Right.

DR. KONIKOW: -- epidemiological study.

MR. FAYE: Oh, yes.

DR. KONIKOW: And --

MR. FAYE: No question.

DR. KONIKOW: -- you may not be able to refine it down any more than we just said.

MR. FAYE: Maybe we can't; yeah. I don't know whether that precludes the attempt or not. That's hopefully what -- where we'll get -- gain some insights from you-all.

DR. JOHNSON: Okay. How should ATSDR address the issue of lack of monthly groundwater production data when monthly data are required for the epi study?

MR. FAYE: Well, let me say a few words about that too. We now have good monthly data back to 1980. All right? And we have -- prior to 19 -- 1980, we probably have, maybe, three, four, five snapshots in time of the well capacities because the well capacities have changed through time.

So what we can ultimately do -- what we possibly should be able to do, using the monthly data that we do have now from 1980 through 1984 and the well capacity data that we have for that time, possibly rate the -- that use as a factor of -- as a factor of capacity. And then, as the capacity changes back through the historical record, adjust that on a monthly basis. And knowing what the annual record is -- we know what monthly variability is now from the -- from the detailed records that we have for those four, five, six years -- develop a model of activity. Okay?

MR. MASLIA: One of the pieces of information that we've just recently obtained, which has been referred to, is this plant accountability record. I actually have a copy with it, and it goes from 1990 backwards 'til they started keeping the records.

What's in it is it lists -- for example, it lists the pump house or well house and treatment facility and anything by all the different water-plant areas at Camp Lejeune. It references a card number, which is my understanding how records are referenced to or kept in the vault at Camp Lejeune. That should -- at least, we'll make the attempt at going back there and pulling whatever information is in there.

Up until we got that information telling us or suggesting that we go into this storehouse of information and start looking someplace, it was like looking for a needle in a haystack. You don't know where to turn to look. At least now we have some directed means. Whether that yields useful information or not, I can't answer, but that may -- in fact, just this last week -- I think it was last Thursday or Friday -- I received from the EMD folks at Camp Lejeune the -- was it from the '80 to '80 --

MR. ASHTON: '84.

MR. MASLIA: '80 through '84 monthly production records by every water system. So this information is still coming in. And as we have -- as we refine -- excuse me -- our approach based on recommendations from this panel -- also I think that goes hand-in-hand with hopefully obtaining additional data we may find. In other words, we have not given up on trying to locate the earlier information.

DR. JOHNSON: Okay. Anything else? Lastly, Question 8: Is it sufficient to use an annual average recharge or infiltration rate and assess climatic conditions to derive monthly recharge rates? Are other methods or techniques available to derive monthly recharge data? Does anyone know?

DR. CLARK: [off microphone]

COURT REPORTER: Sir, I need you to use the microphone.

DR. CLARK: I'm sorry. Could one use some of the meteorological data we discussed to get estimates?

MR. FAYE: Yes. That's our plan now. We have monthly rainfall, pan evaporation records for the entire period of interest, starting in the early fifties and going up into the nineties. And once we can decide on this baseline annual recharge, whatever it is -- 14 inches, 13 inches, 15, something like that.

Whatever that is, then we can use that -- and we compare that then to the -- we have -- what we'll have from that -- from that long period of meteorological record, we'll have an -- a long-term average annual rainfall as well. So we can equate that 14 inches of recharge to the long-term average rainfall. And then, using the monthly data, we can prorate that out.

We can say, well, for 1963 the recharge -- the annual recharge was only 10 inches and prorate that out on a monthly basis, using the meteorological record. 1975, it was 16 inches and prorate that out, using the meteorological record. And hopefully, we can develop a recharge schedule for the various stress periods that way. It's not -- it's not, you know, it's not rocket science, but it is somewhat practical and common-sensely and straightforward. So hopefully, it might work.

DR. CLARK: Can you get an estimate for changes in soil permeability over that period of time?

MR. FAYE: There may be some agricultural records at an experiment station somewhere down there in the coastal plain where they -- where they collect those -- that information, I guess, almost daily, particularly during dry periods. We haven't looked for it.

DR. DOUGHERTY: The only comment I have with respect to using the preset and then generating the variations of the record is that that may be excessively rough compared to the infiltration function at -- as it accretes to the groundwater system. So it may be useful to -- basically the unsaturated zone acts as a buffer and --

MR. FAYE: Sure.

DR. DOUGHERTY: -- and a smoother, so it may be useful to use a very simplistic, one-dimensional model, representative of characteristic depths to groundwater --

MR. FAYE: Oh.

DR. DOUGHERTY: -- to reduce the roughness.

MR. FAYE: Mm-hmm. And then what would you -- you would -- you would bleed off the rainfall with some estimate of ET or loss, using, what, pan evaporation data or something like that?

DR. DOUGHERTY: That's one approach. The other approach may be to do a simple, straightforward extension of what you're doing now.

MR. FAYE: Oh, okay.

DR. DOUGHERTY: You have an average --

MR. FAYE: Okay.

DR. DOUGHERTY: -- from the average prorate. That's the loading to the top of your reactor.

MR. FAYE: Right; right. And the advantage of what you're saying just because we think we got 14 inches of recharge or maybe the 1 inch of recharge during a particular month -- because of the thickness of the unsaturated zone, the water table may not see that for another month or another two months.

DR. DOUGHERTY: Right. The unsaturated zone acts as --

MR. FAYE: Yeah.

DR. DOUGHERTY: -- as bank storage.

MR. FAYE: Yeah. And the advantage of what you're saying would allow us to look at that antecedent condition pretty nicely.

DR. DOUGHERTY: Perhaps. The other advantage is that it may smooth out some rewetting problems that you may have because it's smoother rather than rougher.

MR. FAYE: Oh, yeah; right; okay.

DR. LABOLLE: You might try -- with regards to that, you might try the -- I think it's been released. But one of the researchers in our office was developing --

COURT REPORTER: Can you get nearer your microphone, please.

DR. LABOLLE: -- the sat/unsat package for Modflow. And it's not a full unsaturated code, so it doesn't have its complexities that you'd -- that you would normally associate with that --

MR. FAYE: Well, that's good.

DR. LABOLLE: -- an enigmatic wave --

MR. FAYE: Okay.

DR. LABOLLE: -- approach.

MR. FAYE: Yeah.

DR. LABOLLE: And it will provide the buffering that you're looking for. It's essentially, you know, a modified recharge.

MR. FAYE: Oh, that would be nice. What's this person's name?

DR. LABOLLE: That's the -- Dave Prudic is working on that with Richard --

MR. FAYE: Oh, yeah, I know Dave.

MR. MASLIA: Oh, we know Dave.

MR. FAYE: He's a personal friend of mine.

COURT REPORTER: One at a time, please.

DR. LABOLLE: Rich and Dave are the two --

MR. FAYE: Okay.

DR. LABOLLE: -- that have been developing that, so --

MR. FAYE: Oh, okay.

DR. LABOLLE: I think it's either been released or it's in testing, one or the other.

MR. FAYE: All right. Well, it's time to harass Dave.

MR. MASLIA: Lenny, would you know anything -- would you know anything about if that's been officially released by the survey?

DR. KONIKOW: To the best of my knowledge, it's not officially released yet.

MR. MASLIA: Okay.

DR. JOHNSON: Okay. We have plodded through these eight questions, and I offer the panel the opportunity to further elaborate on any point, something you, maybe, have forgotten and wished you had brought up as an earlier discussion. But this is going to be pretty much the conclusion of comments on the groundwater modeling. Anything that any panelist wishes? Please, James.

DR. UBER: Well, I just -- I'm no groundwater modeler at all, but I've heard a few people talk about source terms. And I just offer this as an idea for it to be shot down, I guess. I wonder whether some more time should be spent on working your way back to the source, to your, you know, your hardest number, which I guess is your estimate of how much PERC they used on a monthly basis.

So in other words, I mean, I don't know how a dry-cleaner operates and how much they lose --

MR. FAYE: Well, we don't either.

DR. UBER: -- and how much is diluted with other -- with water as it goes into the septic system and whatnot. But should more effort be spent on modeling that process?

MR. MASLIA: I think -- if I can do that one.

MR. FAYE: Have at it.

MR. MASLIA: That's really -- and this may be an inappropriate term, but I'm going to use it anyway. I can get shot down. That's really a facilities management-type question that you're asking. How was the facility managed, and can we glean any information as far as how we classify or quantify the source that goes into our groundwater model?

In other words -- and that, I think, goes back to this data-discovery issue. Can we pull tax records? Can we perhaps find -- and I don't know the issue. But if you look at deliveries, deliveries to the dry-cleaner on how much they use, we should see an upswing during the Vietnam period, obviously.

And then perhaps through the -- there's a dry-cleaner -- National Dry-Cleaners Association. Because my dry-cleaners -- I asked him once about PERC, and he gave some handout from them. So I know they have a national organization. They may, in fact, have some information we have not looked on on typical uses, historic uses. That's an area, I agree, I think we need to really look at.

DR. WALSKI: So related to this, we're doing all this sophisticated stuff, going back through tax records and all that, why don't we just talk to the guy that ran ABC Cleaners? I mean, get somebody who was the manager and interview that person and find out what they did, I mean --

UNIDIENTIFIED SPEAKER: Because he's dead.

COURT REPORTER: Either at the mike, or (laughter)...

DR. WALSKI: If he's dead, then I think one of his employees or somebody should know what went on there. There should be somebody who worked there that's still alive.

MR. FAYE: I think we're also dealing with, Tom, something you pointed out a few minutes ago with regard to the operation of these water-treatment plants. And that is, you know, there's a broad spectrum of the way folks do things, and I think -- and we had two -- we have two examples right there.

We have the ABC Cleaners, who were, obviously, exceptionally sloppy, to put it kindly, and we have this Globarama place, who was very -- they were very efficient in their operations and how they -- how they tracked their and collected their PCE waste. So, yeah, we need to try to find out as much as we can about that. And all of that affects the source term, and there's just no denying -- and we wouldn't that -- the source term is a critical, critical, critical feature of the fate and transport model.

DR. LABOLLE: You might want to look at one of these other simple models for looking at a dissolving source like that, you know, a DNAPL, like we're dealing with here.

MR. FAYE: Mm-hmm.

DR. LABOLLE: And I've actually run some of these in the past. I forgotten the names if it. Something called 3-D? Does that sound --

MR. FAYE: There's something called Fate 5. There's a number of them out there.

DR. LABOLLE: And, you know, that may be helpful, I think, in --

MR. FAYE: Mm-hmm.

DR. LABOLLE: -- because, you know, what's been mentioned is one aspect, which is facilities operation.

But then below that, you know, you've got the unsaturated zone. You've got the source entering in there. And you're looking at the saturated zone, not the unsaturated zone.

MR. FAYE: Right.

DR. LABOLLE: So it might be useful in helping to refine what the source may have looked like once you get a handle on how much is entering the subsurface.

DR. JOHNSON: Mr. Ensminger.

MR. ENSMINGER: I just wanted to add one thing. I know that depositions were taken prior to Mr. Meltz's death by the EPA and some different law firms. And those are available.

MR. FAYE: Do you know where?

MR. ENSMINGER: Yes. I'll tell you.

DR. JOHNSON: Okay. Thank you for your comment. Anything else on groundwater?

(No audible response)

DR. JOHNSON: Looking at tomorrow, let me bring to your attention that we begin at eight a.m., not 8:30. So there's a time change, so be here a few minutes before eight. We will begin, Morris, with your presentation on the water-distribution system, an update on that work, and then go from there into the set of questions that the agency has brought forward.

As a matter of, perhaps, a take-home assignment to the panelists, we're going to be talking about these four charges. And clearly, we've already discussed some of this. And tomorrow at the working lunch, we need to begin formulating some specific responses to these four charges. And I would ask that you simply look at these four charges tonight, maybe put a few notes in the margin. And that will help us perhaps go through these in a more efficient fashion tomorrow.

With regard to the hotel, is there transportation provided this evening as well as tomorrow? It's a very accommodating hotel.

MR. MASLIA: There probably is. If there's anyone out in the lobby -- you mean going back to or going out to a restaurant?

MR. MASLIA: Going --

DR. JOHNSON: All of the above; yes.

MR. MASLIA: The hotel is very accommodating, and I will see if anyone's out in the hallway to answer that question.

But if I -- if I might just -- about a 60-second point here is, again, on behalf of the technical staff -- and I assume I won't get beat over the head by agency management for speaking for the agency, although Bill's backing his chair up right now, so maybe I shouldn't. We do very much appreciate your input. It's very useable. It's from people who've seen a variety of cases, both public and private contamination cases.

One of the things we take into consideration -- for example, if we modify or go down a different path, taking the information that you have provided us, we still need to provide our other audience, the public and others, a technical reason why we have chosen to change direction. In other words, so that may still require us to say, "Well, we did a cursory review of Hadnot Point, and, based on recommendations from the panel and what we're seeing right now, we're not going there any longer."

And that's just, for those who are not familiar with the way ATSDR operates, we do have this other audience to, at least, you know, address or at least acknowledge their questions. So that's the other side to that. You're obviously not charged with, but our mission is charged with. So while some of these questions may seem like why did they ask these questions or why are they posing it, the answer may be obvious. We do -- we're posing them because we have another audience to acknowledge and to provide respectful answers for. So we do appreciate your contributions and look forward to continuing down with the distribution side tomorrow.

DR. JOHNSON: May we leave our materials in this room?

MR. MASLIA: Absolutely. It'll be locked up.

DR. JOHNSON: Okay. Anyone want to say anything?

(No audible response)

DR. JOHNSON: If not, thank you for a good day.

(Whereupon, the proceeding was adjourned at approximately 5:08 p.m.)

EXHIBIT 8

THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

convenes the

EXPERT PEER REVIEW PANEL

ATSDR'S HISTORICAL RECONSTRUCTION ANALYSIS

CAMP LEJEUNE, NORTH CAROLINA

VOLUME II

The verbatim transcript of the meeting of the Peer Review Panel, held at 1825 Century Boulevard, Room 1A/B, Atlanta, Georgia, on Tuesday, March 29, 2005, taken by Diane Gaffoglio, Certified Merit Court Reporter.

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C O N T E N T S

Volume II
March 29, 2005

Legend of the transcript:

[sic]	Exactly as said
[phonetic]	Exact spelling unknown
--	Break in speech continuity
...	Trailing speech or omission when reading written material
[inaudible]	Mechanical or speaker failure
[microphone]	Speaker is off microphone

P A N E L I S T S

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P R O C E E D I N G S

8:07 a.m.

DR. JOHNSON: Good morning. Good morning, one and all, and I hope you all had a restful evening. Before we ask Mr. Maslia for any housekeeping kinds of things, let us welcome one of our panelists, Benjamin Harding, who had airplane difficulties that we've all encountered over our careers. But we welcome you and ask that you, for the record, identify yourself, your affiliation, and lastly to any overarching comments on the materials that you received from ATSDR.

MR. HARDING: I'm Benjamin Harding. I work for a firm called Hydrosphere Resource Consultants out in Boulder, Colorado. And I think, if I had to sum up what I thought in an overarching sense, I would say that the work that's been done here is impressive. One of the things I think that was identified by the other panelists as well is that we need to deal with the issue of uncertainty and try to deal with that in a quantitative way, I think.

DR. JOHNSON: Thank you. Do you know all the other panelists?

MR. HARDING: The ones -- I think I've met everybody at this point, and some of them I knew prior to this time, so...

DR. JOHNSON: Why don't we take a couple of minutes and just go around; name and affiliation, please.

DR. POMMERENK: My name is Peter Pommerenk. I'm with AH Environmental Consultants.

DR. SINGH: I'm Vijay Singh from Louisiana State University.

DR. WALSKI: Tom Walski, Bentley Systems.

DR. KONIKOW: Lenny Konikow, U.S. Geological Survey, Reston, Virginia.

DR. UBER: Jim Uber, University of Cincinnati.

DR. DOUGHERTY: Dave Dougherty, Subterranean Research.

DR. CLARK: Bob Clark, formerly with EPA and currently a consultant.

DR. JOHNSON: And I'm Barry Johnson, School of Public Health, Emory University.

Morris, do you have any housekeeping things before we begin today's work?

MR. MASLIA: Just, again, to remind anyone if they've got their cell phones on to silence them or turn them off, whichever you prefer. And again, any of the audience in the back here, your conversation can be picked up by the mikes, even if you're turning to your partner.

And one last thing, more towards the -- for the panelists, Dr. Johnson gave me a homework assignment last night and to see if we could reduce or perhaps modify the questions and answers for the second day with respect to the water-distribution systems, and I did some of that. I handed Dr. Johnson a copy, and I will hand the panel out a copy when we get to that time so we can go through them and cover all of them in a little faster manner.

I've combined a couple of them as well. So other than that, Dr. Johnson, that's it. Oh, the -- if you haven't deposited your money -- I think it's $5 for the working lunch. Ann is taking the money outside. Just, either at break, leave the money there, and they'll go out and get the lunch. Thank you.

DR. JOHNSON: Okay. Thank you. My purpose in asking Mr. Maslia to take another look at the list of questions that bear on the water-distribution systems was that these questions were prepared some time ago. And he and the agency have received some information since the preparation of these questions, and that led to, in my mind, as to whether all of those questions were still of importance to ATSDR, and so Morris has reduced the list in response.

With regard to one housekeeping matter from the Chair, today's agenda shows, at 2:30, us going somewhere in executive session. And I gather that that was put in as an opportunity for the panel to sort of closet itself and say things, perhaps, in the absence of ATSDR staff.

In fact, that would be the case, and we would have ATSDR staff there initially to answer any early questions, but I would then ask them to leave so that this would be a totally candid kind of executive session amongst the panelists. Do you want to maintain that or forego it and simply continue all of our deliberations here in a public forum? And it's -- really, it's up to the panel to decide. If you feel that need, we'll certainly do it. What is your preference?

DR. CLARK: I don't have any problem with continuing in a public forum.

DR. JOHNSON: Is that all right with all of you? Tom, is that all right?

DR. WALSKI: It's all right with me.

DR. JOHNSON: Okay. Then we'll just continue everything here in public session. And the main thrust of that executive session was to finish our response to the four elements of our charge -- the first two, we will address at the working lunch -- and also to craft some kind of communique.

I asked Mr. Maslia last evening: What did they have in mind as a communique? And his response was: answers to the four charges -- and which we will be preparing as we deliberate this morning and early this afternoon. It seems like we can fill their desire for a communique and still doing it all in public session.

I also want to alert you that, at the end of our deliberations and toward the end of the meeting, I'm going to ask you the same kind of question I asked you at the beginning, and that is: To what extent are you comfortable with the, what I call, the protocols that are in play, both for the groundwater modeling as well as what you're going to hear today, the water-systems modeling? To what extent are you comfortable? Are you -- do you have something you'd like to sort of red letter as key advice to the agency? But just where are you personally in regard to what you have heard over these two days?

And I don't foresee us taking any kind of vote as a panel. If you feel that that is a need, then let's discuss it. But by voting as a panel, it seems to me to put ATSDR in a bit of a bind and potentially in a bit of a bind. But they will have the benefit of your advice and your recommendations as individual panelists. Does anyone have a problem with the panel, as a body, not taking some kind of vote on whatever, but speaking as individual panelists? Tom?

DR. WALSKI: I'd prefer it that way. It's pretty hard to get this group to agree. I mean, Jim and I probably agree only about 10 percent of the time. So, you know, it'd be pretty hard to get a unanimity on the panel here, so...

DR. JOHNSON: Well, let the record note that Jim is smiling (laughter).

DR. UBER: It's one of the 10 percent.

DR. JOHNSON: Which is part of the 10 percent. Well, if the panel feels, during the course of the day, to change some of these suggestions, put it on the table, and we will -- you will debate it as a panel. Okay.

Having said that, Morris, are you ready to begin updating us on the water -- water-distribution systems work?

MR. MASLIA: I sure am. Good morning, everybody. And, Claudia, if we can go ahead and get the overview. My plan this morning is to give an overview of the approach for the water-distribution systems analysis and then go into the field testing that we've done to date on the present-day water-distribution system.

And as Bob said yesterday, if you would like to interrupt me or ask a specific question that's either among the questions that are there or that comes to you as you're sitting here, please, feel free to do so, and I will try to answer it as best as I can.

We're all familiar with Camp Lejeune, hopefully, since yesterday. And again, for the present-day system, we've got two water-treatment plants and three water-distribution systems. Just for your information, our piping network has been obtained from data from autoCAD drawings, supplied by Camp Lejeune, as well as through their contractor, AH Environmental, also provided update on piping. And so it's a combination of information as well as us being in the field and observing pipes or asking questions and then defining or having updated information.

This was three bullets of activities based on the entire project, and we talked about, obviously, yesterday, the groundwater issue and some uncertainty issues which still apply to today's issues. But specifically, today we'll look at the potential distribution of contaminants and water-distribution system models.

And let me just add, as Dr. Johnson mentioned, I updated the questions and answers that were prepared a while back based on discussions yesterday. I have not done that with the slide material. So some of the slide material is presented, not in contradiction to your advice or your recommendations, but that they were prepared a while back. And I thought I would just go with what I had prepared.

So again, the chronology, which we still need to refine in some areas. The one point to make here: What is called Montford Point is presently known as Camp Johnson and is not in existence. It's serviced by the Holcomb Boulevard water-treatment plant. And the treated water goes to Tarawa Terrace ground storage, and that's where it gets its water from.

Basically, we were asked by the epidemiologists to quantify historical exposures for the purpose of their epidemiologic study. And so our understanding is that if the systems are completely separated, completely isolated so you've got three hypothetical systems, they may or may not have any contamination in them. Then, of course, there would be no need to reconstruct the actual distribution system historically, but rather we could assume everyone would receive the concentration based on our groundwater modeling and the source concentration there.

Based on information and talking to people to date, we know at some point in time the distribution systems have not been operated independently or they have been -- a better word is there's been interconnection. Exactly how long that is -- we've heard information on two weeks. We see other data that suggests maybe there were other opportunities for the systems to be interconnected.

And so if that's the case, then we need to do some amount of historical reconstruction to try to get a distribution of contaminants within those systems. So, as we see it, there are two approaches that we can do the historical reconstruction. One, we can use historical water-distribution system data. This is data from the operators of the system, cycling on and off of wells, flows, demands.

And what we have at least found out, in looking for information, is that the information is sporadic. We talked about that yesterday. There may not be any record specifically of cycling on and off pumps and wells, or it may not be in existence. Bob, did you have a question?

DR. CLARK: Morris, yeah, I had a question on the exposure assumptions. You're assuming that everybody who lives in a system that's independently operated is exposed. Is that --

MR. MASLIA: That would be the assumption.

DR. CLARK: Okay. But you're not taking into consideration things like activity patterns --

MR. MASLIA: No, we're not.

DR. CLARK: -- water use by individual homes and that sort of thing?

MR. MASLIA: No. If you wanted to take into account water use, you would either have to have some measured and demand-type consumption metered information. At a Marine Corps base -- and I assume at military bases in general -- they do not meter household water. We'll actually address that issue a little later on.

And as such, they do have -- they've got a production meter, obviously, that's going into the system. But because in some of the areas you've got mixed use -- say bachelor housing, industrial. In some of the areas, it's more homogeneous: total family housing. We would have to derive some estimates of that.

DR. CLARK: Right. To the degree that you can't do that, then that constitutes the potential for error, I guess, in the analysis.

MR. MASLIA: Yes.

DR. CLARK: I guess Frank's not here.

MR. MASLIA: Yes. Just as an example, when we were doing the work in Dover Township, we had quarterly billing records for about 18 or 24 months, and we -- I shouldn't say "we." I should say Jason put those in about a month at a time, putting them in by hand.

But they came out. Where we measured, I think it was 7.5 million gallons per day on a test. With the billing records, we came out with 7.6 million gallons. It was right on target. We don't have that here, and it's -- so that's just not available.

DR. WALSKI: Okay. It did bring up the question of historical data. One other source of data is the fact that a lot of the engineering work of this in the past was done by the NAVFAC IINCOM LANDTIV up in Norfolk, and I haven't heard them mentioned. Have you gone up through their records? They may have some of the construction drawings and such that, you know, they don't have on post. Have you talked to --

MR. MASLIA: Let me talk about that now. We do have historical maps as paper copies, for example, as housing areas expanded. We've actually got maps that tell us how many more housing units were added and which pipelines may have been added. So from that standpoint, we do have that information.

When we've requested, even on the present-day system, say, for example the network drawings, if they haven't had them at Camp Lejeune, they have provided it to us either through their consultant. So I assume if they haven't had it on base, they have gone up to the Navy facilities. We are aware of that.

And, in fact, on the -- which I'll get to a little bit later on. There was a conservation study done. Most -- the Air Force and Navy developed this water-conservation analysis, a software. And we requested it, and I know they did go up to Norfolk to get a copy of that, and actually, that has formed the basis for some of our demand categorizations.

So I'll get into that, but we are aware of that, and when needed, we have requested. But we personally have not gone up there, but we know someone has gone up there because of the information that we've obtained. Were there any more questions up to that?

The second approach then would be to -- in view of the lack of historical system operation-type information would be to develop a present-day system model; gather information on that; and then to, what we're calling, deconstruct the present-day system: removing pipes as they were removed historically and using the assumption that we've been told that they pretty much operated in a similar manner; use that to do the historical reconstruction or come up with historical systems.

Now, one of the differences we have found out, say, from the Dover Township work, unlike in Dover Township where the network changed at least every year, whether it was addition of pipes, hydraulic devices, or anything, there were just major -- major changes in only certain years at Camp Lejeune, for example, the addition of the Holcomb Boulevard plant.

From what we've been told and what we've been able to find out, they were not adding sections of pipelines every year. That sort of simplifies, at least from a simulation standpoint, where we can make some larger assumptions. So that we have found out, and that is why it's still very important on this chronology, especially with the Holcomb Boulevard plant. If we can isolate that, the start-up, to a month and year, it will really help us out.

And this is the approach up to this time that we have been using to calibrate models for the present day; get a description of the present-day system in terms of operation, in terms of facilities; and then work backwards in time. The information in front of you and what we've been -- and what we'll discuss today, obviously, is just for the present-day system, but hopefully, we can also get some recommendations for the historical process.

And that's -- so the approach then would be to apply the output from the groundwater model, and that's the arrival of the concentration from the contamination. And then either apply it to Approach A or B, and as I've indicated, we have gone with Approach B because of the lack of information from the historical standpoint.

And that's really a summary of just the approach and what has prompted us to take the next step, which is the field investigation and understanding the present-day system. So at this point, are there any other specific questions on the approach? Yes.

MR. HARDING: Morris, there's a high-level question from the -- going up to 20,000 feet and looking at this for a minute -- and this may have been answered yesterday since I wasn't here, so if it has, just somebody can take me aside and tell me.

And that is, is that in the event that or in the case where -- these systems were served by a single source essentially. The wells were blended into a water-treatment plant and then supplied to the distribution system, and those systems weren't interconnected then.

MR. MASLIA: Did you say were or were not?

MR. HARDING: Were not.

MR. MASLIA: Okay.

MR. HARDING: So we have independent systems served by a single point of supply. Then there's really no need for any hydraulic modeling in my understanding of the kind of etiology of disease that we're talking about. That is, these are chronic, relatively chronic, exposures.

So we don't need to know, with a precision of hours or even days, when a particular change in concentration occurred. So the calculation -- essentially, everybody in the system -- when you're averaging things out over a period of days or weeks, even that level is going to get the same exposure, the same concentration.

So it seems to me useful to divide this up into the epochs, if you will, of the configuration and operation of the system and decide, you know, what the benefit is of doing the detailed hydraulic modeling and when that benefit's going to accrue because at some point -- at some points, all of the uncertainty, all of the arithmetic basically falls on the groundwater model. And at that point, once you know the answer to groundwater model and the dispatch of the wells -- if you've got innumerous wells, you have to understand that. Once it gets into the water-distribution system, it's no longer an issue.

MR. MASLIA: Right.

MR. HARDING: So we need to understand that to evaluate when you need to do, if you need to do, the detailed hydraulic modeling.

MR. MASLIA: Our assessment of the water-distribution system, when we were first presented with the opportunity to assist our division of health studies on the epidemiologic study, was really twofold.

First -- and I am not an epidemiologist. I'm probably stepping way off on the plank here. But my understanding on some of the health outcomes, birth defects, there -- they need some information in the first trimester, and I think it's Days 21 through 28 or something like that. So they had mentioned some daily information to us, and Dr. Bove is not here. But David --

MR. HARDING: I probably can answer most of the questions.

MR. MASLIA: Okay.

COURT REPORTER: I need you to get to a mike then.

MR. MASLIA: Oh, okay. But that was our -- one of the questions we had: Could we provide that kind or at least on a monthly, looking at trimesters, monthly information. Yes.

DR. CLARK: I wonder if everybody would be equally exposed because you're talking about people that may -- you know, women who might be in the household, maybe, 18 hours, 16 hours a day with children as opposed to some of the active-duty Marine Corps personnel who are off doing something else.

And I wondered if maybe one way to deal with that is sort of at least classify the percent of population who falls into these different categories who would have different kinds of exposures.

MR. MASLIA: We started down that road, and that's in the next presentation or at least classifying building types and the type of people that occupy those buildings, and that's in the next presentation. And it significantly varies by the different distribution systems, which I will get into. Can I put that off until we get to that? Yes.

DR. UBER: A point of clarification on that, Morris: You're only concerned with exposure of pregnant women.

MR. MASLIA: That's right.

DR. UBER: Okay.

MR. MASLIA: That's right. Women who were living in family housing, although they may have given birth off base --

DR. UBER: Right.

MR. MASLIA: -- because of the movement of the enlisted people, the enlisted men, as they took them off base. Some of them may have been pregnant during the period of exposure while on base, but then actually delivered off base.

DR. UBER: Right. Understood. But the exposure characteristics, the only ones that are of interest, are the exposure characteristics of the women who had been on base at some time during first trimester of pregnancy.

MR. MASLIA: Well, there's Dr. Bove. Let him --

DR. BOVE: What happened?

MR. MASLIA: The question was: We're interested in exposure of women, pregnant women, who were on base during only the first trimester.

DR. BOVE: No. That's for -- well, we have different outcomes, end points. I know I have to get to the mike.

COURT REPORTER: You knew what was coming.

DR. BOVE: Right. We have different end points, and for neural tube defects and oral clefts, it's the first trimester. But we -- because there's some uncertainty as to when the first trimester occurs, we asked for three months. We asked for the whole year before birth. And we're looking at the first six months of that period: three months before conception, three months after conception because we don't know when conception really is.

So we leave a wide window there to determine exposure for oral clefts and neural tube defects. For childhood leukemia, since we're not sure -- all the evidence seems to indicate prenatal exposure, but we'll ask up to one year of life for childhood leukemia and non-Hodgkin's lymphoma.

DR. UBER: Okay. So you're interested in exposure of women three months before pregnancy, three months --

DR. BOVE: Conception; yeah.

DR. UBER: -- three months before conception --

DR. BOVE: Yeah.

DR. UBER: And three months after conception and --

DR. BOVE: Because we're not sure when conception is. Right.

DR. UBER: Right. And you're interested also in exposure of infants.

DR. BOVE: For childhood leukemia --

DR. UBER: Childhood leukemia.

DR. BOVE: -- up to one year of life.

DR. UBER: But you're not concerned about exposure of active-duty military personnel who are -- I assume -- I can't remember when that changed, but I assume at that time they were all men.

DR. BOVE: Well, we're going to be asking in -- their drinking-water exposure, no. No. We're concerned about other exposures. We ask a wide range of questions in an interview. Okay.

DR. UBER: But not for drinking water?

DR. BOVE: But not for drinking water, no. I think -- we're really focused on that period of time. Okay.

MR. HARDING: Before you go --

DR. BOVE: Uh-huh.

MR. HARDING: Morris, let me just express --

DR. BOVE: I'm not going. I'll just sit there.

MR. HARDING: -- my understanding of how this system worked and ask a question of both you and Dr. Bove, which is if we go back to the case that I mentioned where we've got a situation where the system operated independently and was served by one water-treatment plant, then what came out of that water-treatment plant was going to reach a home in a matter of days or hours. It would stabilize, given the operation of the tanks. But if we look at the historical data we have a few snapshots here that Tarawa Terrace -- Tarawa Terrace. How do you pronounce it?

MR. MASLIA: Tarawa.

MR. HARDING: Tarawa was pretty stable. The measurements that were made in the water-distribution system were all within the factor of one and a half of each other, it seems like. So my question here is that when the wells -- the major influence then on the concentrations in that system would be the cycling of the wells if the wells in a well field had different concentrations, which might occur three times a day, it sounds like, something like that.

So for the question for the doctor, assuming that that understanding is correct, then is: What is your time resolution in terms of understanding? What kind of averaging period is acceptable to you, and what kind of precision on estimates of, ultimately, human intakes that you're going to make as you assess this? What's your level of precision both in terms of time and magnitude that's -- that you need to have in order to make a conclusion?

DR. BOVE: I mean, we're going to be looking at monthly averages. So to do that, you know, at least weekly levels. But beyond that, it's unclear. It depends on how variable the data is, I guess. If there are spikes during a particular time, we'd like to capture that. But if there aren't, then, I guess, by week -- week by week.

COURT REPORTER: Can you go to the mike, please?

DR. BOVE: Yeah. A week-by-week assessment might be sufficient. You know, again, it depends on whether there are peaks. If, in fact, the water that went in was also the first water that came out and there are times when there are slugs going out so that the tap-water sample data that we have is not really reflective of what might occur at the tap. In other words, you know, it may be more closely related to that -- what's in that well actually than -- so there would be, instead of 200 parts that would bring us to the max, something like ten times that much, we'd like to be able to capture that, I guess.

MR. HARDING: That's what my question is: Are we dealing here -- orders of magnitude differences?

DR. BOVE: Well, that would be. Yeah.

MR. HARDING: Right. But, I mean, but you have to answer this because you've expressed this desire to have a six-month window of time. And the question is: Do you need to know what happened in the third week of that six-month window with a precision of two or ten or what? This is what I'm getting at.

MR. MASLIA: Frank was asking me what we did in Dover Township. And in Dover Township, they used the same approach of going zero months, not knowing when conception, to twelve months and the --

MR. HARDING: What was the resolution?

MR. MASLIA: And the resolution -- the model was obviously run on an hourly basis, and then we gave them an average over a month period.

DR. BOVE: But we weren't -- we weren't -- we weren't dealing with concentration at Toms River.

MR. MASLIA: No. No.

DR. BOVE: I mean, it's a tough question because there's so much uncertainly. I'm more concerned about being able to just determine whether people were exposed or unexposed, given some of the things you'll probably hear today about the confusion concerning interconnections and so on.

But if we can get that straightened out, if I can be confident that the people I'm calling unexposed are unexposed and vice versa, which we -- I produced something that -- yesterday that was handed out to you, which goes over what happens when you can't -- when you have some errors in just doing that and the impact on the odds ratio. If we can get that far, then I can live with weekly -- certainly, weekly estimates about resolution.

MR. HARDING: Well, but you're talking about were they exposed in a given week or were they exposed in a six-month period? Yes or no? What is it --

DR. BOVE: Oh, no. We -- there's two things here.

MR. HARDING: It's like two things here.

DR. BOVE: I'm sorry. Well, I'd like to know on a weekly basis whether they were exposed. Okay.

MR. HARDING: Whether they were exposed.

DR. BOVE: Yeah.

DR. LABOLLE: You mentioned at Toms River, you didn't -- you weren't concerned with concentrations. Are you concerned with concentrations here, or are you concerned with mass?

MR. MASLIA: Let me explain here. It's not that -- that's probably a misstatement. It's not that we were not concerned with concentrations at Toms River. We had an alphabet soup of concentrations that we could not separate out or get any definitive single contaminant like PCE coming through there because of the way that the contamination that was on hand.

So because of that -- and this, again, was part of the epidemiologic protocol -- it was decided by the epidemiologist to go after the proportionate amount and look at comparative amounts of water that each of the study cases received or did not receive from various well fields.

DR. BOVE: What I meant was it wasn't part of the analysis.

UNIDENTIFIED PANELIST: Okay.

DR. BOVE: It wasn't part of the exposure assessment.

DR. CLARK: Morris, I had a question. This may be going -- it may address this later on, but is -- have you looked at degradation by-products in the distribution system at all?

MR. MASLIA: No.

DR. CLARK: Okay. Because you've got a lot of cast iron pipe that's going to build up a very heavy biofilm. You've got lots of biological activity going on, and I'm wondering, with the residence times that you have, if it might not be something you might want to take a look at. I assume when the analysis was done -- a lot of them were done with just plain -- just the same volatile analysis using GC, right, back in the early days when they were looking for THMs primarily?

MR. MASLIA: That's what the lab notes indicate, and that's what they indicate why they could not do it when they saw the presence of the volatile or --

DR. CLARK: So there's no attempt to try to, say, differentiate to see if vinyl chloride might be possibly one of the by-products or not?

DR. BOVE: Well, they did later.

MR. MASLIA: Later on, they did.

DR. BOVE: Not during the THM -- not during the THM analysis; no.

DR. CLARK: I know there's a period there when there were no methods, the standard EPA methods were volatile, so...

DR. BOVE: The issue's about biofilms and residence time.

MR. MASLIA: Not in Tarawa Terrace. It was --

DR. BOVE: Okay. So there's no dead-ends.

DR. CLARK: But there were -- do you know what -- well, you know what the residence times are in terms of the system tanks and so forth; right?

MR. MASLIA: From what we found from our field information -- and I'll present that --

DR. CLARK: Okay.

MR. MASLIA: -- the residence times may be forever.

DR. CLARK: Okay.

MR. MASLIA: And that's one of the issues that we discovered -- or when I say we discovered, during our field testing -- and I'll get to that. I'll just jump to the punch real quick. Even though we allowed fluoride to dilute over a two-week period down to .1 or .2 milligrams per liter, the tanks are still showing one or a little bit above after that.

DR. CLARK: So there is the potential then for very long residence times, biological action, and --

UNIDENTIFIED PANELIST: (Off microphone)

MR. MASLIA: Not the -- I mean, it is.

DR. WALSKI: Well, but just the opposite though. When you had the tanks off-line, that means everybody gets very fresh water. The water in the tank just sits there, and so 99 percent of the people get water that goes straight from the plant to their house, which means the residence time on average is, you know, hours only in the system, not days. And the water in the tank just sits there.

MR. MASLIA: Right.

DR. WALSKI: It may dribble back in a little bit --

MR. MASLIA: Talking about in the tanks?

DR. WALSKI: Yeah, right; in the tanks. The tank water doesn't get consumed. So therefore that water is basically almost off-line except during a fire or something is the only time that water gets drained out of the system. So for the most part, the residence time on average is extremely short in a system like this.

MR. MASLIA: Except we've seen both, both cases. And I'll get into that now perhaps. But we've seen in a later test the tanks filling and drawing, and I've got some data to show that. So --

DR. CLARK: Well, I think it depends a lot on what the record shows as far as tank operation is concerned.

MR. MASLIA: So that -- again, our attempt or our concept was, if I can summarize this, is if we felt -- if we could really understand the present-day operation, that would shed a lot of light on historical operations since we were told they were operated in a similar manner or the operation was in a similar manner, and that was our --

DR. CLARK: So it sounds like there were times when the residents would get water that was fairly aged.

MR. MASLIA: There were times; yes.

DR. WALSKI: But it would be aged in tanks though, not in pipes with contact with the biofilm that much. In the tank, you don't have much contact with the wall.

MR. MASLIA: Right. But again, we've got data to show both cases or at least our interpretation of it, that it shows both cases.

DR. CLARK: You still have biological activity taking place in the tank, too, as you know. So those are just some issues I thought that you might want to at least kind of chalk up and take a look at.

MR. MASLIA: We'll definitely note that down. And, in fact, we're looking at different tank-mixing models, just to let you know. Are there any other questions, suggestions, comments, or -- because what I'd like to do is get into the specificity of the present-day system and the field testing that we've done and perhaps address some of the issues that have been brought up this morning and go from there. Is that okay with the panel?

(No audible response)

MR. MASLIA: Okay. Present-day system. Okay. We started preparing to do some field tests. Again, the present-day information, we had some production information from the utility operators, but specificity as far as hydraulics in the present-day system were not available, and we were, again, interested in ultimately travel times of potential contaminants. So we developed a field-testing program. And so we gathered information on pipeline locations.

I've described how we have obtained that for the present-day storage tank locations; high-lift pump data; operational data -- I'll get into the controlling tanks in a minute -- and production data; and what I'm referring to housing data and facilities' use data, classifying the different building types.

The approach was to construct present-day models, and we've done that for the three different areas: for the Tarawa Terrace, the Holcomb Boulevard distribution system, and the Hadnot Point. And the data that we were interested in gathering would be the hydraulic data, pressure, C-factor data for pipeline characteristics, operational data. This is including the controlling tanks and the on-off cycling of pumps, pipe-flow data, and travel-time data.

Primarily, our thought behind the flow data was that since we didn't have individual household meters and household consumption, if we could get an aggregate of small areas where the type of housing were homogeneous, then we could get a present-day per capita use and per diurnal type curves to service for that particular area, and that was our thought behind the flow metering.

So as of right now, we've got three hydraulically independent models. We're assuming here's where the interconnection between Hadnot Point and Holcomb Boulevard are. There are two sets of valves, one here and one here, that are closed off. And so we've got a model for the Tarawa Terrace-Camp Johnson area --

MR. HARDING: Morris, I got an ADH --

COURT REPORTER: Mike please. I didn't get it.

MR. HARDING: I'm color blind. I can't really make out that pointer very well. Can you just linger a little longer or point with your --

MR. MASLIA: Okay. Can I go over there and point to it? Will that be okay?

MR. HARDING: That would be great. Just where the valves are because that's a critical issue for me.

MR. MASLIA: Is there a pointer over here? How about the pointer and that way?

MR. FAYE: Grab the radio mike.

MR. MASLIA: Thank you.
COURT REPORTER: Now you're getting it (laughter).
MR. MASLIA: Is that on?
MR. FAYE: Yeah.
MR. MASLIA: Okay. This is the Hadnot Point area --
MR. HARDING: Right.
MR. MASLIA: -- to the south, and there's an interconnection valve here and one over here or a set of valves actually that they maintain closed for the present-day system. This area up and to here is what we're referring to as the Holcomb Boulevard water-distribution system. And then this pipe right here from the treatment plant provides water to the ground storage at Tarawa Terrace. And then based on demands and the controlling tank right here, that's how water is distributed within the Tarawa Terrace area up north.
Previously, when we mentioned the Montford Point here, that was in this area over there, which is present day no longer in existence at that treatment plant.
MR. HARDING: So when Tarawa Terrace was isolated, it was that pipe that crosses Northeast Creek there right by the 30, TT-30?
MR. MASLIA: Right there. This pipeline comes over there. And if you cross the bridge, you can actually see the pipe tied or bolted underneath the bridge, the bridge

there. And it comes into here. So what's left -- this is where the original or the former Tarawa Terrace treatment plant was. So the pump house is still there. They've got four high-lift pumps there. And the reservoir, underground storage tank, is still there. Just the treatment facility is no longer there.

MR. HARDING: Now, if I recall from the materials, there was a failure in that pipe due to freezing; is that right?

MR. MASLIA: That, I believe -- we discussed this yesterday. And I believe that's this pipe right here, and that is information we're still trying to get some more definitive documentation on. It's a report that was written in 1991 by Geophex out of Raleigh, North Carolina. We've got a contract number. We have no author that's on it.

We're trying to really -- and it makes a statement that two years prior, meaning about '89 or so, which is outside the study period -- but that might be some indication that there may have been other times that there may have been some interconnections, but that's some of the data discovery that we still need to figure out and find a resolution on.

MR. HARDING: Well, there's valves on the pipe -- the systems are isolated or were isolated by valves; right?

MR. MASLIA: This system and this system were isolated.

MR. HARDING: So the indication was that pipe was only constructed after 1985, the one across Northeast Creek?

MR. MASLIA: Yes. That would be correct.

MR. HARDING: Okay.

MR. MASLIA: Okay. In other words, because prior to the closing of this treatment plant, this treatment plant took care of this area here. So there would be no need to --

MR. HARDING: But that can't be right because originally Hadnot Point served the entire system; right?

MR. MASLIA: That was before Holcomb Boulevard plant came into being.

MR. HARDING: So that pipe existed from the very early days of Tarawa Terrace development.

MR. MASLIA: This pipe here?

MR. HARDING: Yeah. The pipe that crosses Northeast Creek.

MR. MASLIA: That, I could not tell you. Joel, would you know about that? Would that pipe have existed prior to the -- no.

MR. HARTSOE: Excuse me. The -- what he's talking about is the --

COURT REPORTER: Excuse me. Microphone.

MR. HARTSOE: At one time, Hadnot Point served the Midway Park area. That's up north, right there. And the connection that he was talking about, there's two separate connections between Hadnot Point and the Holcomb Boulevard distribution system. But, at one time, when the Holcomb Boulevard plant was not there, the Hadnot Point served only up north at the Midway Park area. It did not serve TT.

MR. HARDING: Okay. And so do we have a sense that that pipe that crosses Northeast Creek was constructed after 1985?

UNIDENTIFIED AUDIENCE MEMBER: (Off microphone)

MR. HARDING: Do you know when it was constructed?

MR. MASLIA: We've probably got that information in our --

DR. POMMERENK: Like I indicated yesterday, there seemed to be as-built drawings from 1984. And in discussing a little more, there may have been a temporary line for some time. But, you know, this is, like Morris said, all not clear at this time, when this -- but it probably wasn't -- hasn't gone on-line, you know, before '84.

MR. FAYE: Is this on? The records that we have indicate that that pipeline was constructed by June of

1985 or in that fairly short time frame and it was operating in June of 1985 or shortly thereafter.

DR. LABOLLE: Is it your understanding that it was constructed to help mitigate the closure of --

MR. FAYE: Yeah.

DR. LABOLLE: -- Tarawa Terrace?

MR. FAYE: Yeah. There was a recognized -- they -- as I said yesterday, Wells TT-26 and TT-23 were shut down in February of '85. That -- and Lejeune immediately anticipated a water shortage for the Tarawa Terrace area, up into the spring and summer months, because of that shutdown.

So they expedited this construction of this pipeline, to the best of my knowledge, so -- and it was -- to the best of my knowledge, it was supplying water from Holcomb Boulevard to Tarawa Terrace to supplement their existing supply by the summer of 1985.

MR. HARDING: Okay. Morris, I have another question.

MR. MASLIA: Sure.

MR. HARDING: And so is the epidemiological study driven by particular individuals or time frames, or are you trying to establish the dose-response ratio? In other words, could you -- after that pipeline is in place in the situation in Tarawa Terrace, if the wells and the Holcomb Boulevard supply both served the area -- it gets complicated.

But, prior to that time, it's not complicated at all. The only complication is how they dispatched the wells and the groundwater modeling. If I understand this correctly -- anybody can jump in if they think I'm wrong here. But prior to that time, you've got a much clearer picture. It's not perfectly clear, but it's much clearer than it's going to be after that pipeline opened.

MR. MASLIA: Yes. The epidemiologic study ends in December of 1985.

UNIDENTIFIED AUDIENCE MEMBER: Last birth; yes.

MR. MASLIA: Yes. Last birth is December of 1985.

MR. HARDING: It's that last -- it's that period from, potentially, 1984, some time in 1984, until December of 1985 that's going to drive 90 percent or 95 percent of your water-distribution effort.

MR. MASLIA: Plus we've got the potential issue, which we've been asked on a couple of occasions now, about the interconnection between Hadnot Point and Holcomb Boulevard.

MR. HARDING: I understand. I'm just trying to get one thing done first.

MR. MASLIA: Okay.

DR. WALSKI: But the point is, though, that if you don't have enough information to know how to do things without the model, running this bad raw data through a model isn't going to make it any better. You know, because the boundary conditions are what's going to drive the model. And so we're still in the -- you know, back to the fundamental principle of modeling, which is: Garbage in; garbage out.

And you don't know when those things are open or closed. And you aren't ever going to know those things because we can't go back in time and ask people or check these things. So why model it?

I mean, basically, you have to say that in this period we know they got contaminated water. At this period, we know they didn't get it. And this period, we just aren't sure and we just can't do it. And running a model with wild guesses in it isn't going to make it any better is the point, back to this chart here I did yesterday.

DR. BOVE: I don't know if this is pertinent to what's being raised here, but my main concern right now and the problem with the previous study was that we called some people, a lot of people, unexposed when they were really exposed. Is that right? Yeah.

And if you look at the chart I produced, sensitivity, which means correctly calling someone who is exposed -- who truly is exposed, exposed, and not calling them unexposed is a -- has a bigger impact than specificity of exposure, correctly identifying the unexposed.

So I'm more concerned right now with being able to say that these people -- certain proportion of the population were unexposed and being confident of that because that was the problem with the last study. And if there are interconnections, we need to figure out how to deal with that in our study. So, I mean, you know, I mean the simplest analysis we can make in our study is simply, as I said before, unexposed versus exposed and being confident that we're identifying the people properly. Okay.

Then, after that, we can talk about the level of concentration and if we have the numbers. Part of the constraints of our study is we have small numbers. You saw the number of cases that we have to deal with. This is not a large population.

In order to do a birth-defect study, I studied 80,000 births in northern New Jersey, and I still didn't have enough really to -- I had small sample sizes when you broke -- started breaking them down into exposure categories. So this is -- you can't go too far in categorizing the exposure before you really have very unstable estimates for the relative risk or odds ratio. So -- is this --

DR. DOUGHERTY: So to summarize and prioritize, we don't need to worry about the exposures at Tarawa Terrace because we can pretty well guess they're all exposed.

DR. BOVE: Except for that period; right? The later period? Right.

DR. DOUGHERTY: So we have -- I think we heard pretty significant evidence that pumps were operating through the entire study period out of Tarawa Terrace.

DR. WALSKI: Until they shut T-26 down.

MR. MASLIA: Yes.

DR. WALSKI: But until that date; yeah.

DR. DOUGHERTY: Possibly. We don't know the level of concentrations at other wells. TT-25, for example, is very close to TT-26, and it continued to operate, as I understand, at least into '86 or '87. So what we're -- the real issue is worrying about the controls rather than the cases. And that gets us out of Tarawa Terrace. Is that fair?

DR. BOVE: Cases and controls is not the way that I look at it. Exposed and unexposed -- we need to identify who's exposed and not exposed.

DR. DOUGHERTY: Replace my language.

DR. BOVE: Right.

DR. DOUGHERTY: And then, is that a fair summary, a first-order priority?

MR. MASLIA: Yes. Yes.

DR. DOUGHERTY: Okay.

DR. LABOLLE: And that falls on -- on this connection between Hadnot Point, I presume, and the Holcomb Boulevard system, essentially, because the potential for an unexposed population here is Berkeley Manor; is that correct?

DR. DOUGHERTY: What's Berkeley Manor?

DR. LABOLLE: Well, I'm looking at this development here, fed by the Holcomb Boulevard --

MR. MASLIA: Yeah. All the housing that would be served by Holcomb Boulevard.

DR. DOUGHERTY: That's very helpful.

MR. HARDING: Now, let me just point out that on 5 February 1985, somebody sampled somewhere in the Tarawa Terrace system and reports 80 parts per billion of PCE, similar to the sampling that was done in 1982.

So, I mean, the whole system, if you just look at these snapshots -- and we don't know what time of day, what day of the week, what the circumstances were, which wells were cycling. But it looks remarkably stable through that period. It looks to me like even into 1985 you could -- it would be reasonable to think that the people in Tarawa Terrace were all -- I want to make a nomenclature suggestion here -- potentially exposed, in the sense that the concentrations were available at their tap, should they choose to turn it on.

So it's a potential exposure. The actual exposure occurs when they drink it, they take a shower, they bathe in it. So they may have had personal habits that they drank nothing but bottled water. They may have had -- they may have bathed rather than showered, which would make a big difference in how much they actually -- how much their intakes were. So we have to bear that in mind.

But the -- potentially, that population up there that lived there, if they used the water somehow, then had an exposure, had an intake. So in that whole area, up through 19 -- through at least, it would seem, February of 1985.

MR. MASLIA: Would it be then your suggestion or advice to just use that 80 parts per billion?

MR. HARDING: No. No. That would not be my advice.

MR. MASLIA: Okay. Then what -- then our question would be --

MR. HARDING: I'm going to defer to the groundwater people.

MR. MASLIA: -- is what number do we use?

MR. HARDING: But let me make -- the point is that the water-distribution system is not a substantial factor in what that concentration is. It's the groundwater.

It's reconstructing the historical conditions in the groundwater and then how the wells were cycled because if you had a contaminated well that was used, you know, once -- one day a month it's going to be real different than if that well was running all the time. So you -- we have to understand that. But the pipes, it seems to me, and --

MR. MASLIA: Would you not want -- let me -- let me -- again, so I understand or at least your approach or your understanding is, if we've got three, four wells, one of them is contaminated or whatever and they're mixing. Number one, you're suggesting that we use a simple mixing model. In other words, you pump groundwater however, assuming we get the information on how they're cycling. Then they're -- you use a simple mixing model, and then assume that that mixed mass was distributed equally to everyone in Tarawa Terrace.

DR. LABOLLE: Yes. That's correct. During the time when the systems were not connected.

DR. DOUGHERTY: Right. And to come back to the question that you asked Ben and Ben deferred on, it sounded like the first-order question was potentially exposed or certainly not exposed and that we don't care about concentrations for.

So the first priority out of that list that was given to us by Dr. Bove checked off. The second one -- it seems to me -- to come back to the end of the day yesterday, all of the focus should be on the source-release model. That's where the focus has to be. And the attention to how much at which well. That will fall out quite easily.

The hard part is the source term. And so you get the source, and in a relatively simple mixing model, if we need to get the second stage of concentrations, and the first-order estimates based on observed data are that the concentrations are stable, but that's only at the very back of the -- at the very back of the study period. So then we have to do the census work and precipitate perhaps more -- careful analysis of precipitation-induced accretion to get concentrations into the ground. But, you know, it really -- the comments this morning were quite helpful.

DR. LABOLLE: What source are you referring to?

DR. DOUGHERTY: ABC.

DR. LABOLLE: Okay. The ABC source itself.

DR. DOUGHERTY: For handling -- for handling the Tarawa Terrace problem.

DR. LABOLLE: I think, also, as important, in my experience, will be not just the source but the geologic uncertainty. For a given source, different geologic models can yield orders of magnitude, several orders of magnitude difference in arrival concentrations to a well.

And that's the kind of uncertainty that you'd be dealing with there. I mean, granted, we see a few concentrations here at points in time that make this system appear as if it's stable. But then again, we've only got --

MR. HARDING: Two.

DR. LABOLLE: So, that -- there's, you know --

MR. HARDING: I understand.

DR. LABOLLE: -- there's not a lot to go with there to assume stability in the concentration. My experience has been that there's a lot of variability in the arrival to wells based upon their cycling and how the systems are run and variation in the source as David had mentioned, so...

DR. KONIKOW: But the point -- one of the points is that you really -- your study isn't starting until 1965 --

MR. MASLIA: '68.

DR. KONIKOW: '68. That gives you 14 years from the time ABC Cleaner [sic] started. So the value in doing the groundwater flow and transport model will be to, you know, start the -- as best we know, they were introducing contaminants into the soil, at least, through the septic tanks very shortly after they started; maybe a year, maybe instantly, maybe a year, maybe two years at most.

That gives you 12 years for it to reach the water table and spread. The groundwater flow and transport models, accounting for uncertainty, heterogeneity, and so on, will give you range of arrival times. But I'm guessing that the bulk of your realizations will get contaminant reaching the wells in that 14-year period.

MR. MASLIA: Oh, no question about it.

DR. KONIKOW: I think all of the uncertainty is going to be the range --

MR. MASLIA: Right; range.

DR. KONIKOW: -- is going to be before your 1968 starting time. So it's worth doing those flow and transport models just to demonstrate that, but I --

MR. MASLIA: Let me, again, and I'm not -- I don't want this to come out right [sic] that I'm questioning the panel. But I'm questioning you because we're, from what I gather, at a critical juncture as to how we progress or what direction we take. So I want to make sure, both for the record and for my understanding, that -- and based on what you said, Lenny, and some others.

It's your suggestion then that more of the effort now be focused on understanding the groundwater flow and transport, in fact, from the source characterization through any unsaturated zone to get to arrive at a -- or a reduced level of uncertainty for the concentration that goes into the treatment plant. Is that --

DR. KONIKOW: Well, you have very limited data against which to calibrate your model. Okay. And you know, in the period that you were collecting data, the wells were contaminated. Okay. So if you're going to run the groundwater model, it's a question of how do you get from zero to that level of concentration that you're calibrating. You start with an initial condition of no PCE in 1954. Okay.

And then you start your model running. And there's going to be speculation upon assumption built into that, and you'll get a range of responses. My hypothesis or my guess would be that all roads will lead to contamination by 1968. You want to do the modeling to demonstrate it. Maybe I'm wrong.

But you want -- the only possible outcome that would differ would be a later arrival, and that may be the first few years there's no exposure. I think that's unlikely, but that's what you want to evaluate, and that's probably the best you could hope from from all of these models.

MR. MASLIA: Would you look at then perhaps putting some effort into different source characterization or operation, a continuous source versus pulsing versus operation five days a week versus seven days a week?

DR. KONIKOW: I don't see the point of doing that. I mean, the only -- the only possible testing, in terms of field testing, that might be worthwhile would be a tracer test to get a handle on travel time in this saturated zone. But I would explore other -- apparently, there were tracer tests done in the Tarawa Terrace area specifically related to ABC Cleaners. And this comes out of a draft, a National Research Council report that I saw.

And they say tracer tests were done there, interwell tracer tests were done there. I don't know what distance the wells were apart. And I don't exactly what the purpose was, but there is some -- somewhere out there is some information, and it would probably be useful to get that. That might help pin down porosity, dispersivity, and travel time.

MR. MASLIA: Okay. We'll look for that information.

DR. KONIKOW: But I'm guessing the outcome is still going to be, from the start of your epidemiological study to the end, Tarawa Terrace residents were exposed, which, if you could support that, it kind of mediates the need for more refined modeling because it's not going to yield anything more than that.

MR. MASLIA: Then from a standpoint of being conservative, from a public health standpoint, let's assume we refine our groundwater understanding and we get it -- get the simple mixing model and get it at whatever concentration we happen to simulate going in. The fact that we may or may not come out with the 80 parts per billion that was measured at the tap, is that immaterial or is that of importance or should we go -- again, supposing we come out with several hundred parts per billion after that?

MR. HARDING: The 80 parts per billion, these are five snapshots that we don't -- and first of all, we don't know the sampling protocols, what time of day, what day of the week, what the conditions were in the system. These are just snapshots.

MR. MASLIA: Right.

MR. HARDING: So, I mean, in between those, it could be 500; it could be two. You don't know. But the point here is: After you've done the groundwater modeling, you've got a one or a zero here on the breakthrough curve having reached a particular well. You still have the question -- and since I'm in the water-distribution business, at least at this panel, I want to make sure we still have a toehold on this; and that is, how the wells were run.

You know, there's still this operational question of how they cycled the wells. And if you had -- if I recall correctly, there was a couple of these, two or three wells -- groundwater people can may remember better -- that were really contaminated at Tarawa Terrace. And then there were several others that were still in operation. So they'd cycle through these.

So the concentrations were going to vary considerably, depending on which well happened to be in service at a particular point in time. And so personally, right now, based on what I know, I would spend a lot of time, in addition to dealing with the groundwater issue, on trying to understand at least statistically how these wells were operated, getting the statistics of those well operations so you can -- you can do some kind of a calculation of the probability that any particular person was exposed at a particular time. And I have to say right now that a weekly time resolution is probably unreasonable.

You know, I just -- you know, the groundwater -- I don't know. Once it's there, the well's going to be contaminated, but how they ran the wells on a particular day is unknown and probably will never be really known.

DR. BOVE: Right. And I was talking to Bob Faye just a few minutes ago over there, and at the wellhead, we'll have issues of seasonality; right? I mean, there will be differences in recharge, so that I'd like to capture because, you know, that will impact -- if we can categorize exposure more than just yes/no, it will be important to know whether the first trimester occurred at a time of high recharge or low recharge. That would be important.

MR. HARDING: I don't think the recharge is going to be as big an influence as to which switch on the wall has been flipped.

DR. BOVE: No. There's two --

MR. HARDING: Well --

DR. BOVE: Right. There's two, you know, general sources of uncertainty here, and I'm just focusing on --

MR. HARDING: You ought to pick the biggest one to deal with. Spend most your effort on the biggest --

DR. BOVE: Well, we have a couple of issues here too because we may have to do additional studies. Okay. So we would like to know when that contamination actually got to Tarawa Terrace. So that's why the modeling has to happen, so that we know exactly when that water got there because, if we have do to adult cancer study, for example -- and that's probably going to be recommended -- that we have a notion of how far back in time the exposure --

MR. HARDING: Prior to 1968?

DR. BOVE: Prior to 1968. Yes; absolutely. So that's why it's important to do the groundwater modeling and then determine that. But beyond that, as Bob was telling me, there's variability at the wellhead, which we have to capture. And then there's variability in the system, which you're pointing out, which we have to capture.

Now, whether -- I just threw out weekly. I'm willing to -- at this point, I'm willing to take what I can get. That's what environmental epidemiologists do all the time. So if monthly is the best resolution that makes any sense, we can work with that.

DR. LABOLLE: When you refer to resolution monthly, temporally, what if I told you that I can give you a range of monthly concentrations and they vary over two orders of magnitude?

DR. BOVE: It wouldn't be unusual.

UNIDENTIFIED PANELIST: For a medical epidemiologist.

MR. HARDING: Yeah; but neither is zero.

DR. WALSKI: The thing is you're going to know they're exposed. In Tarawa Terrace, you know they're going to be exposed from this time until they shut that well off. And after that, they're not exposed.

The real hairy issue is the Hadnot Point to Holcomb one. And I'm afraid there you're not going to get a: Yes, they're exposed; no, they're not. You're going to get: Yes, these people were exposed. No, those people were not. And there's a big chunk of people that we think may have not been, but there may have been a few days that they got it. And that's going to be a chunk of your population. You're not going to get a yes or no for those people because we just don't --

DR. BOVE: We have to whittle down that chunk because we're going to run out of --

DR. WALSKI: But that's going to be archaeology and not modeling. That's going to be finding out -- finding those people who retired who operated the valves and talking to them. And no amount of modeling is going to make up for that type of uncertainty.

DR. LABOLLE: Have you run the binary analysis already with the epi study? The one saying, you know, under the assumption that Tarawa Terrace is exposed during this --

DR. BOVE: That was the previous study. We said that everyone at Tarawa Terrace was exposed.

DR. LABOLLE: Uh-huh.

DR. BOVE: And everyone at Holcomb Boulevard was unexposed. And we left the Hadnot Point situation aside. And we've been challenged, rightly, that the study had exposure misclassification. The unexposed had a lot of exposed people in them because during -- at least '68 to '72, I don't know, they were getting Hadnot Point water, so they were hardly unexposed. And that really attenuates your odds ratio.

DR. LABOLLE: Couldn't you narrow that, your unexposed population, to a different time frame when they actually were unexposed?

DR. BOVE: We could. We were going to revisit that study after this effort was done. But we could do that, sure.

DR. JOHNSON: Well, this has been really an outstanding discussion, and at the risk of imposing upon Mr. Maslia once again, I -- would you -- would you put in a capsule statement what you think you've heard from the panel?

MR. MASLIA: Basically, as I think said 15 or so minutes ago, we need to -- my understanding is concentrate on the groundwater issues. And I'll just put that in the issues, including the modeling, the source, what I call source characterization, a source understanding, trying to either narrow or understand the uncertainties associated with the groundwater parameters, infiltration, recharge, things of that nature, well operation, cycling on and off of the groundwater wells, and then assume a simple mixing model at the plant and assume that's what the people in Tarawa Terrace were exposed to.

DR. JOHNSON: Is that what the panel think that you said?

DR. WALSKI: That's right for Tarawa Terrace.

MR. HARDING: In a summary, yes, for Tarawa Terrace.

DR. JOHNSON: Well, thank you. Let's move ahead.

MR. MASLIA: Is there a need then to go over the present-day system, or...

DR. JOHNSON: Yes.

MR. MASLIA: Okay. Okay.

MR. HARDING: I think -- let's get back to this question here. We have an approach to establish an exposed population and within some range of uncertainty quantify those potential exposures and to calculate the intakes that resulted from that once we know what people did. That's the Tarawa Terrace area.

Now, I understand from the discussion that the second need now is to find an unexposed -- populations unexposed to the contaminants that had a similar lifestyle, you know, geographic location. So we're trying to find another population; right? That's our next -- that's our second need here; am I correct?

DR. BOVE: On the base; yeah.

MR. HARDING: On the base being important because we want them to have similar --

DR. BOVE: It's family housing, so they would be similar. It won't differ by -- too much by housing, and we can control for rank if necessary. We've done that before in a previous study.

MR. HARDING: Right. The reason I made that point of similar other exposures is we can't go off the base and find somebody -- some population. So we have to find some place --

DR. BOVE: Not for this study. Not for this study, we can't.

MR. HARDING: -- some place on that diagram, try to find some place where you can be reasonably certain people were not exposed for some certain period of time, right, specified period of time?

MR. MASLIA: Yes. And I do have, I guess, just another question to understand. Is it your suggestion or understanding then, and going back to Tarawa Terrace, that we would not need to know a diurnal pattern of any type over a 24-hour period as far as to refine periods when they did or did not most likely ingest water?

DR. CLARK: I think you would.

MR. MASLIA: We would need to?

DR. CLARK: That's my opinion. Yes.

MR. HARDING: You would only need it -- you would only need it to try to go back and reconstruct the well operation in my mind. Because once that water gets into the pipe system, assuming there's only one source, it's eventually going to reach every point in the system in a matter of -- if the tanks are really irrelevant, in a matter of hours. And the other -- most conditions. And maybe, if there's dead-ends, it will take a little longer.

But the important part of potentially understanding water demand would be to go back and try to reconstruct how they cycled the wells because they might bring more wells on during the peak hours. They might not. If they're not using the tanks, that's probably what they're doing. I mean, there's only -- if they're not using the tanks then they're matching their supply and their demand quite well. Wouldn't you say, Tom? I mean, that's what you got --

DR. CLARK: I thought they were using the tanks. I thought that was part of what they found out from their study.

MR. MASLIA: Yes. They found out both -- both in different areas.

DR. WALSKI: We can't get rid of that uncertainty, so why try to model it? You know, depending on -- you know, Joe was operating the system in '91 and '92 and he did it this way. And Johnny came in '93 and did it this way. But back in '87, we had Frank did it and he did it this way. And we can't -- we're not going to be able ever to unravel that, I don't think.

MR. MASLIA: You're talking about operating the distribution system?

DR. WALSKI: Yeah; operating the well pumps. You know, we're not going to be able to unravel that it doesn't appear, other than saying on average from the USGS data we know they pumped this much out that year of the well. And that's about all -- that's the level of resolution we're going to have. So talking about hourly --

MR. HARDING: Monthly.

DR. WALSKI: Yeah. Okay. Monthly then. But talking about hourly is just -- we just can't get down to that resolution.

MR. HARDING: Do we have data for individual wells, production data for individual wells?

DR. CLARK: Monthly, I think, isn't it?

DR. DOUGHERTY: I believe you said yesterday it was monthly totals for the system.

MR. MASLIA: Yes.

DR. DOUGHERTY: And then we have snapshots in time of the individual --

MR. MASLIA: Yes.

DR. DOUGHERTY: -- well capacities from the Tarawa Terrace --

MR. MASLIA: We've got monthly totals.

DR. DOUGHERTY: -- capacities, not actual rates.

MR. MASLIA: We've got monthly production, raw-water intake for each of the treatment plants in the eighties. We're missing a couple of years.

DR. LABOLLE: And some notes.

MR. MASLIA: And then we've got some notes on some other --

DR. UBER: Well, you have an understanding of their methodology of operation.

MR. MASLIA: Yes. Yes. We do have an understanding with also the understanding, although it may be qualitative, that they operated in a similar manner historically.

MR. HARDING: I don't want to sound frivolous here, but when going back and trying to figure out how people have run things in the past, I tend to look at their motivation individually. And in a public municipality kind of situation, that typically is cost.

So they'll typically try to run their most efficient resources first. They will get beat up by the city council or the utilities director to try to cut back on your costs. And I don't know what the motivating factors for the operators here were. But you have to ask that question if you're trying to go back and just come up with some hypothesis about how they operated, which may be the best you can do.

MR. MASLIA: Well, I can, perhaps, from what I've observed, or we've observed, one motivation would be to keep the tanks filled.

MR. HARDING: Yeah. But at which wells would they --

MR. MASLIA: I'm saying --

MR. HARDING: You know, it may be that certain wells were maintenance problems. So they would not run those as often. It could be that they had a particular cycling scheme to avoid biofouling. I don't know. But these are the -- I'm not saying that we can determine that now.

But I'm just pointing out that when you go back you're going to interview people about how they ran this stuff. You're never going to know exactly. But you can refine that a little bit by saying: Well, they typically would run this well first because the switch was closer to the -- to the office. I don't know. They didn't have to walk as far. I mean, things like this happen.

DR. WALSKI: Well, we do have some evidence. Somewhere I read here that they ran several -- they ran each well several hours a day was their usual pattern. So we have at least that guidance that it was fairly uniform, that they didn't operate one for three months and then shut it off for three months.

MR. HARDING: Right.

DR. WALSKI: It was more -- you know, several hour cycles.

MR. HARDING: Right.

DR. WALSKI: So we know that the average, you know, contribution from each well over a day was fairly steady. It wasn't changing.

MR. HARDING: And that would be, certainly, one model to think about, you know, would be that they continued that operation, one scenario.

DR. CLARK: But back to the 24-hour exposure, I think you do. Particularly if you get into adult cancer studies and other epidemiological studies, you're going to have to have some sense of what people were exposed when. And it seems to me the only way to do that is to come up with some typical 24-hour cycles of exposure.

MR. MASLIA: That was our -- one of our motivations in trying to understand or at least get some system flows, present-day flows in the system. Now, that may or may not be --

MR. HARDING: But it doesn't -- that doesn't -- what matters is what goes into the system; that is, how they operated the wells, the cycling of the wells. That's what matters. Because once it gets into the system, that defines what the profile of exposure is going to be over the next several hours. If they're using the tanks, then it's going to get dampened out some way.

MR. MASLIA: But are you saying we do not need to know that -- and I'm just using throwing out numbers -- at 4 a.m. there's an upswing in demand? So obviously, on the

Marine Corps base, perhaps, because they're showering at 4 a.m. And then it levels off, and then they come home, you know, at 4 p.m., and the upswing goes up. Are you saying -- it's my understanding that you're suggesting we don't need to know that.

MR. HARDING: Let's separate the two issues here. One is the behavior of the potential cases, the people that were exposed, from the operation of the system. And that information might be valuable in trying to figure out how they cycled the wells. But I would -- I would not. And I'm not an epidemiologist. But based on what work I've done related to this, I would not try to infer what people were doing from the water use of the entire system.

What I would do is try to look at the people, the individuals, to the extent that you can interview them or classify them, as to their behavior. And if you can't, then use population-default probabilities that they would shower at this time. If there's only one source, you're never going to know. No matter what, you're never going to know what happened at a particular hour. You won't. You can't know that. You can --

MR. MASLIA: You don't think we can know that because it's a specialized population on a military base?

MR. HARDING: I'm sorry. I was talking about the water-distribution system.

MR. MASLIA: That's what I'm saying. In other words, when we've been on base anyway, at least our observation is that, as we're conducting field tests at 6 a.m., they're all out jogging, doing exercises. Okay. So they're out of the house or out of their quarters at 6 a.m.

If you look at some of our data, you see an upswing in production or whatever at 4 a.m. Well, that would seem to indicate somebody's using water from at 4 a.m. or using more water. Let me qualify that.

MR. HARDING: Well, I would hope you'd see it at about seven, you know --

MR. MASLIA: No.

MR. HARDING: -- when they come back from running.

MR. MASLIA: That's not what we've seen.

MR. HARDING: My point was that, in the water-distribution system, you won't know the concentrations to the hour. You just can't know that. The behavior of the people, you know, you may be able to infer that from other things you know. But I would not infer it from, at least solely from, the water pattern of water use in the system. That's all I'm saying.

DR. CLARK: But it's that combination of use and concentration that's important in terms of exposure.

MR. HARDING: Right. The concentrations represent what I call the potential exposures.

DR. LABOLLE: Are the concentrations important, or is it the total mass --

DR. CLARK I guess it depends on what you're looking -- I guess if you're looking as adult cancer exposure, I would think the concentrations would be important.

UNIDENTIFIED AUDIENCE MEMBER: We'd like to have that.

DR. CLARK: Every epidemiologist would like to have that, I would think.

MR. HARDING: Yeah. What Eric is saying is that it's the actual mass that enters the body that matters medically, and so it's a combination.

DR. DOUGHERTY: That depends upon the contaminant.

MR. HARDING: The drinking and the -- their behavior because if the water is at the tap and they don't use it, it doesn't --

MR. MASLIA: That's what I'm asking. Not to belabor the point, but I'm trying to understand. If we're saying we want to understand their behavior, short of having activity patterns, would not a surrogate for that be the development, based on data of diurnal patterns for different locations within the base, knowing -- knowing that they -- that you've got a specialized population here. In other words, you've got --

DR. KONIKOW: But is there any hope if you knew the concentration at every well at all times, which you're not going to? But if you did, even given that information, do you know enough about when each well was pumped during the day, how it connected to the distribution system, to the treatment plant, to the tanks, that you could then predict what the concentration distribution within the residential area would be and how it varied with time on an hourly basis? That's just --

MR. MASLIA: No. That, we do not have.

DR. KONIKOW: I mean, it just seems hopeless to try to get hourly exposure data.

DR. CLARK: But you could get typical exposure patterns.

DR. WALSKI: But they're getting the same concentration every hour. So the pattern doesn't really matter.

UNIDENTIFIED PANELIST: Right.

DR. CLARK: Well, it is important. I don't understand your --

DR. WALSKI: If you're getting 80 in the morning or 80 at night, that's not the distribution system.

COURT REPORTER: I need you by the mike; one at a time, by the mike.

DR. WALSKI: Okay. But that's not something you model. I mean, the model can -- let's say you get 80 during that day, and that's into the epidemiology whether they drank it in the morning or drank it at night.

DR. CLARK: Well, it would depend on whether you're using it -- you know, whether you're inhaling it, whether you're ingesting it. I mean, those are very important.

DR. CLARK: Yeah, those are things are exposure patterns and you have to be able to have that kind of information. I think you could get that from a daily exposure -- a daily cycle of concentration plus superimposing upon that the pattern of activity.

DR. KONIKOW: Where are you going to get a daily cycle of concentration from?

UNIDENTIFIED PANELIST: We're not going to get that.

DR. CLARK: I think you can get a typical daily cycle.

UNIDENTIFIED PANELIST: I don't believe --

UNIDENTIFIED PANELIST: Where? Where would the variation come from?

DR. CLARK: I believe you can.

UNIDENTIFIED PANELIST: But it goes through the same place.

UNIDENTIFIED PANELIST: But you don't know that.

COURT REPORTER: Gentlemen (laughter).

UNIDENTIFIED PANELIST: Is she a Marine?

COURT REPORTER: The record is suffering, and you're not getting anything right now. This is for your advice.

DR. SINGH: I think we are playing a little bit of a pundit here. I think the main issue is the water-distribution modeling system here and how does it affect the exposure. That is really the crux of the matter here. That's what he's trying to get at. And as Ben pointed out, as Tom pointed out, I don't think it is really going to make a whole lot of difference so long as we know the concentration and the depth because that is what is going to determine the exposure of the people.

DR. CLARK: But you have to -- I think you have to have the modeling to be able to predict what the concentration of the tap is going to be.

DR. SINGH: Well, I'm not sure really if the water-distribution modeling is going to make that much of a difference to the concentration. I think what we need -- you know, what the groundwater model is giving, that is really the crux of the matter. Once that -- that gives us -- once it goes into the treatment plant, the water comes into the pipes. I don't think the pipes are going to make a great deal of difference unless, of course, as you pointed out, unless we take care of the biology and the chemistry, which they are not --

DR. LABOLLE: Well, that would be another issue.

DR. SINGH: -- which they're not dealing with. Then I'm not sure how it is going to really greatly impact the pollutant concentration which the people will be exposed to.

MR. MASLIA: The fact that -- given that we may not be able to show a difference, you know, day to day or whatever, but rather just come up with a typical day, do we still need to be able to demonstrate that it is insensitive in a formalized way, not just make a statement, but demonstrate in a formalized, approved, or acceptable method, i.e., some kind of model or something, at least running it to some degree to show that this is insensitive and that there's no need to refine it any further?

DR. SINGH: Your snapshot data, on May 27th, 1982, tap water at TT tested: PCE, 80 ppb. Then if you take in the snapshot, February 5, 1985, TT tap water tested: PCB, 80 mpb. And in between, there is a little bit of variation. It seems to me that really that it's not a very wide range of PCE concentration in the water-distribution system.

DR. LABOLLE: It's likely to vary more than, I think, what's indicated by these two snapshots. That's just --

DR. BOVE: Probably an order of magnitude.

DR. LABOLLE: Maybe more; maybe less.

DR. POMMERENK: It's just -- for example, wasn't there a sample point that indicated 12,000 micrograms per liter?

MR. MASLIA: At a well?

DR. POMMERENK: At a well.

MR. MASLIA: At a well, there was 1600 -- almost 1600 parts per billion.

DR. POMMERENK: So hypothetically --

MR. MASLIA: Was that Well 26?

UNIDENTIFIED AUDIENCE MEMBER: (Off microphone)

MR. MASLIA: Well 26 was almost 1600 parts per billion?

UNIDENTIFIED AUDIENCE MEMBER: Uh-huh.

MR. MASLIA: Yeah; 1600 parts per billion.

DR. POMMERENK: Hypothetically, you know, the well could have been turned on in the morning before any other well was turned on, and that got into the tank. And let's say we had some, you know, plug flow there. So the slug of 16,000 -- 1600 micrograms per liter could have reached some consumer within hours or a day. So there is a range of, you know, a factor --

DR. DOUGHERTY: What if it proved less than that because it takes multiple wells to fulfill the demand? Right? Let's say --

DR. POMMERENK: Well, I mean if we assume --

DR. DOUGHERTY: -- three, roughly three at a time, I think, is what we discussed yesterday.

DR. POMMERENK: Well, if we assume that there's always complete mixing and so on. And, of course, there are reserves in the system. So they may draw some water from tanks once in a while, and so...

DR. LABOLLE: But, certainly, that concentration in that well, you know, although we see, you know, a point in time 1600. It could have been 16,000, you know, the month before.

DR. JOHNSON: Mr. Ensminger, do you wish to comment?

MR. ENSMINGER: Let me get up here before I get yelled at (laughter).

There was one test at Tarawa Terrace that did show 215 parts per billion. And that was taken in February of 1985, just prior to the wells being closed down.

MR. HARDING: Was that a test at a well?

MR. ENSMINGER: Yes. And it's in the public health assessment -- no; not at the well. That's at the tap.

MR. HARDING: What was that number again?

MR. ENSMINGER: 215. And it's in the public health assessment.

DR. JOHNSON: I'd like to -- I've been getting sort of a frantic message here from our recorder that she needs to calibrate her recording equipment. So I'd like for us to take about a ten-minute break. We can return and continue this discussion. And I would like to talk with Mr. Maslia as to what you feel you need to present next, if anything. Okay. So about a ten-minute break.

(Whereupon, a recess of approximately seven minutes was taken.)

DR. JOHNSON: About how much time will you need, Morris?

MR. MASLIA: Three years (laughter).

DR. JOHNSON: And more.

MR. MASLIA: No; probably 20 minutes, maybe. Is that too much?

DR. JOHNSON: We'll give you 15 minutes. Okay?

MR. MASLIA: Okay. I'll --

DR. JOHNSON: So about ten after --

MR. MASLIA: Okay.

DR. JOHNSON: -- try to wrap it up. And then we can turn to these questions.

MR. MASLIA: Okay.

DR. JOHNSON: I'm obsessed by these questions, as you can tell.

MR. MASLIA: That's fine. I appreciate that. What the presentation, continuing from this morning is intended to be, is to go over what we understand about the present-day system. So I'll proceed along that road.

This is an example of the Hadnot Point water-treatment plant. Does anybody mind if I stand out here? Okay. But basically our approach is not to model anything within the treatment plant but basically the flow or the discharge coming out, the assumption being that nothing significant would occur to the -- once the wells are mixed to the concentrations within the treatment plant.

So what we have from a link and node point of view is we're just supplying water at a node or at a point to the distribution model and putting in demands and having our tanks. That's the approach in all three models that we have. And this information we obtained from the water utility or from records that we have -- production records that we have.

MR. HARDING: How complete are those?

MR. MASLIA: We have -- as Bob said yesterday, we've got records in the eighties, except for a couple of years, a couple of critical years. We've got sporadic information, and then we also have some in the nineties.

This is monthly data for each of the -- it's production for the total treatment plant, in other words, not by well, but by what the -- the plant took in as raw water and then produced and put out into the system and then what we measured in the field.

Each system is operated -- each of the three systems is operated by using what's referred to as a controlling tank. That's the one with the asterisk. And based on the water level in that tank, that triggers high-lift pumps to push water out into the system or fill the tanks.

We've done some C-factor tests. The -- this is an average of all. We did eight C-factor tests. These are the averages. The ones where it says "C-factor tests" is an average of the tests for that particular pipe type. We found that the cast iron pipes had a -- what we thought indicated more of a smooth as opposed to more rough type characteristic in them.

DR. WALSKI: Morris, roughly what percentage of the pipe was cast iron versus PVC? I guess they're the two main ones.

MR. MASLIA: I have that, and that's in the notes.

DR. WALSKI: Just approximately. Was it like half was cast iron or 10 percent or...

MR. MASLIA: I want to say 60 percent, but I'm not -- it's in the report, and I don't have that off the top of my head. But we've got a table. There was a table in the report that listed it, but we can get you that number.

DR. WALSKI: Okay.

MR. MASLIA: Cast iron; yes. It's 34 percent cast iron.

DR. WALSKI: Okay.

MR. MASLIA: That's present day --

DR. WALSKI: Okay.

MR. MASLIA: -- present-day system. We've also distributed or developed what we're calling demand groups, and this is based on these group -- groupings are based on nomenclature from a water-conservation analysis that was done in 1999 for the Marine Corps at Camp Lejeune.

And we've got this unknown negligible group basically because there was a large disparity between what could be accounted for and what couldn't be. It's about 30 percent difference.

Just to show you the distribution based on our understanding. This is Hadnot Point, and you can see in the Hadnot Point -- and I know -- I apologize, Ben, that this is in color. So let me get a -- I'm trying to think where I put the pointer now.

DR. JOHNSON: Use the microphone. I was referring to Ben.

MR. HARDING: Sorry.

MR. MASLIA: Okay. Ben, Hadnot Point -- this is really the only family housing right up in this area. The area down in here is bachelor housing. And then the rest would be more industrial and other offices and things like that; whereas, in Holcomb Boulevard and Tarawa Terrace -- in Holcomb Boulevard, we've got all this area down here, down here, and down here. That's family housing. And, of course, in Tarawa Terrace, we've got -- that's nearly 100 percent family housing with the exception of some shopping centers.

The number of nodes that it's referring to in the model is basically for in all pipes. These are all pipe models, although we have also developed the network for skeletonized ones as well. That is basically a short description of the present-day distribution systems, and now what I'll do is go through the field testing that we've done.

DR. CLARK: One question is: Do you have a picture of how pipe replacement took place over time? If it's 34 percent cast iron now, one of the issues is going to be, I think, how much of it was cast iron under previous scenarios, I guess?

MR. MASLIA: Here's a picture of how it took place.

DR. CLARK: Yeah. And do you know how much, for example, in 1985, how much was cast iron?

MR. MASLIA: Not right offhand.

DR. CLARK: Okay.

MR. MASLIA: We don't. But we do know because right now they're replacing -- substantially replacing. They've got a building program, say, at Tarawa Terrace. And so they're, as we speak, replacing -- replacing pipes with

PVC. On the other hand, they replaced a pipe going up to the Naval hospital. That's the asbestos cement pipe that we did a test on, and for whatever reason, when they replaced the pipe, they used asbestos cement not PVC.

So I'm -- for whatever reason, I don't know. I'm assuming that's the way the contract -- whoever bid on the contract replaced it with. Okay. Continuing on, we've conducted -- we conducted a test at -- in the Hadnot Point area from May 24th to 27th through monitored system pressures. We retrieved storage-tank levels and we conducted dual-tracer tests.

We injected calcium chloride, and then we also -- it says injected sodium fluoride. We shut the fluoride off to the -- we didn't shut it off. The utility people, at our request, shut the fluoride off. And they used a sodium fluoride gravity-feed system at both treatment plants.

Just some equipment that we used to monitor: pressure loggers. And these are the water-quality monitoring systems. There's a dual-probe system that's ion specific. In this case, it can measure fluoride and what we specify: fluoride and chloride and then conductivity in the other probe plus pH temperature. The single probe can measure conductivity and -- but is not ion specific.

This is the way we attached it in the field, putting them in some plastic housing and then strapping it to the hydrant and flowing the hydrant. And then we also obtained grab samples as well and did some QAQC on site as well as sending grab samples off to the federal occupational health lab in Chicago.

This map here shows the monitoring locations, and you've got that in the reports. We had 27 different monitoring locations for the Hadnot Point. We had nine pressure; nine dual-probe locations, where we did fluoride and chloride; and then nine, just conductivity locations.

As I said, pressure ranges basically between about 55 and 65 PSI and fairly constant. And the topography is fairly flat there as well, which gives you very small hydraulic gradients. And realizing that, that was one of the reasons behind us doing tracer tests, as we felt we would not get any kind of unique calibration even on the present day just looking at hydraulics.

This is some -- I'm just going to show you some data from this test. This is injecting calcium chloride. This is at location F-02. The red line is a model simulation, and the -- or the solid line is a model simulation, and the dots are the data recovered by the logger. Here is an example -- this square box is the injection time and at location F-01, which is -- let's see where is -- on my map, it's at Hadnot Point, which is (off microphone) --

COURT REPORTER: Microphone.

MR. MASLIA: Hadnot Point was located right over here. That's F-02. And, of course, what we found out that that's about a 20-hour lag and which greatly exceeded what we predicted in the model even though the model wasn't calibrated. And so we had thought there may have been some closed valves, and post-test auditing by the water utility, in fact, confirmed we had four closed valves.

And you've also got this drawing in the notebook that we gave you. But you can see right over here. Here was the source at the treatment plant. So we've got down here a couple of hour travel time, down in here, down to here about nine hours; but all the way up to here, between 20 and 26 hours, right here. So that obviously shows the effect of the closed valves and low demand as well. So it just stayed in the system there.

This slide shows you the fluoride concentration in the tanks. We had requested that the utility shut the fluoride off on May 15th. The test took place the week of May 24th. And, in fact, water samples, taken by the utility within -- at the distribution-sampling point showed concentrations of fluoride down around between .1 and .2, so it had diluted down.

But the concentrations in the tanks ranged between --

almost averaged about one from these three tanks. This is the controlling tank right down here. So, of course, it's exchanging water back and forth. So it's getting the -- it's diluting; whereas, these tanks over here really did not show much dilution.

This is an example of -- and it caught us by surprise when we -- in the beginning since we didn't understand how they were operating the tanks and that. Here is some grab sample data of the fluoride, and this is a logger that was near the French Creek tank, which is the controlling tank, which was this tank right over here.

And unfortunately, we had to pull the logger for technical reasons. But we still see the grab sample data rising and chloride concentration indicating a slug coming through here. And then 48 hours later, all of a sudden, we see a slug of -- we reconnected the logger, and we see a slug coming through.

And that is sort of what guided us and then in a subsequent test in instrumenting the tanks, putting loggers on the tanks and seeing that the water was not mixing completely in the tanks.

DR. WALSKI: When you say putting a logger in a tank, are you sampling the pipe going into the tank at ground level or are you taking sample from inside the tank and --

MR. MASLIA: Not from inside. We're putting it on the pipe. And we can see -- and I've got some data to show -- on a subsequent test, you can tell which is the system fluoride and which is the tank fluoride --

DR. WALSKI: Okay.

MR. MASLIA: -- by the spiking, by the spiking of the logger data, in other words, so you know what elsewhere in the system, what the fluoride level is. And then all of a sudden you see a high spike coming through the logger, which is interpreted to be the tank releasing water to the system. And that's when it's -- that's when you're shutting off the fluoride.

Just the opposite is true when you're increasing the fluoride in the system. You'll see low fluoride from the tank now going in the logger as opposed to higher fluoride from the system. And I'll show that in just a few minutes.

Okay. We conducted the hydraulic test in the week of August 25th. Again, this was to determine some C-factors, and we used sort of an innovative fire-flow testing technique where we opened up several -- several hydrants at the -- at different times. We found eight. I think we tested eight different sections of pipe. One of -- because of the piping construction and layout, we were really trying to look at the -- get some information on the Hadnot Point area. But it was just not possible to find, say, a thousand-foot long section of pipe with three adjacent hydrants.

We scoured the maps and stuff and went out in the field, and that just was not a possibility. So we did do fire-flow tests in that area, but -- and for the C-factor test, we used a diffuser, and then we also used a pitot gauge for the fire-flow test in combination with this diffuser.

And this is actually from the summary I showed you before, the three C-factors. These are the actual values that came out, and they were pretty much -- as I said, on the average, they were within the literature published about values. For the fire-flow tests, what we did: We sort of modified the standard approach of putting a gauge on one hydrant and flowing the other. What we did is we used, in this case, two hydrants, flowing -- this is flowing Hydrant 1 here and Hydrant 2 there.

So we would have a static pressure, which you can see basically is about 50 to 53 psi on the observation hydrants. Then we flowed Hydrant 1, which would be this one, 773 gallons per minute. And you can see the pressure drop across all the hydrants. Then we flowed Hydrants 1 and 2. So we'd flow this hydrant and that hydrant, and you'd see a further pressure drop right there.

So that's the total flow coming out. It was about

1300 gallons per minutes. And then, of course, we shut off Hydrant 1 and only flowed Hydrant 2 and then go back to the static case. So that one came out very well, and that was to help us with calibration.

Finally, we conducted, based on our observation of what we saw in May with the Hadnot Point with the concentrations going -- or being delayed and coming in at a later time than we expected at the tanks, we thought we would instrument the controlling tanks.

So we had the water utility put some ports on the pipes leading to the storage tanks, and in this case, we had two controlling tanks. We had one at Paradise Point, which would be right over here. That's controlling -- that's a controlling tank for the Hadnot Point water-distribution system. And then the Camp Johnson tank, which is the controlling tank for the Tarawa Terrace distribution system.

So again, based on the water level in those tanks, that's what triggers the high-lift pumps to turn on or not turn on. And I just -- I showed you there. We monitored the system. We used -- we've got nine of the loggers. So we monitored the fluoride. We shut off the fluoride and recorded as it was diluting.

And then we had the utility turn the fluoride back on and record the increase in fluoride. We did not do any injection on this test. And so, Tom, you were asking about the storage tanks. This is a picture of the Paradise Point storage tank, the piping. And right over here is piping going in and one coming out. And so our loggers attached right here and on the outside of the actual housing but -- so depending which way the water would go, we would either get inflow or outflow and be able to record the fluoride concentration in the logger.

DR. WALSKI: Is that one tap or two taps?

MR. MASLIA: That's two taps.

DR. WALSKI: It's two taps.

MR. MASLIA: Two taps.

COURT REPORTER: Microphone, please.

DR. WALSKI: Mike. Okay. It's two taps, but how do you know that you're not getting the old -- the wrong water, if you had two taps like that? That it's --

MR. MASLIA: If it's going -- if it's going in -- and I'm trying to remember. I think it goes in --

DR. WALSKI: Usually, it fills through the smaller one.

MR. MASLIA: Going in this way. Right. That's the smaller pipe, going in this way. Then when it comes out, it's going to come out that way.

DR. WALSKI: Okay. But some of the -- well, that's okay. It's probably a very minor thing. Don't worry.

MR. MASLIA: So here are a couple of loggers. F-01 is the source. That was put at the -- on the Venturi meter or near the Venturi meter at Holcomb Boulevard water-treatment plant. So that's essentially your source.

This dotted line here indicates when we shut the fluoride off, which was at 1600 hours on September 22nd. And then we turned it back on at 1200 hours on September 29th. And Logger No. 3 was located down here. So Logger No. 1 is over here. Logger No. 3 is here. And you can sort of see the time it takes between here and here. So that's your -- you know, you could estimate an average travel time from there.

This is the example of the loggers connected to the controlling tanks. F-08 is the controlling tank at Paradise Point, which is this one over here. And F-09 is the Camp Johnson tank. That's basically the end of the distribution system as it is today. So, for example, right here, as the system water is being diluted, the system water -- and that's -- our grab samples show that too is down around .2.

So you've shut off the fluoride here, and by this time the system water is down about .2, but you're getting spikes of high -- high fluoride water, which is coming from what's in the tanks. Okay. And then just the opposite occurs when you're increasing the fluoride in the system. And, of course, this tank right here, being at the end of the system, shows a much more attenuated effect.

One of the issues we ran into and I believe we resolved -- but this line down here is the flow of water from the ground tank, the Tarawa Terrace ground tank. So if Camp Johnson tank is the controlling tank, when the Tarawa Terrace pumps come on and it's flowing water, we should see changes in the water level in the Camp Johnson tank. And the problem is, I believe, there was some SCADA and/or telemetry issues because Camp Johnson tank is flat-lining. If it's flat-lining, there should be no water flowing from the Tarawa Terrace.

DR. WALSKI: That's not flat. That's about what you'd --

DR. JOHNSON: Microphone. Mike; please.

DR. WALSKI: Okay. It's not going to drop dramatically because it takes a long time. So it dropped 1 or 2 feet --

MR. MASLIA: Over here. This is flat. That's not dropping.

DR. WALSKI: Okay. From there, it's --

MR. MASLIA: Yeah. Yeah. Yeah.

DR. WALSKI: There are -- it is --

MR. MASLIA: No. No. No. I'm talking about right here.

DR. WALSKI: But there's some issues with SCADA, in that just the lag time that SCADA doesn't continuously monitor and you may miss.

MR. MASLIA: Right.

DR. WALSKI: So it's not unlikely to happen, what you see.

MR. MASLIA: Okay. Lack of -- lack of meter data. We were going with the concept of a district metering area. So, in other words, because we did not have -- or we do not have household meters, we were going to meter certain areas and then be able to come up with per capita demand in that area. Sixteen meters have been installed. And we've got eight in the Holcomb Boulevard and Tarawa Terrace area.

So, for example, say, in Berkeley Manor, by knowing the flows and from here, here, and here, we would be able to come up with a per capita estimate or quantity. And this, in fact, there's a paper that just came out in 2004, talking about that. I've got the reference some place. But basically, using this approach and then trying to quantify the stochastic nature of the demand. And that's in the Hadnot Point area, meters in the Hadnot Point area. And that's it, I think. Oh, five minutes early.

DR. JOHNSON: Thank you. Tom.

DR. WALSKI: Well, the question about the metering now, you did full-pipe metering; right? You just tapped whatever size pipe was there?

MR. MASLIA: Yes.

DR. WALSKI: Did you check the model to see what the velocities were at those points?

MR. MASLIA: Actually, we've gotten into that issue, and we have done that now. I mean, we have that now. We've got an upflows. We've got flows. One of the issues that's been run into -- let me just put this up.

One of the issues that we have run into with the flow meters is the calibration process. And our understanding is from the vendor -- of course, these meters are Dynasonics, and they've got plus or minus 2 percent.

And the issue is at what magnitude -- if you calibrate it for a higher flow and then you're actually seeing a predominantly lower flow, you're going to have a much larger error than that. And just the opposite: If you're calibrating it for lower flow conditions and all of a sudden you flow hydrants or whatever, it's not going -- so what we have done, we were just up there in March and based on seeing the attempt for calibration and seeing what we were running into -- and I can pass a couple of these around and just -- if anybody wants a full copy, then we'll just need to run it through our clearance people.

But this is meter by meter location. And we did use the models as they are right now. They're not calibrated, but we feel they're in the ballpark, in other words. And we did both a table basically giving minimum, average, and maximum simulated flows, pipe diameter and where they are, as well as within each meter giving calibration procedures. And then we also had graphs on some of them. Where hydrants were available, we'd flow that hydrant to change the flow, to check the calibration.

So we also did graphs. So when you go back out into the field to calibrate them, we could know what ranges of flows to expect. You know, basically whether you're looking at flows below 100 gallons per minute or upwards of 600 gallons per minute. So that's where we are with that. We haven't gone back out in the field to do that, but that's the next plan. I'll just pass one around.

(Passing document around)

MR. MASLIA: If the panel would actually like copies --

COURT REPORTER: Mike.

MR. MASLIA: If the panel would like copies, let us know and we'll run it off and get it to you.

DR. WALSKI: Okay. The issue I've run into in these kind of meters is that, typically, the flows in the normal distribution system are very low because the pipes are sized for fire flow and they're down less than a foot per second and these meters are really lousy at a foot per second.

I mean, no matter what you do, you're going to have a really bad range. Almost -- usually for this type of metering, you've got to go in with a smaller pipe; like if you have a 12-inch line, you put in an 8-inch spool piece or something like that to get the velocity higher so that you get something in a range where it's sensitive because, when you're down less than 1 foot per second, no matter what you do for calibration, they're just lousy for those ranges. So what velocities are you seeing in these pipes?

MR. MASLIA: Claudia, do we have those? We can get those for you.

MS. VALENZUELA: (Off microphone)

MR. MASLIA: Yeah; yeah. If you don't mind showing -- we'll pull that up for you, if that's okay.

DR. CLARK: We had some similar experiences in Cincinnati when we tried.

MR. MASLIA: Are you saying so put them in smaller diameter pipes or...

DR. WALSKI: Well, not so much putting them in smaller diameter pipes, but mike the pipe down. Like, if you have a 12-inch pipe, you don't put in a -- just a

12-inch meter. You put in an 8-inch meter so that the velocity is higher for a little while and you have -- but that's a lot more construction cost, unfortunately.

MR. MASLIA: Right.

DR. WALSKI: You want to just tap the pipe.

MR. MASLIA: Yes. They've just been tapped now, and they've been tapped into a variety of diameter pipes. I've got the diameters listed.

DR. WALSKI: Yeah. They range from 6 to 12. But in a 12-inch pipe, to get more than 1 foot per second, you've got to be really cranking the water through it.

MR. MASLIA: Yeah. In fact, we've got one -- well, actually that one's not going to be used. We had one in 24-inch pipe, but that one's not being used. There's no flow in that one. Basically, the majority of them are 12-inch pipes. We've got an 8-inch pipe and then a 16 inch and a 10 inch.

DR. WALSKI: So you need almost -- excuse me. You need about 500 GPM in a 12-inch pipe to get sensible velocity.

MR. MASLIA: Yes. Yes. Yes. And --

DR. WALSKI: And in most of the data, you don't have that.

MR. MASLIA: And we've had to get that by flowing hydrants.

DR. WALSKI: But then when you measure it, though, the actual flows you're measuring are going to be below --

MR. MASLIA: Right.

DR. WALSKI: -- the sensitivity of the gauge, unfortunately. So it's going to be an issue. So -- it's just going to be an issue when it comes up.

DR. JOHNSON: Please.

DR. UBER: Morris, I've just got a quick kind of a boring clarification question here. I was just looking at some of the hydraulic gradeline elevation in this Table 1. And is this -- this is probably just a typo or something, but the controlling tank in the Camp Johnson tank, which is, I guess, the controlling tank for Tarawa Terrace, that's indicated as having a hydraulic gradeline of 107, roughly. Is that wrong, or...

MR. MASLIA: Which table are you looking at?

DR. UBER: Table 1 of -- in the present day, right after the blue page in mine. The reason why I was asking for -- because I was trying to look at hydraulic gradelines between the different areas and that's -- you know, the controlling tank in Hadnot Point is 160, and in Holcomb Boulevard it's 151, and then this is 107. I can't imagine there's that kind of losses.

MR. MASLIA: Oh, that one.

DR. UBER: I assume that it's a mistake.

MR. MASLIA: No. No.

DR. UBER: No. I guess I just don't understand how it operates then, but -- so -- well, if that's correct, see, there's another. The other tank in Tarawa Terrace, which is just, you know, a little ways away, has a hydraulic gradeline of -- well, 142 plus 32. So, you know, over 170 --

UNIDENTIFIED PANELIST: If you add that to that --

DR. UBER: We can't go from 170 to 107; can we?

DR. WALSKI: That's one of the things I pointed out in my comments too.

DR. UBER: Oh, did you?

DR. WALSKI: It looked inconsistent to me.

DR. UBER: Oh, okay. The only reason why I was asking is that -- I mean, if that were -- I was trying to figure out whether there is any -- any infrastructure information, having not been to this area or anything like that, to indicate likelihood of, if there were interconnections, what might be the possibilities of shipping water between them, you know, sizes of pumps, hydraulic gradeline, you know, that type of thing. And if that were true, that that's a controlling tank, it would seem to be hard to get water out of Tarawa Terrace --

MR. MASLIA: Is that just the tank level or the --

DR. UBER: Well, it's the hydraulic gradeline and the controlling "controlling tank."

MR. MASLIA: Joel, did you have or Brynn have any --

DR. JOHNSON: Come to a mike, please.

MR. ASHTON: Joel was just telling me -- that was our operator -- that the elevation difference between Tarawa Terrace and the Montford Point or Camp Johnson tank is about 7 feet.

MR. MASLIA: Seven feet.

DR. UBER: Okay. So there's a mistake there.

MR. ASHTON: There must be a mistake there, but there's about 7-foot elevation difference between the two.

DR. UBER: I don't want to belabor the point if it's a mistake. I assumed that it was, but -- okay.

DR. JOHNSON: Well, thank you for the comment. Do you have something else?

DR. WALSKI: Getting back to the graph that Claudia put up on the screen, you're going to have problems with that -- with these meters then. If the velocity is around .1 to .2, you're really down at the very low range of where that meter's good, unfortunately. If that's an average day kind of condition that she's got there, that doesn't bode well for accuracy, unfortunately.

DR. JOHNSON: Okay. Any further points?

DR. CLARK: Just a follow-up that we've even found some cases where we've got negative velocities when we knew that wasn't the case. So -- yeah -- at those local meters.

DR. JOHNSON: Morris, thank you for your presentation. Why don't you have a seat there at the table? And I would also ask Dr. Bove to join Mr. Maslia at the table. Let us turn to the set of questions and issues that the agency asked that you consider. And there is a revision to this, but the revision is being passed around.

The first question is -- and we've had some substantive discussion on this already, but...

Are the distribution-system tests conducted to date and the one planned for summer 2005 sufficient to provide ATSDR with required data for reliable calibration of present-day models?

Tom, would you like to take a lead on that?

DR. WALSKI: Yeah. It's outstanding. I mean, it's the best data study I've ever seen, probably. And it's probably more than they need for this study because you're not really doing fire-flow analyses. So you don't really need those high-flow tests. So, if anything, it's a little bit of overkill. But they did a great job.

DR. JOHNSON: Other comments from the panel?

DR. CLARK: That was my reaction too, that they're really kind of a state of the art of testing from what

I've seen so far.

DR. JOHNSON: Turning to Question 2 then: Considering the lack of household-consumption data and diurnal-curve characteristics, will applying the "district metering area approach," using the 16 system flow meters, provide adequate and sufficient information to develop per capita consumption data and diurnal-curve characteristics? Are panel members aware of other approaches that could be useful?

DR. WALSKI: Well, the more rudimentary way to do it is just to do a mass balance on the system. You look at flow in, plus or minus changing tank levels, on an hour by hour basis. And that's usually good enough when you don't have submetering because, unfortunately, as I was saying here, the velocities are so low at those points that the accuracy of these gauges aren't going to be that good at those really low velocities. So just the mass-balance approach may be adequate.

MR. MASLIA: Can I ask a qualifying question? Do you not need to then have, you know, reliable SCADA information for that?

DR. WALSKI: Right. Yes.

MR. MASLIA: Okay. And --

DR. WALSKI: And that's --

MR. MASLIA: At least we've been informed that, you know, the SCADA equipment is old at Camp Lejeune. And, you know, at some points in time -- at least some times when we were testing the test, there is some question as to their reliability, that it doesn't have it. So that was one of the issues we had discussed with the folks at Lejeune is -- as to why we decided to go with a metering approach. So -- but you would need the reliable SCADA information then.

DR. WALSKI: Right. The question though is usually it's a lot cheaper to recalibrate the SCADA system than it is to put in all these meters and the vaults and all that. But that's something where I don't know the details. So I couldn't really say.

MR. MASLIA: Okay. I just wanted to clarify that.

MR. HARDING: I think we have to keep in mind the purpose for the estimates of water use. And I'm not completely clear on that. I think in Tarawa Terrace we've decided we probably don't need it, other than to deal with the well cycling. And in this particular circumstance, I -- now, it's referring specifically to the work at Hadnot Point; right?

It isn't clear to me that we're going to -- that a model is required at Hadnot Point if our second objective is to establish an unexposed population. So I think we just need to keep that in mind. But get -- if we do want to establish hourly or subdaily water-use characteristics at the water-treatment plant, then I think Tom's right, that it's much easier to measure tank levels and flows at the plant than it is out in the system.

DR. BOVE: Let me just say one thing. We do want to know who was exposed to TCE. So we do want to know not only who's unexposed but who -- how many were exposed to Hadnot Point.

Originally, when we did the earlier study, we had a very small group that we thought were exposed to Hadnot Point. We found an odds ratio of 1.5 for small-for-gestational age, if I remember right. But we would like to also look at trichloroethylene if the numbers are there. And the numbers would be there if we find that some of the Hadnot Point water went to Holcomb Boulevard for any length of time beyond '73 or whatever.

DR. WALSKI: Was there distribution -- or any kind of distribution measurements of TCE at Hadnot Point, or is -- I mean, we talked to Jerry during the break and he says there were well measurements, but were there any distribution measurements of TCE?

DR. BOVE: At Hadnot Point?

UNIDENTIFIED PANELIST: Yeah; at Hadnot Point.

DR. WALSKI: Okay; because I wasn't seeing it in this one list.

DR. BOVE: In the old assessment, there were.

DR. WALSKI: Okay.

DR. DOUGHERTY: Let me go back -- the recorder has a question.

COURT REPORTER: Well, the recorder didn't hear what was coming from behind me, and I think it was the answer to one of the questions. So it's not in the record. If you want it in the record, please, identify yourself and get to a microphone.

MS. HOSSOM: Okay.

COURT REPORTER: Thank you.

MS. HOSSOM: Hi, I'm Carole Hossom. I wrote the 1997 Public Health Assessment. And at Hadnot Point, I believe the data shows -- excuse me -- 1400 parts per billion TCE at Hadnot Point.

DR. BOVE: Tap sample?

MS. HOSSOM: Excuse me?

DR. BOVE: Tap sample?

MS. HOSSOM: Tap; drinking-water sample.

DR. WALSKI: Okay. Was that -- so there was one measurement made there historically, or were there --

MS. HOSSOM: No. There were a few, but a handful.

DR. WALSKI: That was the range of numbers because it wasn't on this summary sheet here, and that's why I was asking if we had much.

DR. LABOLLE: Okay. Was TCE the principal contaminant there, or was there also PCE?

MS. HOSSOM: For Hadnot Point, TCE was the principle contaminant and degradation products of TCE, not PCE.

MR. HARDING: Okay. While you're there, don't -- because if I recall correctly -- I don't have that open in front me -- there was also an estimate of vinyl chloride.

MS. HOSSOM: Right.

MR. HARDING: Was that -- was that at any measurement of that, or was that just a calculation based on assumed degradation?

MS. HOSSOM: It was a -- because the laboratory-detection limit was only ten parts per billion, the -- it was estimated at below that to be eight. Although it was not calibrated below ten, it was an estimated measured value.

MR. HARDING: Okay. So it was detected.

MS. HOSSOM: It was detected.

MR. HARDING: But not quantifiable.

MS. HOSSOM: But not quantifiable.

DR. DOUGHERTY: So is that a quantitation limit, you're talking about, and not a detection?

MS. HOSSOM: Correct. It was quantified, but it was below the limit. So that's how it was reported as an estimated detected value as opposed to not detected. Does that clarify that?

MR. HARDING: Uh-huh.

MS. HOSSOM: Okay. So Hadnot Point was TCE. Tarawa Terrace was PCE; majority contaminants and then degradation products.

DR. JOHNSON: Okay. Thanks.

MS. HOSSOM: Thank you.

DR. JOHNSON: So with regard to Question 2, Morris, what do you think you have heard?

MR. MASLIA: I've forgot to give myself a copy.

MR. HARDING: Well, can I --

DR. JOHNSON: Please, Ben.

MR. HARDING: I'm still not sure we can answer Question 2 yet because I'm confused again. And forgive me, but, Dr. Bovey --

DR. BOVE: Bove.

MR. HARDING: Bove. Sorry. I understand now that, okay, we're also interested in the TCE exposures in Hadnot Point, and you talked about also looking for exposures in Holcomb Boulevard. But it seems to me that -- let me just see if I can frame this. And I apologize if I get this garbled. But in doing this analysis, we're going to compare the exposed populations to an unexposed -- I think you guys call it -- case control or whatever.

DR. BOVE: Just keep with exposed and unexposed.

MR. HARDING: Okay.

DR. BOVE: Because cases and controls are both exposed and unexposed.

MR. HARDING: Okay. So we have to find -- ideally, we'd like to find some populations on the base that were exposed to TCE. We already have established that there's a likelihood, high likelihood, that you can identify populations that were exposed to PCE at Tarawa Terrace. But then we also need to find a population that's unexposed. So that population that's unexposed would potentially be in Holcomb Boulevard during periods when the two weren't interconnected.

DR. BOVE: Right.

MR. HARDING: Okay. Now --

DR. BOVE: But -- but there are interconnections. And that's what I'm concerned about.

MR. HARDING: Well, representing those interconnections is the complicated part of this. So the question I have is -- is that: Can you select your unexposed population from time periods where we're reasonably certain there were no interconnections, where Holcomb Boulevard operated independently of the other water-distribution systems?

DR. BOVE: Well, that's the question, though, I think; isn't it?

MR. HARDING: Well, no. Is it adequate for your purposes? is what I'm asking. You don't have to -- do you have to -- do you have to have an unexposed population that goes from 1968 to 1985, or can you pick a population that, potentially, let's just say, from 1971 to 1981?

DR. BOVE: No. We have to be able to determine for that whole period who was exposed and who was unexposed. Okay. So -- and if we -- we can misclassify people as exposed or unexposed, but we need to know that.

MR. HARDING: Okay. Well, can we have three groups: exposed with some degree of certainty; unexposed with some degree of certainty; and we don't know, which we put aside? See what I'm saying?

DR. BOVE: See, the design of the study is that you -- we use the whole time period as the -- I mean, the population is all the births during that time period. Okay. We take a sample of all the cases from that time period, and we take a sample of controls. The controls are supposed to give us some reflection of the exposure -- the proportion exposed in that population. That's the purpose of a control series.

We're using that whole time period. So we have cases during that whole time period. We'll have controls during that whole time period. We need to assign exposure properly to those cases and controls. So the -- in the previous study we didn't do a case-control sample. We can do what you suggested because we can just -- we took everybody. So we can decide, all right, we'll just take this part of the population. But with a case-control sample, you take a sample of that whole population. You have to be able to assign exposure for that whole period of time.

DR. DOUGHERTY: As I recall, the Holcomb Boulevard came on-line in '73, the treatment plant. Is that --

MR. MASLIA: Between '71 and '73.

DR. DOUGHERTY: Somewhere in that time period.

MR. MASLIA: Yeah.

DR. DOUGHERTY: So -- and then the interconnection was turned off.

MR. MASLIA: No. We don't know.

DR. DOUGHERTY: We don't know that for sure?

MR. MASLIA: We know --

DR. DOUGHERTY: And we know that --

MR. MASLIA: -- at certain times, we know the interconnection between Hadnot Point and Holcomb Boulevard. I believe it's January. There is a date on the chronology. January of '85, we know there's a period in there that there was an interconnection because of a failure of a pump or whatever at Holcomb Boulevard. So there was an interconnection.

DR. DOUGHERTY: And at the other end, we know that the connection at Tarawa Terrace came in somewhere in the '85 and possibly '84 with a temporary line. Maybe even '83, I think we heard, with a temporary line. So the period prior to 1971, we can say pretty much with certainty that Holcomb Boulevard people received water from Hadnot Point, which makes the classification straightforward. And let's see --

MR. HARDING: Well, you're a groundwater modeler, so you shouldn't be saying that.

DR. DOUGHERTY: No. This is strictly about whether there's a possibility as in a pipeline --

MR. HARDING: Yes.

DR. DOUGHERTY: -- that exists or doesn't exist. And so we can take care of that much of the window. You can fill in the rest of the blanks.

MR. HARDING: Well, but the reason -- I may be belaboring this point. But the reason is is that I'm trying to establish whether there's a way to avoid trying to do the complex and the highly uncertain water-distribution modeling, given the very sparse amount of facts we have about it.

And if -- and I want to put this question to the panel. Maybe you'll tell me to shut up about this. But the level -- we don't need to know a lot about the diurnal patterns of demand, if we're going to use more of a mass-balance approach to this. And so if we have this period of time -- is it weeks? months? years? -- that we absolutely must include to complete this study, that's a different story than if we can pick the times when we have reasonably good certainty.

If we have to include all of these periods, it's my opinion that we have to be very honest about the very high degree of uncertainty in the periods where we're doing water distribution fate and transport model. So I don't know. I'd like to hear what other people have to say because I've beat this horse pretty hard.

MR. ASHTON: I would just like to clarify one thing.

DR. JOHNSON: Come on up.

MR. ASHTON: There's a little bit of confusion about when the systems were interconnected. After this '72 plant was constructed, unfortunately, the two systems -- Hadnot Point and Holcomb -- they're at different pressures. There are quite a bit of difference in the elevation of the water tanks. So we keep, normally, those belts closed.

The operational procedure now -- and I'm not sure how long this dates back. But we contact the State when we open those valves to get approval for interconnecting the systems. We have two different operating permits for the systems. And so those systems are separate, and they're kept separate.

The line that we were talking about yesterday between the Holcomb system and the Tarawa Terrace system, that is something that has been confused, and we're in the process of clarifying it with both the construction drawings that we have to install the lines and also the operators that are familiar with the system. And we'll clarify that for you very soon, and that's what we're working on right now. But the people aren't here that have that information. But we feel it's in our construction drawings.

DR. BOVE: Would there be a record of every time you connected Holcomb Boulevard and Hadnot Point then?

MR. ASHTON: That's unfortunate. I don't believe there is unless the State has --

DR. BOVE: But if you record -- that's what I mean.

MR. ASHTON: -- unless the State has a record, which they might.

DR. BOVE: Okay.

MR. ASHTON: And I have no way of knowing what they have. But we'll try to find that out. We've got a request -- there's been some turnover at the State. We have a request through the State to try to get -- see what records they do and don't have, so...

MR. HARDING: Is there a distinct grade difference between the three systems, and if so, can you say nominally what the -- what grades they were, what grades they ran at?

MR. ASHTON: Yeah. I don't have the exact information of the difference in the elevation between the Hadnot Point and the Holcomb.

MR. HARDING: Which one was higher?

MR. ASHTON: Okay. I believe -- I believe the newer system is higher, if I'm not mistaken.

MR. HARDING: The newer being Holcomb?

MR. ASHTON: Meaning the Holcomb system, I believe. But I can verify that. The -- as Joel says, he wasn't sure which system -- the tanks, of course, were not -- there were quite a bit of difference in the tank levels. And, of course, we try to keep our tanks full for fire-protection purposes, and that is the reason why that valve is normally closed and we have two separate systems.

DR. UBER: Just on that point, the data in that same Table 1 shows a 9-foot grade difference from -- actually, contrary to what you said from Holcomb -- I'm sorry, from Hadnot Point to Holcomb in that direction for the controlling tanks.

MR. ASHTON: So you're saying that the Holcomb plant is lower, you're saying?

DR. UBER: That's what -- just -- that's just what this data in the table shows --

MR. ASHTON: And I'll verify that.

DR. UBER: -- by 9 feet.

MR. ASHTON: That's -- that's -- we have records of all the differences in elevations. The guys who -- the guys that had that plan, he'd have it off the top of his head, but I don't, unfortunately.

DR. UBER: Yeah. I mean, that would be -- that's, of course, quite useful information to know in terms of interconnectedness. So that would be -- that would be good.

MR. ASHTON: The USGS has took with them all of the elevations. So we have all that information.

MR. MASLIA: We have land-surface elevations at the tanks.

DR. JOHNSON: Ben had put on the table sort of a request for reaction to a proposal. I didn't hear much reaction. Did I miss something?

DR. CLARK: I can give you my answer to Question 2, and I think the answer's yes. I think it's probably the best way you can go about it to develop diurnal patterns using this district metering approach, given the fact that you don't have other data available.

DR. JOHNSON: Okay. Let's move on to Question 3.

MR. MASLIA: Can I ask a question?

DR. JOHNSON: Sure; of course.

MR. MASLIA: And it's sort of encompassing early -- both days, and it's more of a, I guess, philosophical one. But I'll ask it anyway.

We acknowledge, both on the epidemiologic side as well as the modeling side, that there's a great deal of uncertainty. But what I'm hearing is -- or what I'm interpreting is that perhaps we should just throw our hands up even if we quantify it or make a gross assumption, very simplifying assumption, and that is, not degrading that approach. That may be a valid approach. But then the agency still has other parties to answer to.

And so my question is: How does the agency go about saying -- do we go about saying that this is the best we can do and we can refine it no further, or do we -- that's what I'm trying to clarify.

DR. WALSKI: Here's what I was going to suggest later on --

MR. MASLIA: Yeah.

DR. WALSKI: -- but since you brought it up now, I might as well talk about. It seems like -- my approach would be is to take what you've got now and say, "Okay. We know these people were exposed. We know these weren't. We're not sure about these." And in about six months use the model as best I can -- in about six months, study, write your report, and say that we could spend another two or three years on this and we can refine the numbers a little bit.

But, unless you have some hope that two or three years of more work is really going to make the numbers better, I think, you know, wrapping up the modeling part of this in a short time and saying this is -- this is -- call it interim report to cover yourself. But say, "You know, we can -- you know, in a couple of months we can wrap this thing up, give you a good answer, and maybe we can get it 2 percent better if we spend another three years on it or something" is the way, I think, it's going to all play out is my prediction. And I could be totally wrong in it. You probably have some people...

DR. JOHNSON: And my opinion is: Someone who doesn't know much about this whole area of work, they're -- one of the parties you have to be concerned about is the scientific community. And I always found it very useful to try to anchor on those data that you had confidence in. And things that might rise to the level of speculation you discard, unless there's some really good reason for doing otherwise.

And so your response to those other parties who may want you to do God-awful things that may surpass your ability to do, you simply have to say that that's not possible. The science just doesn't take us that far. And we are going to base our work, whether it's in the area of water modeling or epidemiology, on the most reliable data in which we have confidence. And that's as far as we can go. That's as far as the science will let us -- take us.

DR. BOVE: Well, I still think there's a lot of work that could be done to get other data that's available, both records from the state, if necessary, or other memos and material that might give us a sense of how -- whether these systems were in -- used in an interconnected fashion.

And so I think that that's, more than modeling, is what I would push for. It's a lot more of getting that information from the vault that would help us clarify some of these questions.

DR. JOHNSON: That may be true, but you have to ask the question of: Well, what's it worth? And what am I willing to invest to go beyond what I have now with which I have some confidence? And as Tom characterized it earlier this morning, you're getting into perhaps the area of archaeology and that's -- may be quite appropriate. Do you -- I think you have to do something akin to kind of a cost-benefit effort to determine if it's worth it.

MR. HARDING: I would say that along those lines that the question can be framed as: Where do you want to spend your resources? And let me first respond to Morris and say, if you're interpreting what I was saying, I'm not saying throw up your hands at all.

What I'm -- what I'm advising is essentially the same thing here is that we ought to ask ourselves: Where can we get the most bang for our buck? And if I had to say right now where that is, it's in trying to refine the understanding of when the contaminants reached the wells at Tarawa Terrace and then -- I don't think we have much of an understanding about what happened at the wells at Hadnot Point if we're looking for exposures to TCE. So those are two areas where more emphasis could be put than on the water-distribution modeling.

And then when we get back to this issue of Holcomb Boulevard, the purpose of the Holcomb Boulevard analysis is to establish unexposed populations. And I think that you have to ask yourself: If we've got these sporadic and poorly defined periods where there was potentially some contamination in that system, think about whether you can exclude those periods from your analysis as a way of saving a huge amount of effort that can be spent better, to my way of thinking, in trying to reconstruct, for example, what happened at Hadnot Point in the groundwater.

So that's my take on it, and that's why I've been asking these questions now because I'm not sure that the

-- if you want to do diurnal-demand reconstruction, there's various ways to do it. But I'm not sure whether you need to or not. That's my point. That's why I was having trouble answering the question.

DR. WALSKI: The impact of your suggestion is (off microphone).

DR. BOVE: We would lose some cases in a situation where we already have a small number of cases, and we would have to take a new sample of controls to fit the new population we're talking about. We've already sampled control, sent them to the vendor. We could -- and the process of interviewing will start, as you heard, next week. But that could be put on hold.

But my problem with this is that we don't know. I mean, we can -- I guess we can -- I mean, we don't know when the interconnections could have occurred, I mean, you know, the water flowing back and forth. So when would you say -- what groups of people, what periods of time should we exclude from our study?

MR. HARDING: Well, let me put the question another way. If you don't know when the interconnections occurred, how are you going to model them? I think you just have to bite this bullet. And you have to -- here is our best determination of when these systems were -- you have to do this no matter what. You have to say when were they connected and when were they unconnected. And what I'm saying is: Once you've made that determination, don't take the effort to model the interconnections.

DR. BOVE: No. Right. And I'd like to get these records from the state, if they exist.

MR. HARDING: Well, I think that's -- I think that's a good way to spend your money, and I think that doing the archeology in a case like this may well be warranted to figure out what happened. But once you've figured that out, then -- then really you've got to ask the question: Is it worth spending an enormous amount of energy to model these relatively short periods at the expense of doing what I think is more important?

And here, I'm speaking here as a ground -- or as a water-distribution person. But I think that the groundwater case at Hadnot Point is -- am I missing something, or do we know anything about the historical pattern of contamination at Hadnot Point?

DR. WALSKI: I think one of the things we talked about yesterday was, it's so complex that we really can't model it though. We kind of threw up our hands on that one and said, "We know there was contamination, and we know well-monitoring points, but there are so many sources there --

UNIDENTIFIED PANELIST: Yeah. Didn't I hear

160-something?

DR. WALSKI: -- but I can't tell exactly which source went to which well.

DR. DOUGHERTY: That was the limit of information that we've had to review. So the answer is: I don't know. We may have some kind of generalizations.

DR. BOVE: I mean, we've been asked to determine when contamination arrived at Hadnot Point too. I mean, this is -- this was our charge early on. So forget the study for a minute. We were asked that question. And there are people out there who want to know the answer to that. And I don't know if we can provide that, if that's what you're saying, because of the multisources, and we don't have that information on those sources.

DR. JOHNSON: I think Jerry has a point to share, please.

MR. ENSMINGER: As far as the actual contamination of the Hadnot Point water system, you have earlier recorded data at the Hadnot Point system, actual analytical data, than you do at the Tarawa Terrace system. You have a report of October of 1980 from the Army hygienic team that came in there to do the preliminary test for TTHMs that identified chlorinated hydrocarbons in their water, extremely high levels.

And behind that, in parenthesis, he wrote "solvents."

And they had several tests. They didn't find the hydrocarbons in Tarawa Terrace until 1982. But you do have analytical data which shows the actual contamination of the Hadnot Point system in 1980 prior to Tarawa Terrace.

DR. BOVE: But we don't have it before that, and that's --

DR. JOHNSON: Speak in the mike, please.

DR. BOVE: What we're trying to find out, though, is when the contamination first arrived. I mean, that -- that's going to be the difficulty.

MR. ENSMINGER: Well, the hottest well in Tarawa -- or at Hadnot Point was Well 651. We do have the historical data as to when that well was constructed, and it was 1972. And it was constructed at the back corner of the disposal lot, which had been in operation for some 30-odd years at that time. And when it was tested, it was 27,000 parts per billion of VOCs. I mean, it's not hard to figure out that that well was contaminated the day it was sunk.

DR. JOHNSON: Okay. Thank you very much.

DR. WALSKI: But you don't need a model to prove that though. I think that's the point. We can do that without doing sophisticated modeling for that.

DR. CLARK: Frank, what do you think the potential is for getting more data from the state that may be better to find exposures in the system? Does anyone know that? Does anyone know that?

MR. MASLIA: Early on, we -- Bob Faye and I went up to Raleigh to look through the historical records, and in the historical records, we found some information for the forties, fifties, sixties, and then nothing after 1969 until the 1990s. There's not a single sheet anywhere.

DR. JOHNSON: Okay. I want to move on to Question 3. Is ATSDR's approach of developing three water-distribution system models appropriate to address answers needed for the epi study?

DR. CLARK: I think it is.

DR. JOHNSON: Lord love you for that. Thank you for that answer.

MR. HARDING: I don't think, based on what I know, that it makes sense to develop models for these systems. That's based on what I know right now is, that in the sense of using a modeling code -- I mean, all of what we're going to be doing is modeling. But a simple mixing model, I think, is appropriate.

The time when you would need to do something more sophisticated is during these periods of interconnection, which we can't even define and potentially will never be able to define. So based on that, I think that, yes, three models are appropriate. But they aren't -- they don't need to be a fully sophisticated hydraulic water distribution fate and transport model.

DR. JOHNSON: Well, that's a substantive comment. How does the rest of the panel feel?

DR. LABOLLE: I thought I heard something previously regarding the need to go back historically, in a related study or as part of this study or an extended part of this study, and look at cancer risks. And in that context, I think, I see that the Hadnot Point was connected with the Holcomb Boulevard system during the period that you had mentioned.

And if that's the case, possibly in those -- you know, those subtime periods there where there's the interconnection is here, employing. But other than those periods, I tend to concur from what I've heard here that the sophistication in the models may be sufficient at this point to answer some of the questions.

DR. CLARK: I think the sophistication should be at a level that you can create some typical diurnal-exposure curves. That's my opinion.

DR. WALSKI: Mine is that it's probably not worth the effort, given the amount of data we have here. We'll disagree to --

DR. CLARK: We'll disagree on that.

DR. JOHNSON: James.

DR. UBER: I think that -- so first of all, the issue of interconnectiveness is different from the issue of understanding temporal -- or diurnal variation in concentration. What I'm hearing and what I would agree with is that more archaeology on the interconnectiveness should precede further refinement of the water-distribution system models.

I think that if you found through the archaeology that the interconnections were frequent and of long duration that that would be different from finding out that, you know, there was never any period when Holcomb was putting out less than one MGD. And therefore, from a simple flow balance, you cannot have had significant contribution of water in that area from another system, you know.

So I think that -- I think that the effort needs to be driven by those kinds of factors. I frankly don't think that the information is on the table right now to know -- to answer that question.

DR. KONIKOW: The distribution model -- in terms of when the interconnection was opened, I'm assuming that that connection was not the only source of water to Holcomb Boulevard, or was it? Because if it wasn't, then the distribution model could help refine which neighborhoods or sections received water from Hadnot Point versus which did not. And that might be very useful.

MR. MASLIA: Right.

MR. HARDING: I might add that the point Jim made earlier on the elevations of these tanks will prove to be critical in that assessment because, if our goal is to isolate the Holcomb Boulevard population, if that ran at a higher grade than Hadnot Point, then we've got the answer. But it isn't clear at this point.

DR. LABOLLE: I think, also, it's important to keep in mind that when you're all done and you're refining, for example, these diurnal curves that the source concentrations to these systems are going to vary over orders of magnitude potentially. And potentially -- and I say "vary in time" -- the actual source may have.

And the uncertainty is potentially an order of magnitude or more, two orders of magnitude, in these concentrations at the wells. And that's due to both geologic uncertainty and uncertainty in the source concentrations, as David has brought up, so...

DR. JOHNSON: So what have you heard, sir?

MR. MASLIA: Well, I go on vacation in about six months. No. The -- I mean, we're still -- we're still talking about two major issues. One is data discovery, and the other, again, is basically using simplified mixing models.

DR. JOHNSON: I heard a rather strong endorsement that the "archaeology" should be, maybe, pushed before other things -- pushed ahead before other things.

DR. CLARK: Is archaeology the same thing as data discovery?

UNIDENTIFIED PANELIST: I would agree with that; yeah.

DR. JOHNSON: Yes, I think it is. Turning to Question 4: Based on information provided by ATSDR -- to ATSDR by U.S. Marine Corps, pipelines connecting to Hadnot Point water-treatment plant service area with the Holcomb Boulevard water-treatment plant service area were opened for emergency purposes only.

Does the panel agree with the ATSDR approach that, because of this characteristic, these two areas can be and should be modeled as two separate water-distribution systems?

DR. UBER: The answer to that is easy. That's -- if we answer yes to that, then -- then that -- then we don't need to do the archaeology, and we probably don't need to do the distribution-system modeling with -- you know, I know that Bob feels differently. So I would say that -- I would say that the answer to that is that you have to do -- I haven't seen the archeology to support saying yes to that.

MR. HARDING: The answer is: Challenge the predicate.

DR. UBER: Yeah.

DR. JOHNSON: Excuse me?

MR. HARDING: Challenge the predicate.

DR. JOHNSON: Challenge the predicate. Do others wish to weigh in on this? Peter?

DR. POMMERENK: I can just agree with the previous two speakers. If, for example, during main breaks, those valves were open to supply, you know, a portion of either system and we can -- certain windows occurred and how long, you know, the question would be then: Is that of significance for the epi study, if it's just a one-day interconnection or not.

And, you know, if it's not, then, yeah, there is two separate systems, and we -- I agree you won't need the sophistication of the water-distribution system modeling that is conducted right now.

DR. JOHNSON: Anyone else? I gather this is ATSDR's preferred direction: to consider them as two separate systems; is that right?

DR. BOVE: Not if it's not true, it isn't.

DR. JOHNSON: I don't think that was part of my observation.

DR. BOVE: Sure, that would be the easiest thing.

DR. JOHNSON: What will you need to know in order to make that decision?

DR. BOVE: Well, if it was just one day, you know, we probably wouldn't have to worry about it. But if it was for months at a time that the water was flowing from Hadnot Point to Holcomb Boulevard, then we need to know that. I mean, I don't --

DR. JOHNSON: I understand. Okay. Question 6: An innovative approach for fire-flow testing was employed at Camp Lejeune, using continuous recording pressure monitors simultaneously at several fire hydrants while different combinations of hydrants were flowed. Is this approach technically sound and beneficial? Ben.

MR. HARDING: It seems sound to me. It's better than anything I've seen. So Tom's gone into a moment here. But it's a really interesting approach, and it seemed to work real well.

DR. POMMERENK: We've done a similar approach at a different military base where we had continuous pressure recorders, and it works very well. And I'm glad to see that employed in this study as well.

MR. HARDING: I would make this point, that in terms of calibrating the model you do need to have good data on the tank elevations. And so if you've had doubt about the SCADA system, those ought to be resolved because that's the other boundary condition you need.

DR. CLARK: Did you skip the question on: Should ATSDR consider using probabilistic analyses deliberately, or was that --

MR. MASLIA: I think -- I mean, we answered that. I don't have an extra copy of the sheet I handed out, but is that grayed out?

DR. JOHNSON: Oh, that was my oversight, to be blatantly honest with you. And you can write that off to early dementia. And we will return to that. I thank you for making that observation. Eric, do you have a comment?

DR. LABOLLE: No. It was the same comment about the earlier question.

DR. JOHNSON: Well, with my apologies, let us return then to that previous question: Should ATSDR consider using probabilistic analyses to assess the variability and uncertainty of, one, water distribution-system model parameters; two, nodal demands; and three, system operations? If so, what specific methodologies would the panel suggest or recommend?

MR. HARDING: Well, the answer in my mind is, to the general question of using probabilistic analysis is, yes. We had significant discussions about what needs to be represented here in a simulation.

And -- but what does get represented should be represented as uncertain variables in a probabilistic framework, and the most commonly accepted and readily accessible technique for that is Monte Carlo simulation of one sort or another.

So I think that ATSDR should not just consider using probabilistic analysis. They should do that, and they should frame the resulting intakes -- what I call intakes, body intakes, of these materials in an empirical or calculated set of credibility ranges based -- you know, with probabilities assigned to them. That's my view.

DR. CLARK: I think that it would be great if they can do that; yes. One technique that they might look at is the PRP approach that Steve Buchberger is using at the University of Cincinnati for individual household use and -- which I think fits your -- within the framework that you're talking about.

MR. MASLIA: Bob, would that not then require us to have flow information?

DR. CLARK: You'd have to make some estimates about individual household use; right. But you could aggregate those into demands or metered demands.

MR. MASLIA: Well, I'm saying, but we would need some metered information then.

DR. CLARK: If you had your -- going back to the idea that you have the metered district approach.

MR. MASLIA: Well, that's the question because at least -- I may be jumping the gun, Dr. Johnson, as to what I'm hearing. But I'll go ahead and take another opportunity. What I'm hearing is that we should not proceed any further with the flow meters because of issues. Tom --

DR. CLARK: I think you should, so...

MR. MASLIA: Oh, okay. That's what -- I want to make sure we get that out and get a clarification on that. Could we have the panel address that issue? Just to give you the status, they're in the ground. Okay. They're operating. They're not calibrated, so...

DR. WALSKI: Well, I think the real source of uncertainty though is the well data. So if I was going to do a Monte Carlo simulation of this, I would not use demands of the houses as my undetermined variable or my C-factors at my variables that I would do statistics on.

I would use which wells are firing at which time. That's the one that I would treat as the stochastic variable because that's the one that's going to have the greatest impact on it is which well.

So you say, "Okay. We roll the dice, and this is the pattern of wells we're going operate, and we roll the dice again and see this pattern." Because I think that's the one that's going to cause the greatest variability in the results. We do have some data from the installation-restoration reports and things like that as to well concentrations.

You know, which wells were on at which time are going to make the real issue and not which house showered at this time versus which house flushed their toilet at that time. It's not going to be what's going to drive TCE.

DR. UBER: I think that this question is connected, in an obvious way, to all of the other ones, as far as I can tell, that we've talked about. The only other comment that I'd have to add is I would be -- I would be all for doing things probabilistically, assuming that they can be framed in a way that ends up being meaningful.

And my only problem with this is that I think it's basically tantamount to rolling back stochastic hydrology before it existed and just saying, "Should we invent this over the next two years?"

And I don't -- I don't think that you're starting from ground zero. I think you have things like, you know, Buchberger's PRP model and stuff like that. But you have really no -- you have no existing theory of any weight to -- with which to say roughnesses are spatially correlated or demands are -- how -- what their spatial, temporal distribution looks like. And so I think that, you know, you could get in trouble there by trying to do that.

DR. LABOLLE: My experience has been that the geologic uncertainty in the context of the Monte Carlo is going to swamp out everything else. And that simply just translates directly into the arrival curves at these wells, which the sources to these systems. And as I've mentioned several times, you know, can you tolerate a couple of orders of magnitude, variability due to uncertainty in those curves?

Because when you start Monte Carlo-ing geologic uncertainty, that may be what you find out is the outcome. And so in my experience, though, it's going to swamp out other things. That may or may not be the case if you're actually seeing the exposed and unexposed population change based on roughness or something -- something of that sort, depending upon where these interconnections occur.

DR. BOVE: But -- see how I can phrase this. The variability you're talking about, it's not a daily variability. It's not a weekly variability. It's a much larger time frame.

DR. LABOLLE: Well, we have -- you have two things: variability and uncertainty. The variability in the geology, it's spatial variability; and the geometry, the hydraulic conductivities -- however you want to frame the geologic characterization. But it's heterogeneity essentially.

Then we have uncertainty. What is that? All you have are samples at a few points in space out there. And in particular, this TT-26 at Tarawa Terrace, which appears to be the main source of contamination potentially, although that's uncertain too at this point. And the source location are two points which have been characterized somewhat, I guess, as the source by monitoring well data in Tarawa Terrace by some log there.

But there's, for the most part, subsurface is not sampled. And so all that -- all that material that fills in these points, there's uncertainty there. And it's not layer cake, as the models represented. At least, it's not likely to be. Those are simplifications made for modeling purposes, and that -- the uncertainty in that, if one were to pursue modeling that, one would find, likely find, that that uncertainty would translate to a great deal of uncertainty in the arrival curves, and modeling that uncertainty is a different level of modeling than what's been proposed thus far, than what I've heard. It's not simply twisting the parameters in the existing model.

It could be. I mean, you could approach it that way, but there would also have to be a great deal of spatial refinement in the vertical, potentially in the horizontal, and then the way in which we change those parameters.

We'd have to have some kind of geologic and context and probabilistic context related to the geology and its characterization.

MR. HARDING: I would like to really agree and support the opinions of both Eric and Tom, that the groundwater uncertainty is going to swamp everything else. And then it's the well operation that determines the introduction of the contaminants into the system. So it seems to me these are the two most important factors and that the -- we have to deal with the issue of interconnection and whether you're going to address that, but even so, those are the two most important things. And those should -- and they're really uncertain, so they need to be expressed in probabilistic terms.

DR. JOHNSON: Okay. Are there any other comments on this? Let's finish with Question 7. Is it feasible or necessary for ATSDR to simulate the complete 18-year historical period on a continuous basis? And in red, pink here, Ben, for your -- will monthly --

MR. HARDING: I can see it.

DR. JOHNSON: Just was trying to be helpful. So how do we answer that? Tom.

DR. WALSKI: You don't need distribution modeling on a continuous basis. I mean, it's nice if you want to do it, but I just don't see it as being that important because essentially we don't have a good way to determine which wells are operating at which times. So, you know, why beat the -- this dislinear to death just because we have nice models that'll solve it?

DR. CLARK: I agree with you, Tom (laughter).

DR. UBER: Our colleagues agree.

UNIDENTIFIED PANELIST: Even monthly simulations are going to be tough, but I suspect that's what --

DR. LABOLLE: I would like to add something since I had presented premeeting comments and suggested maybe averaging exposure over the month would require continuous modeling because that was my experience in another modeling effort in which I was involved. But in that modeling effort, we had multiple entries into the distribution system, and at the time, I was thinking along those lines. But this system with the single point of entry during much of the time periods of interest here, I don't think it's going to get you much.

MR. HARDING: I want to say that I think the ATSDR should try to calculate the potential exposures on a continuous time-series basis, whatever that time step is. Now, as I've probably said a hundred times here, I don't believe that in almost every case that requires water distribution fate and transport modeling, but I think you should try to reconstruct to your best estimate, basically, a set of probability, just empirical probability distributions, for the breakthrough curves for the model and for the contaminants that enter the system so that you have a time series that you can then correlate to the activities of the individuals. But that probably doesn't require what we term water-distribution modeling. It does require calculations that are really modeling, but it isn't using a modeling code, continuously or otherwise.

DR. LABOLLE: I don't recommend monthly time stepping in a fate and transport model for the groundwater as an input to your system. I think that's going to end up being a much smaller time scale than the information that's available, simply due to constraints and the way in which these models are run to get a numerically valid result. And that's going to give you something, curves, out of these models that are on a temporal scale, which is much finer than a -- it's probably going to be fractions of day, and that's the kind of output you're going to see from there.

DR. JOHNSON: This completes these questions. Morris, Frank, anything else you'd like to put before the panel in the spirit of this kind of specific questioning?

MR. MASLIA: I'm still unclear on the flow-meter issue. It's a critical issue for the agency and the Marine Corps, and it may be that the panel has differences of opinion, which is fine. But I think for the record we really need -- if there's any way --

DR. JOHNSON: You want some clarity as --

MR. MASLIA: Yes.

DR. JOHNSON: -- to position.

MR. MASLIA: Position; yes.

DR. JOHNSON: Tom, do you want to start?

DR. WALSKI: Well, if you've installed them already, I would try and get them calibrated and see what I could learn from them. But I wouldn't -- the ultimate impact of that on the final bottom line of the study is going to be really small. It's not -- you know, the fact is though that, you know, it doesn't hurt to know that. But I wouldn't really spend a huge amount of resources on it. You know, try to get them calibrated because, looking at what Peter just showed me, the threshold on those things is like 2.2 feet per second. And most of the time, you're below 2.2 feet per second, so it's questionable whether you're going to get good data out of those things.

DR. JOHNSON: So why do it?

DR. WALSKI: Well, it's in there, so try it.

DR. JOHNSON: No. That's not a reason. Tom, that's not a reason. Why do it if it's not going to give you anything of use?

DR. CLARK: I think it -- I'm a little more optimistic than Tom in terms of what data you're going to get out of it. I think that plus the flow balancing of the tanks using SCADA data would probably give you a pretty good estimate as to what the demands are in those zones.

DR. JOHNSON: Peter, yes or no?

DR. POMMERENK: Well, I'm not quite sure whether, you know, any background noise, electrical noise, at those low flows will really be able to help us detect significant flows in those oversized mains; that somebody indicated earlier they're oversized for five of those. So, yeah, the question is: Are we going to get any useful data out of it? So if we have to open hydrants to perform the calibration, that is -- it's fine, okay to calibrate it, but in reality, this is not the flow that we usually see. So my expectation is that there may be no useful data coming out of that.

DR. JOHNSON: David, do you want to weigh in on this issue?

DR. DOUGHERTY: No (laughter).

DR. JOHNSON: Okay. That's a very fair response. Lenny.

DR. SINGH: I think it may be --

DR. JOHNSON: Please.

DR. SINGH: -- it may be opportunity to ask Morris as to his experience so far with regard to metering the flow.

MR. MASLIA: The -- it goes back -- one of -- the concept of installing a flow-measuring device goes back because of the inconsistency in the SCADA data originally and trying to get at two things: getting a total flow, which you can sum up from the different locations; and at the same time, while you're getting a total flow, you can also do the area, area-type analysis.

One of the issues we ran into is that we've got a report, the conservation study, which admittedly is taken from a water-budget standpoint -- but showed approximately a 30 percent difference in water going in and coming out. Of course, you can just allocate that. You know, one method is just distribute that equally every place. That may or may not be accurate.

So that was another factor, in that we've got a documented approach that summed up water use and was plus or minus 30 percent. From that standpoint -- that was not acceptable from an epidemiologic standpoint. So those two factors taken in combination led us to suggest that by installing flow meters we could accomplish two things at one time.

We would have -- we would be able to quantify by summing up the various flow meters production versus flow, and then really establish is that 30 percent difference reality, or was that just a method or a consequence of the method that was used, the inaccuracy in that first method? And at the second time -- at the second point also be able to, at that point in time, determine areas, specifically family-housing areas, due to the absence of individual house meters.

At this point in time, as I said, the meters are in. The modeling that we've done to date -- and I'm saying this so you can understand because the comments about the low flow are an issue. We had -- when we did the test last May at Hadnot Point, we had -- I won't say significantly -- we had larger, larger flows. And that model to date, the present day, is probably the best of all three.

The subsequent models for Holcomb Boulevard and Tarawa Terrace, we've attempted to do the calibration based on flow information in levels this fall and winter. And that's, of course, when we've been trying to install or calibrate these meters during a period, which admittedly is a -- even based historically is extremely low, low-demand conditions.

Our attempt or our plan was to have them calibrated in sufficient time so for the peak-demand season, then you would have the higher flows. We're still aiming for that, and that's why I needed some feedback from the panel is that all our attempts to date have been trying to calibrate them under exceedingly low-demand conditions.

DR. POMMERENK: One question: Have -- based on your preliminary data collection, can you tell anything about the accuracy of those meters, whatever you've measured so far? Or have you collected any data and compared it with -- you know, Claudia showed us that graph earlier about one location. Could you compare, I mean, instantaneous flow rates and maybe cumulative flow rates?

MR. MASLIA: Well, that's why we prepared the --

DR. POMMERENK: Okay. That was passed on.

MR. MASLIA: Yeah, it was passed on. But the concept behind that -- so that when we're in the field, we prepared a minimum, a maximum, and an average, then we would be able to see immediately -- we have not had that before -- you know, if the flow meters were somewhere in between those range of flows. We'd be okay. We'd go ahead with the calibration.

On one meter, as it turned out -- this was on the 24-inch pipe -- obviously, there's no flow. It turns out to be a by-pass or a pipe to balance some tanks. And of course, we're not -- you know, we're pulling the meter and not using the meter there. As it turned out, that was not a useful location.

But we do have some preliminary information based on the model simulation, which we're hoping would guide the calibration process. However, what we -- what we have seen is if you assume the meters have been calibrated and we come up for QAQC, when we do flow a hydrant, you know, increase the flow from up to, you know, 600, 800 gallons a minute, there's a substantial difference in what the meter's recording and what we're flowing.

What they have done for the calibration process, just so everyone's clear, is they go down into the manhole and strap an ultrasonic, a trans, which is plus or minus 1 percent. And then you read the Dynasonic, which is supposed to be plus or minus 2 percent, so we figure, you know, they should be within a few gallons per minute of each other, and they're not.

DR. JOHNSON: Does anyone else wish to comment? Peter.

DR. POMMERENK: Just one more question: You mentioned the 30 percent difference between a water-conservation study results and water-production records.

MR. MASLIA: That is -- that is correct. And that's not a critique of the study. I'm just giving you --

DR. POMMERENK: No. I'm just wondering: What do you attribute these 30 percent discrepancy to? Is that -- is that mis -- over- or underestimating household demands or commercial demands, or is that actually just an estimation issue so you're not assuming it's leakage, or --

MR. MASLIA: Well, no; no. I'm not assuming it's leakage. It's both the -- what I attribute it to is that methodology is a water budget, adding up, you know, lavatory, sinks, showers, and things of that nature and coming up that way. I don't believe -- it may be a small amount of leakage, but I don't have any knowledge on that so I attribute part of it, at least, to the -- to that methodology.

I don't know if that's a standard, acceptable amount of difference or not. And in the other -- and so what we wanted to, again, determine with the flow meters is we've got on one hand the total production or total delivered water at the plant. Okay? So that's what -- and that was our only other number. So even in the models that we have right now -- for example, Hadnot Point or whatever, you've still got this if you use the water-conservation study.

That's how we spatially distributed building use and all that type of use per building and all that. And we've got a 30 percent difference. We can evenly distribute it or not, and that's another -- again, what we were hoping to obtain with the flow-meter information is a more quantifiable estimate or even areas where you have better estimates than other areas.

DR. JOHNSON: Yes, Peter.

DR. POMMERENK: I'll let Tom go ahead for a while.

DR. WALSKI: Well, first of all, I'm assuming that when you measure the discrepancy the production was higher than the estimated consumption; right? Your estimate was production was up here and what the method says was down here; right?

MR. MASLIA: Yes.

DR. WALSKI: So it was higher. The production was higher. So, yeah, it is likely that there is leakage to that extent. And also, they're thinking about these methodologies that you're using that are based on typical, average customers. And one thing that you learn is that you never have a typical, average system. So that type of discrepancy is not, you know, anything that would alarm me.

You know, they say, "30 percent. My God. That's a lot." But no. It's not really. It's not that bad.

DR. JOHNSON: Peter.

DR. POMMERENK: Yeah; just the other issue. You mentioned you were waiting for higher demands during the summer for doing additional validation of the metering data or --

MR. MASLIA: What we were -- what we -- and we're still anticipating to cal -- we're trying to calibrate the meters during this period -- winter, early winter, fall, winter -- in anticipation of collecting about six months of metering data to be able to capture the high-demand period.

DR. POMMERENK: But have you -- has your review of past production data indicated that there is substantial -- a substantially higher demand during the summer months?

MR. MASLIA: Yes; yes. The USGS reports show that.

DR. POMMERENK: Okay. I'm just asking the question. We have recently completed a related study, and my recollection -- and I may be wrong -- we didn't really see a pronounced summer. I'm willing to share that data with you, so...

MR. FAYE: It's a difference of -- it's how you define "substantial."

DR. POMMERENK: Okay.

MR. FAYE: But I'm looking -- I have the reports with me; unfortunately, not exactly here in the room. But off the top of my head, I'm looking at -- I'm thinking of perhaps a 20, maybe 25 percent difference between, say, a demand from January through March versus, say, June through September.

DR. POMMERENK: Okay. I would think substantial is if you're maxed is a factor of two or three over the average annual demand, daily demand. So you don't quite see --

MR. FAYE: No.

DR. POMMERENK: -- those.

MR. FAYE: No.

DR. POMMERENK: Okay. With respect to the flow metering, obviously, the increases in flow during the summer are not expected to increase that much; right?

MR. FAYE: Maybe I can invent a different way of saying it, but the average daily demand, for example, during the period -- and this is basewide; basewide, not selective to Holcomb Boulevard or Tarawa Terrace or whatever. The average daily demand during July and August would perhaps be 25 percent higher, greater, more than, the average daily demand during January through February -- January through March. Okay?

DR. POMMERENK: Thanks.

DR. JOHNSON: In summary then, is it fair to say that there -- that some panelists have some concerns about the flow-meter work and would suggest, given limited resources, particularly personnel, that ATSDR look at this in terms of, in effect, what the cost/benefit is? Is this data worth what it's going to cost you to get? Is that a fair statement? Should it be changed? Morris is looking, I think, for a rather clear statement from the panel.

DR. CLARK: Well, given where you are in terms of actually installing the meters, how much more effort would it take to actually do the next step?

MR. MASLIA: On our part, probably a couple of weeks with a couple of people. That's basically the time to calibrate the meters. And then, of course, on the Camp Lejeune staff, because they assist us in collecting the data, downloading the data -- it's going around to 16 meters once a month. They have the capability of storing more but, say, once a month downloading the data.

So manpower-wise or labor-wise, I don't think it's -- it's the calibration process that's intensive, and it only seems more so intensive because of the past attempts that, obviously, we have made and have not been successful. But now that we've got sort of a step-by-step how-to manual and some estimates of what we expect to see the flows to be based on our model simulation, we're hoping that it will go much -- you know, on schedule. So basically, you're talking about a two-week effort with a couple of people from ATSDR.

DR. JOHNSON: Okay. Last comment from Tom.

DR. WALSKI: Okay. I've got more comments. This is my last (laughter).

DR. JOHNSON: It's the last one on this issue.

DR. WALSKI: Okay. The -- to put this thing in perspective, the calibration data is the calibration of water -- calibrated water-distribution model, which we aren't sure we're going to need. So first of all, we have that issue to get over.

But, in the meantime, since we have made this investment, I think it's worth getting like a month's worth of data and just looking at it and seeing what does a month's worth of data say. And then we can decide if it's worth doing several months; just for the background information. It may be good for the utilities' people just to have this data to help them manage this system even if you don't use if for calibration.

So I'd say, you know, try it for a month. There's going to be some places where you have shuttling between the tanks where the velocities are going to be high, and you are going to get good information. There are going to be some dead-end areas where you're going to be below the threshold half the time or so, and it's not going to be very useful information.

But get a month's worth of data, and if it looks good and the people from the utility think it's worth collecting, then keep on collecting it. And then if you do have to use it to -- if you decide to do a more detailed model or a more detailed calibration, you'll have it. So that's the way I would put it in perspective.

MR. MASLIA: One point, Dr. Johnson. Actually, it's an answer to Peter that came to mind with respect to variation in production or flows. When we were doing our testing in May of 2004 at Hadnot Point, we were seeing on the average of about 2100 gallons per minute being produced out of that plant during the week of our test, more or less.

When we came back in August, although we were not testing Hadnot Point, I just took the opportunity to go over to the chart, and it was up at 3,000 gallons per minute, so...

DR. POMMERENK: Okay.

DR. JOHNSON: Any more? Tom, anything else on this?

DR. WALSKI: Mm-mm.

DR. JOHNSON: Thank you. The panel, I think, has done an extraordinarily excellent job of responding to these questions and issues as well as those yesterday. The work that remains for the panel is to respond to the four specific charges, and we've talked about almost all of them. And so that's the work that remains.

I foresee us being able to finish by around 1:30 and such. That means that a public comment period needs to be moved up, and I'd like to offer the opportunity now for any comments from the public. Yes, Ben.

MR. HARDING: Can I just ask one --

DR. JOHNSON: Please; of course.

MR. HARDING: -- question before we do that?

DR. JOHNSON: Yes.

MR. HARDING: We have this amended question, issues, and discussions page, which has explicitly marked out certain bullets. And then on the original sheet, there's issues. On page 3, there was integration of groundwater and water-distribution systems. Did we deal with that yesterday? Was that -- or has that been implicitly X'd out?

DR. POMMERENK: X'd out.

MR. HARDING: X'd out. Okay. It just --

MR. MASLIA: That was my -- that's why I didn't bring it up. I didn't X it out, but, based on the discussion that we've gone today, that becomes a moot point, at least from my interpretation.

MR. HARDING: Okay. That was what I thought, but I just wanted to make sure.

DR. JOHNSON: Okay. Comments from the public. Mr. Ensminger.

COURT REPORTER: I need to go down.

DR. JOHNSON: Oh, excuse me. Let's take about a ten-minute break.

COURT REPORTER: All I need is two minutes, if you just want to continue.

DR. JOHNSON: No. I think the panel needs to have a break. Let's break until lunch arrives.

(Whereupon, a recess of approximately 28 minutes was taken.)

DR. JOHNSON: Okay. The floor is open for comments from the public. Mr. Ensminger.

MR. ENSMINGER: Not so much comments. I had a few questions on some of the things that were brought up during the discussion. It was brought up by one of the members from the Camp Lejeune delegation that North Carolina State requires separate permits for multiple water systems, and I have a question is: How long has that been -- requirement been in place?

MR. ASHTON: I'm not --

MR. ENSMINGER: Whenever you open and close a valve? How long has that requirement been in place?

MR. ASHTON: I'm not sure how long, but I can try to find that out there and also, you know, the -- I can certainly find when we got those permits for the water systems as well.

MR. ENSMINGER: And another thing about the Holcomb Boulevard water system was that it seems that there were a limited number of wells initially assigned to that water-treatment plant. Were the wells that were assigned to Holcomb Boulevard initially able to keep up with the demand for the area that it serviced?

And the question of on the flow meters, there seemed to be a lot of dissension about that because of the oversized pipes. Would the installation of choke points -- somebody brought that up -- improve the accuracy and the velocity? I know it would increase the velocity of the water going through them. Would it increase the accuracy of the data? I mean, you're talking about 16 flow meters. I don't know if all 16 are on 12-inch oversized lines.

DR. JOHNSON: Tom or Peter or both?

DR. WALSKI: Well, to increase the accuracy, whether or not we need it is still the question. So that's why I'd say: Don't spend this money until we're sure we need that extra quality of data would be the way that I would leave it.

DR. JOHNSON: Peter?

DR. POMMERENK: I agree.

MR. ENSMINGER: And on the Hadnot Point water system, the questions of historical data as far as contamination of certain wells, the installation-restoration program has the accurate data now for each well that was contaminated in the Hadnot Point system. They have the actual contaminants that were in those systems or in those wells, and they know what the sources were. So as far as reconstructing, you know, and doing the historical, there would be some work involved in it, but that data is available.

DR. JOHNSON: Okay. As I commented before lunch, I think we can certainly be through by 1:30. Some meetings go quicker than anticipated. I have been in many meetings where it's gone the other way and you reach 2:30 on the third day and you realize you're not done. And so this is quite to the contrary. And the preplanning done by ATSDR was really very, very well done, and presenting the issues and questions to the panel has helped us go through some of these tough matters that the ATSDR is going to have to deal with after we leave.

So my goal is to have us out of here around 1:30 or so. I propose to provide a formal response to Questions 3 and 4 in the charge to the panel. I discussed with Mr. Maslia before lunch if all four were still relevant, and he indicated that we had really done a good job discussing questions or Charges 1 and 2. But he asked that we do provide a formal response to Charges 3 and 4. Charge 3 is now on the screen, and so that spares me having to read it to you now. How does the panel wish to react to this third charge?

DR. CLARK: One area that it seems to me that ATSDR might consider is looking at the degradation by-products of some of these oxidated chemicals, and I think there's a potential there that there might be things like vinyl chloride in the system, which I think would bias their results. And I hadn't gotten a sense of how much of that has actually been done.

DR. SINGH: Number 2 shows that we -- ATSDR already has started with their groundwater modeling. One portends to consent to the analysis, and the other one relates to the accounting for the variability recharge. I think those are the two issues that ATSDR should take into consideration.

DR. JOHNSON: Other advice on this charge?

DR. KONIKOW: Well, the groundwater modeling that we discussed -- and I think that's been focused on the Tarawa Terrace area. And I guess maybe we should talk for a minute about the need for looking at and modeling the groundwater flow and contamination in the Hadnot Point area or the Holcomb Boulevard area. Or do we just accept that Hadnot Point wells are contaminated over the whole time?

DR. LABOLLE: In addition, Lenny, you had mentioned previously -- and I concur with the need to at least demonstrate that contaminants arrive to TT-26 or demonstrate that they may not, depending on the outcome of the models within this for the 14-year time frame, for example, and to the extent that the study period's going to be pushed back further.

In addition, somebody mentioned other periods of time we might be looking at the cancer risk. You may want to actually have a model that's useful for protecting the uncertainty in the arrival curve itself. I'm not sure if you're planning on going back before '68 at Tarawa Terrace.

MR. FAYE: Our intention has always been -- largely due to modeling considerations as well as others, but our intention has always been to begin the groundwater flow simulations at Tarawa Terrace with the beginning of operations of the WTP and the well fields, which would be like 1952, '53, and then simulate that forward to '94, which is the end of our relevant water-level record.

DR. LABOLLE: But the question would be the period of time from '54 through '68.

MR. FAYE: Yeah. To transport -- very definitely. We would do the fate and transport simulations as well for that period of time.

DR. LABOLLE: Well, but are they going to use it in the epi study?

MR. FAYE: That, I don't know. But I would just feel comfortable doing that. If we don't, there's always going to be a question there: Did the contaminants arrive at the wells in one month, six months, five years, or whatever? And I think that's an important consideration.

DR. LABOLLE: I'm not suggesting that it not be done. Actually, I'm suggesting that the degree of effort put into this will depend upon whether or not the epi studies are in the future pushed back to earlier dates, I think.

MR. FAYE: That, I don't know. But our -- as far as the modeling is concerned, I can speak to that, and our plans from Day 1 have been to provide those simulations from the beginning of the WTP operation and the well-field operation, which would be, as I said, 1952 or '53.

DR. KONIKOW: For all three areas?

MR. FAYE: Just for the Tarawa Terrace. Lenny, as we said yesterday, we're using the Tarawa Terrace because it is a "simpler system." But it is a little simpler. So that's our -- what would you say? That's our prototype effort, and if we think we're successful there, then we can advance ourselves to -- if necessary.

I mean, if the epi -- epidemiological demands require that, then we can advance to a more complex system where we have this confidence that we've built on and attempt that, which would be Hadnot Point.

DR. KONIKOW: So is the default option then in the epidemiological study to assume that the Hadnot Point system was contaminated over the whole period of time?

MR. FAYE: I don't know what their default position would be. But based on the data that I've seen and how the wells are positioned with respect to obvious sources of contamination and whatever, yeah, I would say that there -- whoever said here today that when the particular well was actually opened up and began to be used, it was probably contaminated at that time. I would say that that's an accurate statement with respect to perhaps a number of wells, supply wells, at Hadnot Point.

And also through time -- I mean, the wells may have been -- in 1941 when the wells were constructed, there probably was no problem. And then over the years, as the facility grew and different things were done land-use-wise, why, yeah, they probably became contaminated.

MR. MASLIA: Two issues. If we go into Tarawa Terrace, from a groundwater fate and transport standpoint, if we don't start at predevelopment, then we have some real issues to address with antecedent conditions, and then we're going to have to do some more uncertainty modeling as to the effect of not knowing the antecedent conditions, which I think adds to our effort and, I think, overpowers the amount of additional effort, just by starting from before the -- from predevelopment and running them out. My understanding is we can also -- we can vary the step size in MODFLOW, can we not?

MR. FAYE: Oh, yes.

MR. MASLIA: Yes. So we could use larger -- if we see there's no contamination, you know, for a certain number of years in the beginning after some trial runs, we can make those larger, larger step size, and then when we think it is down to a much smaller -- as you said 15 day or less.

I've actually used even smaller time steps for that previously and do that. And that would be, at least initially, my approach is not to complicate our analyses even more with trying to guess antecedent conditions but let the model do the work; in other words, circuitous development.

MR. FAYE: Yeah. At that -- yeah, the issue then very rapidly moves from a code-capability issue to a number-crunching issue, so that's where you're at there.

DR. LABOLLE: I wouldn't bother corseting the time study, in my opinion, simply because, I mean, you're probably not going to be constrained by the time it takes to run this model. And what that would then do is lead to possible numerical errors and a plume that doesn't look like the plume that the model was intended to solve for.

So you might as well just leave them at the required resolution to obtain a numerically valid solution. I'd be more concerned about the assumptions in the model itself than those kinds of issues and the underlying geologic characterization, which it looks like, you know, you've done a good job approaching that.

But the -- it's the way in which one deals with the uncertainty in there. And if I were to make any recommendation, I would recommend an approach to dealing with geologic uncertainty be incorporated into the analysis so that one can examine the uncertainty in the geology and its effect on arrival, potential arrival, to these various wells in the vicinity of this ABC's Cleaner there and of the -- some of the wells that are reported -- reportedly clean throughout the periods of interest may have actually seen contamination because they simply weren't sampled continuously.

MR. FAYE: Right. They're --

DR. LABOLLE: And others that -- I'm sorry. Excuse me.

Others, you know, that have seen contamination, we don't know when the contamination arrived. And to the extent that maybe all of these are swamped out by concentrations of TT-26 and the models begin to show that, maybe you can lay these issues aside because the mixing that appears to have been in this system. All wells are mixing.

You may not need to pursue, you know, the groundwater modeling past that point in terms of determining what arrived at these other wells. But there seems to be another issue -- and I think that you and I discussed during the break -- where if TT-26 is turned off and these other wells have taken over --

MR. FAYE: Right.

DR. LABOLLE: -- and yet there may not be sampling at these wells to assess whether there was contamination arriving to them, and some of them are quite close to TT-26 and appear to be very capable of intercepting the plume.

MR. FAYE: That is a real issue; absolutely.

DR. LABOLLE: And so then you're left with modeling to resolve that.

MR. FAYE: That's right.

DR. LABOLLE: And once again -- I don't mean to belabor the point -- but I think it's geologic uncertainly that is going to swamp out a lot of other uncertainties in all of these modeling efforts of the water-distribution system. And that's going to be one of the main players. That and the source, as David will know.

MR. MASLIA: The other question or issue with respect to the Hadnot Point -- as Bob said, we're using Tarawa Terrace first. But if we assume or can assume that at least some of the wells were sunk into an aquifer upon production that was already contaminated, does that then not bring the problem in trying to simplify matters to a materials mass balance where if we knew the cycling on and off of wells we could calculate the concentration of the mixture on there? And that might then alleviate also any detailed numerical modeling of the Hadnot Point area with the large and nonpoint specific sources.

DR. JOHNSON: Okay. Let's then turn to Charge No. 4. And as that comes up on the screen, let me ask kind of a housekeeping detail of Mr. Maslia. Are arrangements being made for transportation to the airport? I mean...

MR. MASLIA: My understanding is some -- some people have arranged with the hotel shuttle, and all that needs to be done is to call the hotel shuttle when they are ready to board that hotel shuttle. Ann Walker or Joann can do that once we tell them we're -- we're finished.

DR. JOHNSON: Okay.

MR. MASLIA: If people want -- what?

DR. WALSKI: The shuttle doesn't bring us to the airport, does it?

UNIDENTIFIED PANELIST: There is a shuttle.

MR. MASLIA: There is a shuttle.

DR. WALSKI: Yeah. But not the -- a different shuttle; okay.

MR. MASLIA: Right.

DR. WALSKI: Okay.

DR. CLARK: We're better off sharing taxis.

DR. WALSKI: Right. I think so; yeah.

DR. LABOLLE: Along the lines, yeah, I spoke with the driver on the way here, and he mentioned that he's trying to get us a large van to be able to go to the airport from here. And I have to actually have them deliver my bags here, and I mentioned that you --

DR. SINGH: Yeah. My bags are at the hotel.

(Whereupon, a conversation ensued off the record.)

DR. JOHNSON: Charge No. 4 gets under the matter of the project schedule. It seems -- it seems, at least to the Chair, that there have been a number of rather significant suggestions as to perhaps how to reorder the work that is anticipated. That makes it a little bit unclear, at least in my mind, as to how that works out in terms of a project schedule. But I would look forward to the comments from the board -- from the panel.

DR. CLARK: Subject to the comments that have made by the panel, it seems to me that the three-year planning projected cycle is probably a reasonable one to work towards.

DR. DOUGHERTY: Tom had suggested six months.

DR. WALSKI: Yeah. I can see you're getting to the point of beating a dead horse after a while that possibly you can do this in about six months unless you find that missing notebook. You know, the notebook that was on top of the refrigerator back in '85 that fell behind the refrigerator? And they move it, like, next year, and they find this notebook with all the data in it or something. Unless you find that kind of a notebook, I don't see three years of work giving us a much better answer than we can in probably about six months.

MR. MASLIA: Can I qualify that last charge so that everyone's on the same playing field here?

MR. FAYE: Did you look behind the refrigerator?

MR. MASLIA: I've looked in at a lot of places, including down a manhole. The three years was the total, not three additional years. That was three years of project length, and we have spent length approximately, what, a year or more? Less. So we really are only talking about another year and a half or so.

The initial schedule called to have some preliminary fate and transport modeling results with Tarawa Terrace by this September, which I believe we're on track for that. The question is the additional work, taking the suggestions of the panel. I've been trying to simplify them on the Hadnot Point area, assessing some preliminary flow data from the meters. Would, you know, the three years be sufficient? And the one comment I would have, given a perfect world where, even if you had to look for data, in six months would probably be acceptable.

Being -- doing the kind of detective work that we have to do with historic data, I would say shortening -- my experience would be on this project that that would really be constraining the agency to shorten it any more than that, but I'm open to some concrete ideas where -- Bob wants to.

MR. FAYE: I don't know, Tom. Maybe there's some pharmaceutical issues related to your comment there, but there's just no way in the world (laughter).

DR. JOHNSON: I don't know what that means. I'll speak. If no one else will speak, I'll speak. What are the pharmaceutical issues?

MR. FAYE: There's no way that I can imagine or devise or anticipate that we could -- we can fulfill the requirements or the suggestions of the panel here with respect to the groundwater-flow models and the fate and transport simulations and provide a comprehensive, complete, technically defensible written product in a six-month time period from today. I think that's a very unrealistic -- that would be a very unrealistic proposal or recommendation. And that's based on 30-some years of experience.

DR. WALSKI: But we have put those -- we've taken out, pretty much, most of the distribution modeling, and we're taking a fairly major chunk of the scope of work out --

MR. FAYE: Yeah, but the --

DR. WALSKI: -- and also cut out most of the modeling at Hadnot Point, too, for groundwater. So we've --

MR. FAYE: No. Let me clarify that. First of all, the -- there -- the -- as the time-line chart, I guess, that you've been -- that you have -- the groundwater modeling and the distribution modeling were parallel efforts. Okay. They weren't -- they weren't a series situation: One gets done and then the other. So those were all parallel efforts.

And so, I mean, we planned to converge the completion of the two efforts, at a point in time merge the results and then go on from there. So I think, as far as that parallel effort with respect to the groundwater-modeling situation is concerned, we're right on the regional time lines. I think we conformed to them very well.

And as Morris said, the -- we're having -- we're planning to have some fate and transport simulation results by the end of September, this fall. I think that's -- with a bit of work, that's probably doable. So -- and realistic. And so then I would anticipate finishing that project completely: providing the written report, the appropriate peer reviews, et cetera, et cetera, would still take most of the next year after that. So --

DR. CLARK: Don't you also have to integrate the epidemiological studies --

MR. FAYE: Exactly.

DR. CLARK: So you're talking, what, probably another six months to a year?

MR. FAYE: Absolutely; yeah; yeah. So there's a -- even conforming exactly to what I've heard that you folks will probably recommend, this three-year time interval that we're looking at now with about a year and a half or so left is still extremely ambitious. And I don't know. I mean, maybe I'm just all wet, but I'd like to hear from some of my groundwater colleagues on the panel to tell -- to say -- is that -- are you -- have you been smoking something, too, Bob (laughter)?

DR. JOHNSON: Well, there's a clarification.

DR. DOUGHERTY: What is the terminus of the three years? Is it the delivery of the water-modeling results, or is it the delivery of the epi results?

MR. MASLIA: The original schedule was three total years to deliver the final historical reconstruction to the epi people.

MR. FAYE: With all of its elements.

MR. MASLIA: And that included another -- another peer panel to assess the historical or the final report, as we did in Dover Township.

DR. DOUGHERTY: And the Hadnot and --

MR. MASLIA: Right.

DR. DOUGHERTY: -- Holcomb?

MR. MASLIA: That's -- that's correct. I will add --

DR. DOUGHERTY: Or whatever may be done with Hadnot?

MR. MASLIA: Right. I will add that Frank and I and the epi team had discussed, in fact, with Marine Corps headquarters, back in February that it was going to be a challenge, an extreme challenge, if we were going to the distribution-type stuff to even keep to that three-year schedule; an extreme challenge.

I think based on some recommendations here that three-year time frame becomes a more realistic and attainable goal. And that's really -- but, again, there are a number of, still, work efforts and implementing recommendations that you have made even with the simplifications.

DR. DOUGHERTY: My personal feeling is then that -- and take the comment with a grain of salt because I really haven't seen the detail of the work plan for the other two portions of the site in terms of groundwater modeling and its impact. But I think the schedule is going to be aggressive because of the additional emphasis on the archaeology, as we've been calling it, and that really takes a lot of calendar time. It takes a lot of calendar time.

MR. FAYE: Absolutely.

DR. KONIKOW: I think, also, if the goal is to do an advective/dispersive transport model and that hasn't been started yet, that takes time. And that's going to take time.

MR. HARDING: If I might speak specifically about this July schedule --

MR. MASLIA: This is July of? Is that in the July book?

MR. HARDING: It's revised 13 July. It's the current.

MR. MASLIA: Right. There's probably one in September. I don't know if you've gotten it. We've revised it somewhat for -- in September. But you can go ahead. That's probably within a six- or eight-month period.

MR. HARDING: So if you look at this, the geohydrology of groundwater flow, fate and transport work appears to end, roughly, the end of this fiscal year, which is --

MR. MASLIA: Which is September 30th.

MR. HARDING: Of 2005?

MR. MASLIA: Yeah; that's correct.

MR. HARDING: And then what extends beyond that is water-distribution system historical models; actually, water-distribution system present-day models. But we, I think, suggested that you dramatically compress that --

MR. MASLIA: Yes; yes.

MR. HARDING: -- which, I think, may move that out of what appears to be the critical path in this thing. Now, I tend to disagree with Tom because I have been swearing off all my pharmaceuticals recently.

But I think more time is necessary to characterize the Hadnot Point situation, but I don't really know that business. That's the groundwater people's business. But I go down here to this methods' development -- and maybe this was dealt with yesterday. But there's the GA calibration methods, tank mixing, and dynamic linkage of groundwater transport and water distribution models, which I think can be eliminated.

And I think that uncertainty methods in groundwater flow transport and also in terms of water distribution -- or if we want to say integration of exposures and intakes and that stuff. Dealing with this in a -- dealing with uncertainty and quantifying it can be expanded. But that should not affect the overall length of the schedule. But those bars down there on all those methods' developments are really driving the schedule out to the right, and those should be essentially, I think, eliminated.

MR. MASLIA: Those were based, again, when -- were based when the schedule was developed, based on our previous experience, which they did drive the time frame. Although they were -- or at least now we see them as complementary, not driving the schedule.

And from the discussions that we've had here the last couple of days what, again, I see driving the schedule are two issues: the archaeology or data discovery. That is very time-consuming and labor-intensive as well as the methods to better understand the uncertainty with respect to geologic issues at Tarawa Terrace and going to the full-blown fate -- full blown as opposed to the effective full fate and dispersive transport models.

MR. HARDING: Well, I want to emphasize that I think that you can make a contribution, both to the understanding of this situation but also to the practice, if you would, instead of spending your resources on some of these methods that relate to linking the models, if you would spend more of your effort on quantifying and propagating uncertainty through the methods.

That is going to contribute more to a realistic assessment of the epidemiological situation in my view and also to the practice here because this is something that has been an undercurrent in all the discussions. But the practical matter of how you do this -- it's not like it's unknown, but it's something that could use some effort.

It would be a good thing for you to shift resources to that area, I think. That's my view, and I think that helps both your schedule, and, also, it puts your resources in a more appropriate area. And I agree with you that the resources should be spent, understanding the Hadnot Point geohydrology; is that right? Hydrogeology transport.

DR. DOUGHERTY: In my premeeting notes, I had compared the July version of the schedule with the version of the schedule on a preceding page of the handout. And even at that time, last summer, the areas in which the greatest slippage had occurred appear to be in collecting background information and then the development of the historical network information.

I don't think that we've reduced or accelerated those particular tasks in the last two days. And since those seemed to have been the ones that already grew before we had our two bits to say, they may slip further by as much as the six months that Tom talked about; my gut feeling.

MR. HARDING: When you say "slip," you mean be compressed?

DR. DOUGHERTY: No. I mean they've stretched out.

They have been extended when you compare that page to the previous page. And what we're hearing is there continues to be data discovery that has some significance with interconnects, monthly pumping rates that are not yet complete. And their significance to the outcomes -- the requirements for the outcomes seem significant enough that they're going to stretch longer than I thought they would when I walked in here yesterday morning.

DR. JOHNSON: Well, that would seem to conclude our response to these Charges No. 3 and 4. My view of what remains is to offer, indeed encourage, any kind of dialog amongst the panelists on any issue that hasn't been addressed to your satisfaction, any matter that you brought up in your premeeting comments that has not been addressed to your satisfaction, and any points that might represent some differences of view within the panel. Put those on the table to the extent you wish to discuss them.

Following that, it's kind of an open-discussion opportunity. I'm going to conclude the meeting by asking each of you as panelists what you would recommend the agency do in regard to what you've heard about the groundwater work as well as the water distribution work.

And I don't know that -- as I said earlier this morning, that we want to take the individual advice and recommendations and attempt to synthesize them into a panel product. I don't know that that's in ATSDR's best interest because, to some extent, that may tie your hands.

But I think it is quite fair to ask each of you as individuals your comments on what you would recommend for the future. So with that on the table, what else do you want to deal with as a panel? Open discussion on points that haven't been addressed and then closing by asking you your individual comments; vis-à-vis, advice; recommendations; but not going that third step and attempting to compile a panel body of recommendations. How does that resonate with you, Morris? You're the primary user of these deliberations.

MR. MASLIA: I actually would prefer not having a vote, as you say, but rather having everyone's individual opinion or summary of their understanding of what took place today. I think that would be much more beneficial to us.

DR. JOHNSON: Is it fair for the panel to say, as a body, that we consider this work as extraordinarily important for various reasons, certainly in support of an epidemiological study, but for other reasons, as articulated by Ben, as a study that will advance the practice in the field as well? I'm paraphrasing. If I misstate this, please correct me.

But is it fair for this body to go on record, saying this is pretty important stuff with the epi study and the work that involves water protocol and that we would encourage ATSDR, given the importance of this work, to have resources that are commensurate with that importance? Does anyone want to take issue with that? Are you comfortable with saying that for the public record as a body? Important stuff. Let's get the resources that match the importance and urge ATSDR to provide those resources.

DR. SINGH: I think so. I think this is a very important study. This integrates hydrology, geology, hydraulic engineering, and health sciences. So it's a very important study, and it should be encouraged. And obviously, we would like the agency to provide commensurate resources.

DR. WALSKI: But we also have to be concerned that the marginal benefits exceed the marginal costs. And some of the things I'm still not convinced that they are from my perspective. But, you know, I'm just one voice.

DR. JOHNSON: Does anyone else wish to speak to the issue of importance of study and commensurate resources?

DR. CLARK: I think I would support all of your characterization of the importance of the -- both as sort of the movement for the state of the art, the idea of integrating groundwater and surface water modeling activities and then tying together with epidemiology.

I think there's also -- I'm sure the study's going to be scrutinized carefully by the public. And I guess what I'm concerned about is that we appear to do a study that's somewhat short of the best that we can do, then we could be criticized for that, for not taking it seriously and not understanding the public health implications of it because they're very serious because there's a lot of water systems that have similar kinds of problems.

And I can see that this could lead to, maybe, a further study or a more in-depth study of better understanding of what those exposures might be for other water consumers. So it seems to me that you've got to take it seriously and think of it as scientifically defensible. And I say resources are there. Use the resources to accomplish the end project -- the end goal of the project.

DR. JOHNSON: Anyone else? Eric? Ben.

MR. HARDING: I want to build a little bit on what Tom's saying because I started -- I think I -- I guess I started this ball rolling a little bit. And I want to say that just because something is possible doesn't mean it should be done. And I think that we have to ask ATSDR to really focus on important areas here. And this -- I think this is what we're all going to address individually.

But I think the study is important in the two ways that you mentioned, and if ATSDR puts their emphasis on the areas that will contribute to an understanding of this situation and improving the practice, I think then it can be a very important study. I just want to echo Tom that it's important to make that and not take the resources and use them in areas that are going to just be generating friction.

So I'll make more specific comments, and I'm sure we all will. But I would like to see particularly -- this area of dealing with uncertainty quantitatively is an important one that's moving more into the practice; out of the universities and into practice. And I'd see some more effort spent there.

DR. JOHNSON: Thank you. Eric LaBolle.

DR. LABOLLE: I think this -- it may come back to something I touched on yesterday, which is: What is the role of these models that are being developed? And I think the answer at one point was, well, to provide monthly or submonthly, you know, concentrations, for example, with regards to the groundwater model and its inputs to the distribution system model.

And that may not be the role of the groundwater model. The groundwater model may play a role in simply bracketing the uncertainty in those concentrations that arrived, and the groundwater model may not be used to even predict the specific inputs used on any realization because that could certainly -- may be so great that one may just want to throw their shot at particular concentration inputs over time.

It depends on how much detail is put into these models and how much more effort is put into them. And I think from what I've heard -- essentially, I think everybody has a valid point hovering. And Tom, essentially, you know, we need to -- they need to make the best effort. You know, you certainly don't want to waste resources. But I think that the role of these models is really critical. You know, at what point do we say we're just, you know, beating a dead horse here?

DR. JOHNSON: Yes, Lenny.

DR. KONIKOW: In terms of the epidemiological study, is there a desire or a capability to look at the role of all the various contaminants? I mean, we were talking about PCE at the Tarawa Terrace. But there was also a benzene pollutant, and there's some TCE and PCE and some vinyl chloride at Hadnot Point and a longer list of contaminants. I mean, is this -- is there enough information to factor this into the epidemiological study?

DR. BOVE: Do you want me to answer?

DR. KONIKOW: I mean, this gets to, you know, what we might use the groundwater transport models to help define.

DR. BOVE: I mean, I don't think we have any information as to when Hadnot Point had more TCE than benzene. We don't have that data so that -- what we'll -- the way that we've characterized Hadnot Point exposure is to a mixture of VOCs, TCE being the main component. But if we're going to say -- if we're going to infer from that -- if we see, for example, an elevated rate of childhood leukemia or whatever, we will be able to say, at most, that it's this mixture that caused the exposure, similar to what we did at Toms River when we said that -- what was the -- the Parkway well field, which consisted of TCE, PCE, and this exotic chemical, styrene, acrylonitrile trimer, and which one was it?

Well, they were all together. You know, or when I studied trihalomethanes, well, which one caused the neural tube defect increase? Was it the chloroform? Was it HX? What -- what was it? That's how Hadnot Point looks to me. It's a mixture with TCE being the main component, and to make inferences, I would have to say that TCE is the main component. But, just as you said, there's benzene. There's all these other contaminants that could also cause or be suspected of causing childhood leukemia.

DR. JOHNSON: Okay. The floor is open for things that you think have been not addressed or not addressed adequately, things that you commented on in premeeting. So let's put them on the table. David.

DR. DOUGHERTY: I'm just going to return to your suggestion because the panel statement had, in terms of advancing the state of the art, and just comment that what it really looks like to me is the other bookend to Dover Township that really is going to help define the limitations of the methodology because there's such great uncertainty here as compared to a very different case at the other end.

DR. JOHNSON: Thank you. Ben, do you want to start? Anything that's not been put on the table or put on the table to your dissatisfaction?

MR. HARDING: I thought that's what we were doing just now. Then we got interrupted to respond to your charge.

COURT REPORTER: Microphone, please.

MR. HARDING: Again, the issue, monochloride, we've raised it a couple of times, but I think it's something that should not be neglected in our reconstructions.

DR. CLARK: I think that the issues have been addressed pretty thoroughly in an open forum. I'm very satisfied with the discussion.

DR. JOHNSON: David?

DR. DOUGHERTY: (Shakes head)

DR. JOHNSON: James?
DR. UBER: Well, just a couple of very specific, small questions.
DR. JOHNSON: I'm trying to make the point this is an open discussion.
DR. UBER: Open discussion; okay. Just because I had a couple of items here that I didn't have -- obviously, I didn't think I had answers to, and I was just curious. In the -- in the Hadnot Point area, what kind of plant production data is available now and historically?
MR. MASLIA: Basically the same that we have on all the plants. When we have asked for plant introductions, the one that we have monthly data for -- well, it gives us a chart, and it lists all the water-treatment plants.
DR. UBER: Okay. So nothing more than monthly?
MR. MASLIA: I haven't looked at the actual individual well records at Hadnot Point, but for the plant --
DR. UBER: The plant is monthly. So they didn't have to report anything daily or didn't report daily water production?
DR. POMMERENK: Actually, they do.
DR. UBER: They do?
DR. POMMERENK: I mean, in the recent past, I have personally have data from 1998 on this daily production at

each of the plants.

MR. MASLIA: But not for the present -- not for the study period?

DR. POMMERENK: No; not for the study period. The information was also for the current.

MR. FAYE: All of the data that I'm familiar with from Hadnot Point, from the well-construction data to the contaminant data to the supply data, you could probably generally characterize that as at a higher level of quality and number -- somewhat higher level of quality and number than what is available or what was available for Tarawa Terrace.

We can define the relevant issues that we've all talked about in a well-production contamination, temporal distribution of contaminants, spatial distributions, et cetera. We can probably define that somewhat better at Hadnot Point. Historical record: somewhat better at Hadnot Point; not greatly record, but somewhat -- greatly better, but somewhat better than we could at Tarawa Terrace.

DR. UBER: But with regard to temporal resolution --

MR. FAYE: That too.

DR. UBER: Okay. So the subtext of that is that -- the only reason why I'm asking that is because I'm thinking of the issue of interconnectiveness. And I'm thinking of just, in terms of the simplest model, if one had daily water production and one had information on base, then, you know, conceivably, you could look at a statistical approach that would allow you to say, with some degree of confidence, all of the water was -- all of the water within this area was coming from this plant or, no, there's definitely a shortfall. It had to come from somewhere else. That's why I was asking that.

MR. FAYE: I don't think -- the folks from Camp Lejeune can correct me. But I don't think the actual amount of water available versus need at Hadnot Point is not an issue. Where it was an issue was at Tarawa Terrace for a couple of years.

DR. UBER: I was talking about the Holcomb area, whether or not that ever got water from, you know, the other two interconnects. So it was my recollection you got about .8 MGD here and you got about three down here. That's the data that I saw. And so I'm thinking, you know, does it go down to .4 and go up to 3.4 on a statistical basis? That's what I'm trying to think about.

MR. FAYE: Everything that I know regarding the connection between Hadnot Point and Holcomb Boulevard is that there -- over the years from 1973 to the present, there were possibly some very short-term, intermittent connections between the two systems; i.e., Hadnot Point to

Holcomb Boulevard. Okay? That's that connection.

Between Holcomb Boulevard and Tarawa Terrace, there was a supplemental connection, also possibly intermittent; but a lot more continuous than the previous situation between Hadnot Point and Holcomb Boulevard between 1985 and 1987 Holcomb Boulevard to Tarawa Terrace. Okay?

DR. UBER: Okay. Well, that's just -- that degree of certainty that you just expressed is contrary to what I heard before. I mean, that was our whole -- the whole basis of our discussion of, you know, is Hadnot distribution system a self-contained entity or is there significant -- I'm sorry.

Is Holcomb a self-contained entity, or is there some leakage from a contaminated area? That comment just indicates that, no, or very, very intermittently. And so I'm -- yeah; with the exception of those two years. That's right; with the exception of those two years.

That was so -- we go back to the comments before that was when we were saying, you know, we need to have some archaeological investigation to look at this. So I'm, frankly, uncertain about the degree of certainty, I guess.

MR. MASLIA: Yeah; yeah. We definitely agree with that. And that's my take on the discussion this morning would be to put some effort into trying to reduce the uncertainty or refine the understanding on the interconnection issue.

DR. UBER: Okay.

DR. BOVE: It's very important because we're going to be telling people and putting it on our Web site that if you lived here at this particular time you were exposed or not exposed. This is going to be information for everybody -- anyone can see on the Web site, so we need to nail this down.

DR. UBER: Okay. So that was my rationale for asking those questions about the production -- production data. The other thing that I was just curious about is I think -- I guess I know the answer to this. But is there any data at all on customer complaints (laughter)?

MR. MASLIA: Well, this past spring I was on the airline, coming back to Atlanta, and one of the Marines that was on there with me -- they knew that we were doing some testing. And he says, "Well, the water tastes fine, but I could use a hot shower."

DR. UBER: All right. You know the reason why I was asking that is -- and I don't know anything about the -- I don't know anything about taste and odor thresholds for the levels of these contaminants. But if they had any kind of record-keeping of complaint data or things or even in terms of surveys of people. If anybody here knows anything about taste and odor thresholds, it might be an interesting survey question. You know, did the water smell like gasoline, that type thing.

DR. JOHNSON: Okay. Any unfinished business, Lenny?

DR. KONIKOW: Well, I think yesterday in the modeling we had lots of specific comments and everything, and I'm sure you'll consider them. I have just one residual specific question, which I don't recall was addressed, and it may have been.

But in advective transport, I think Bob said -- or at least I remember reading in the report -- that he placed or seeded particles 600 feet, I believe, east or west of ABC Cleaners; west, I believe. And this somehow led to the conclusion that the source of PCE in TT-23 was not the ABC Cleaners. Am I remembering that right or wrong?

MR. FAYE: Well, you're -- you are remembering it right, but the conclusion is wrong. It was just a poorly written statement, Lenny. What I meant to say was that, yeah, I think ultimately the PCE anywhere in that vicinity, the source was ABC Cleaners.

DR. KONIKOW: Okay.

MR. FAYE: It's just that when the -- when TT-23 was turned on, probably some time in the summer of 1984, and only operated for, maybe, four or five months and in January of 1995 all of a sudden here are these elevated concentrations of PCE found in the well and you're 1600 feet from ABC Cleaners, the conclusion that I was trying to draw or make was that, obviously, whatever PCE entered that well in that very short interval of pumping had to be much nearer the well than ABC Cleaners.

And then I went on to the explanation of the overlapping, contributing areas and suggested a possibility for how that area north, immediately north, of TT-23 had become somewhat contaminated with the PCE. So you remembered it right, but I wrote it wrong.

DR. KONIKOW: That's okay. Thanks.

DR. JOHNSON: Tom, unfinished business?

DR. WALSKI: Okay. Well, since I've been accused of being on hallucinogenics, I might as well continue hallucinating here and make an observation that I think's going to happen is: If we sat here today and figured out about when the plume hit Well TT-26, we could probably -- with the data we have, including the model we've run, we could probably say it's about the six-month window.

So what we're going to do is take another year and do -- and possibly do a tremendous job. It's going to be an outstanding modeling job and put all the uncertainty on, and I'll bet the answer's going to be about the same six-month window that we go today. That's my prediction of probably what is going to come out of the results.

But having said that, I think, you know, the study team's outstanding. I have tremendous respect for the ATSDR people: Bob and the others. I think they're doing just a super job, and, you know, if anything, they're probably doing a little too good of a job, but that's, you know, not a bad criticism.

DR. JOHNSON: Okay. Thank you. Vijay, anything that's not been addressed to this point that you'd like to bring up?

DR. SINGH: No.

DR. JOHNSON: Peter?

DR. POMMERENK: I don't have anything either.

DR. JOHNSON: Eric?

DR. LABOLLE: I'm clean (laughter).

DR. JOHNSON: This is a government facility, gentlemen. I don't know if there's anyone out there with bottles waiting for us or not.

DR. LABOLLE: But I would like to comment on the six-month factor. I really -- I think that that's -- not the six-month factor, the six-month window of arrival time here.

I think that that's a bit optimistic. Actually, my experience has been if one were to really address the level of uncertainty of the hydrogeology with a method capable of doing that -- and at this point, I don't see that that is in the cards for this, given the time frame in which they want to complete the job and the approach that's been taken already. I think you're already down a path that doesn't allow for the kind of thing I refer to.

But in that context, I think one would find that the uncertainty in arrival would actually be much greater than that, possibly. I mean, TT-26 may be close enough to the source that that's narrowed down some of the six months and is still kind of optimistic.

DR. WALSKI: So I'm even being too optimistic then.

DR. LABOLLE: But it may be -- it may be quite -- it may become clear with a little more analysis that it certainly did arrive prior to the study period beginning in '68. And that's something, I think, that that's another role for the groundwater model in this context.

DR. JOHNSON: Okay. Before I, starting with Eric, ask for your individual recommendations and advice on the groundwater work or the system distribution work, Morris and Frank, are there things that are unfinished in your minds? Are there things that you want the panel to address now that haven't been addressed?

MR. MASLIA: No; only, Jim, you did ask about water quality complaints, and Jerry just brought this document here. Under Item No. 37, it says, "There have been complaints concerning water quality residents aboard Camp Lejeune." And that's dated -- I don't have the exact date on this, but it's one of the released Camp Lejeune documents. So there apparently have been complaints. But other than that -- '93. It's 1993.

Other than that, we've gotten -- or at least I've gotten some clear indications and clear assessment of what we've done and what we need to do. And I'd just like to thank each one of the panel members. I think it's always better to have internal discussions as opposed to, as Frank said, putting it out on our Web site and then hearing the discussions.

DR. JOHNSON: Don't be too conciliatory. You've not heard their final recommendations. Frank, anything that's not been discussed to your satisfaction?

DR. BOVE: Thank you very much.

DR. JOHNSON: Okay. Starting with Eric and then working our way around, I'd ask for your individual recommendations as to how ATSDR should proceed, given this day and a half of discussions, and you can give that advice, make those recommendations any way you wish: specific to groundwater, specific to the water-distribution systems, or both. So here's your -- at least for this meeting of this expert panel. What are your recommendations?

DR. LABOLLE: I suppose I'd begin with regards to the water-distribution system, parsing out this chronology, as has been suggested by members of the panel, and focusing on those times when we know there was contamination in the system and there wasn't interconnection and assessing the need for the water-distribution system during those times -- the water-distribution system model during those times.

And I think the model itself that's been constructed to date may be useful in this for showing that, you know, what comes in this one line into the system reaches the tap. It may be obvious to those of us sitting here, but it may not be obvious to the public. And I think that I would recommend at least demonstrating that to the effect that it can be demonstrated and then identifying those other areas where the water-distribution system model may be important.

And I think if there's effort to be put into that that's what I would focus on in terms of the water-distribution system model. In terms of the groundwater model, as I mentioned several times, you know, my principal concern is with the geologic uncertainty and the source terms to the system and how they're modeled and a way to the uncertainty within the context of the model.

If there isn't the plan to do that in a realistic way, a geologically realistic way, then one should acknowledge, you know, the outcome of what they're seeing and the uncertainty in the outcome with regards to the pre-existing characterization that kind of went into it and the inability to modify that within the context and the constraints of the modeling approach.

And I think that that's important because that's -- what it's going to do is constrain the model outcome to kind of a precondition, you know, range of exposure estimates that don't necessarily encompass the degree of uncertainty that we really have about this system.

DR. JOHNSON: Thank you. Peter.

DR. POMMERENK: Yeah. My recommendations follow almost exactly on that line. I think the focus on the groundwater modeling should be on determining the range of concentrations and times that the contaminants may have arrived or may not have arrived at the wells. And as the panel has, in my opinion, fully stated that's the driving force for everything that is downstream of that.

So again, yeah, the focus should be -- you know, several suggestions have been made, you know, for example, Monte Carlo simulations and so on, to derive a measure of the uncertainty of those values that come out of the groundwater model.

With respect to the water-distribution modeling, if I understand this correctly at this point, the main uncertainty that we have right now left over is the degree of interconnection between Holcomb Boulevard and Hadnot

Point. Although we have heard -- we've heard two opinions that think that these interconnections were only intermittent and short-term connections. It would be good to just be certain of this fact, if possible, and go from there.

If, indeed, these interconnections don't have any effect on the epidemiological study, then we can essentially proceed and say, you know, whatever comes into the plant goes out everywhere in the distribution system, and that would essentially eliminate the need to, you know, develop further sophisticated distribution-system models.

My recommendation is not to continue on the field efforts at this time until these issues have been resolved. That's all I have.

DR. JOHNSON: Thank you. Vijay.

DR. SINGH: Essentially, I would just reiterate what has already been said earlier as well as this morning and yesterday. First of all, I would like to take this opportunity to state on the record that the ATSDR group, especially Morris Maslia and his group, have done really an outstanding job, and I have nothing but admiration for their work, both quality-wise as well as scientific rigor-wise.

Having said that, coming back to the groundwater modeling area, as we have cited so many times, I think it's important that there is a clear statement and a clear discussion of the model assumptions, the hypotheses, as well as the model limitations because no model is a perfect model. That's why we call it as a model.

And from the standpoint of public, I think it's very important to say very clearly what the assumptions are and what the model limitations are and which model hypotheses are, which directly would reflect on the quality and the reliability of the model.

And then the issue of uncertainty and risk analysis that we have been discussing since yesterday -- I think in the groundwater modeling area -- this issue has to be clearly, explicitly taken into consideration, and then there has to be a better accounting of the recharge, which really has not been done so far. Recharge has been taken as an average value on a yearly basis, which in my view is a very gross estimate of the rainfall water that goes into the ground.

After all, it is the rainfall water which enters into the ground which is responsible for transporting the contaminants into the groundwater body. And so it is, to me, of importance that the water percolation and the water recharge are more accurately estimated and included in the groundwater modeling area.

In terms of the water-distribution network, I think what Peter and Eric have said, I tend to concur with. The original effort on water discovery, I think, will be well worth the effort because there is no substitute for data, for data is the only source through which we get the information through which we communicate with nature. So I would strongly suggest that they continue their effort in terms of discovering or rediscovering the archaeology of the data as far as they can go.

But I also tend to concur with Tom in terms of the water-distribution modeling. I think the important point here is once the groundwater model produces water contamination through which we can quantify the water contamination at the wellhead and we can also have some data on the water contamination in terms of time and the depth. I think that is what is essentially going to be primarily responsible for determining the exposure from an epidemiological viewpoint. And I think that, to me, is essentially the central issue, which is what all this interval is meant for.

And so I'm not quite certain if a very detailed water-distribution modeling is really necessary. I think a simpler one might suffice, but if they have already done it and they're doing it, it certainly it's not going to hurt.

DR. JOHNSON: Thank you. Tom.

DR. WALSKI: Okay. Thanks. Yeah. I want to just second, I guess, what other people have said, and we have an excellent study team here, and they've done a very high-quality job. And it's just really ironic to find myself in the position of not selling modeling because usually that's what I do for a living is sell models and try to get people to use them. So I find myself, kind of, in an odd position here of saying, "Don't put too much emphasis on the models, but go for the real data."

And trying to -- I think, maybe, you might remember things better if I could just tell a story here. There's a guy walking down the street and sees another fellow on the ground on his hands and knees, looking around. The first guy -- he goes, "Well, what are you doing down there?" And he goes, "Well, I lost a $50 bill. I can't find it.

So the second guy comes and helps the guy look for the $50 bill, and after about five minutes, he says, "Well, how come you haven't found it? I mean, where did you lose it?" And he goes, "Well, I lost it over there in that vacant lot." And he goes, "Well, why aren't we over there looking?" And he goes, "Well, it's dark over there, and there's broken glass and rats and stuff. I don't want to go over there."

And I think that's kind of the position that the study team is in. It's kind of nice to work with models, but I think they're going to have to spend their time in the archives with the rats and the broken bottles, looking for data because that's where you're going to get the most for your effort is not being under a light in a nice area, but going to the archives and digging. And I think they're a qualified team, and they're going to do a great job with this.

DR. JOHNSON: Great. Thank you. Lenny.

DR. KONIKOW: Well, again, I second all the comments that have been made up to now. I again just reiterate with the groundwater modeling and the transport modeling that ultimately we're limited in what we can do in terms of the available data. I mean, you know, we don't have concentration data before 1980 or '82. And so everything we do for looking at distribution before then is going to be a little fuzzy.

We'll do the best we can with the flow model. You'll do the best you can with the flow model based on the distribution of pumpage, and that may be about the best you can do. In terms of, you know, the modeling approach and sensitivity analyses, this is all stuff that should be done. And one of the things to keep in mind is that your hydraulic heads in your flow model may be relatively insensitive to certain things to which the concentration distribution is highly sensitive.

And so there's not necessarily a direct transfer value in terms of the sensitivity analysis and uncertainty analysis between the flow and transport model. So it's just something to be aware of.

DR. JOHNSON: Jim.

DR. UBER: I'll leave it to the groundwater colleagues to talk about the -- what particular elements to include any probabilistic analysis or whatever form that may take, and I think that's clearly appropriate. My only reason for mentioning that is that I would have a suggestion that -- about the way the results of those analysis be portrayed. And specifically, for me, I focus on the precise connection between the groundwater resource and the water-distribution system, which is this pipe header that comes from the well field and goes into the distribution system.

And I think that the results of that stochastic analysis should be expressed in terms of the uncertainty or some type of interesting plot of the variability or uncertainty or both in that concentration that it is delivered to the distribution system, considering not only the uncertainty and the geohydrologic variables and the model set-up, but also the uncertainty in how the wells are operated.

I believe that if the uncertainty in that quantity is quantified within some bounds, then what we have been talking about today, which is to, maybe, allow data discovery to drive the train for a little while longer. If we continued on data discovery and then you had the results of that uncertainty analysis, then between those two, I think it would become clear what to do, if anything, more with the water-distribution system model. And I would just leave it at that.

DR. JOHNSON: David.

DR. DOUGHERTY: Well, yeah, I think people have hit a lot of the points, and we could repeat them several times, as we have through the past couple of days. I think the summary that I have is that the model complexity is too far out in front of the data in the characterization of the uncertainties. It's something that can be corrected, I think, and reasonably without major correction. It's just a correction.

The three issues that come to mind, and two of them are on the groundwater side and one's a general, easy observation about the archaeology, about interconnects. And so that's number three, but the first two are about the things that drive concentrations in the groundwater delivered by the wells.

There's the pumping schedules that, I think, keep coming up, but I'm not sure we can do very much about them. The things that we haven't characterized enough are source, the mass loading, and the accretion; not just the reinfiltration but the septic returns and making sure we've got those in a time -- reasonably timed; very, very consistent with the climate.

And finally, making any statements about the groundwater issues for Hadnot, I don't feel comfortable about it. I don't think we've had enough conversation or information about that, and that may be something that you may need your next panel to tend to.

DR. JOHNSON: Thank you. Robert.

DR. CLARK: Well, I don't think I'm going to say anything new or original, but I am generally supportive of the current plan. But I think with any project of this complexity and magnitude, there always adjustments that take place in the process. And it seems to me that a couple of those are the re-emphasis on data discovery, which I think is a very important issue.

But the uncertainty issues with regard to the model parameters and the stochastic nature of demand and then the consequences of those yield in terms of the output and data reliability. It seems to me that the real issues surrounding this study are really going to come in the public health and public policy area in terms of the epidemiological results. Excuse me. That's going to be the one that the public is going to look at, and the public health community is going to look at very, very carefully.

So I would suggest anything that needs to be done to support effort to make it more scientifically defensible is an important aspect to the project with the only comments, which I've made before, that the issue of transformation by-products is an important one to look at.

And also, what has actually been measured, I guess, in terms of some of the samples that have been taken prior to the establishment of the MCLs or vault organic chemicals, and this concludes an excellent team. I'm more impressed after listening to the presentation than I was before when I read the background data.

DR. JOHNSON: Thank you. And Ben.

MR. HARDING: I want to thank Morris and ATSDR team for the opportunity to sit in on this panel. I'm very impressed with what you guys have done. It's an eye-opener to see some of the kinds of efforts you guys have made.

What I want to suggest is that now you sort of step back and take a higher level look at this again. Take a little break. Reassess the requirements, starting with the epidemiological study. Just say, "What is it that we absolutely have to have and what are the things that are just sort of nice?" And probably just toss the latter. But certainly prioritize your requirements, and then make a decision based on a prioritization how you want to use your resources best.

With regard to the groundwater, which I can only kibbutz about, but I think it seems clear that the Hadnot Point situation requires some more understanding and possibly some more quantitative work modeling simulation.

I think in support of that and in support of, also, the water-distribution system, it's appropriate to do more of what we've referred to as data archaeology and continue in parallel while you're assessing your requirements. It seems that the groundwater work should express the uncertainty of, at least, the arrival time quantitatively and in a probabilistic framework.

With regard to the water-distribution system, the big issue here, it seems to me, is -- well, it may not be the biggest issue, but it seems to be the most contentious -- is to understand these interconnections. And I would suggest that if it turns out the systems are interconnected and they're interconnected in such a way that water flows from Hadnot Point into Holcomb Boulevard based on the grades that you consider excluding those periods of time and those populations that are affected, if you could possibly do that, rather than trying to model that particular situation.

Otherwise, in the other periods where the systems can be viewed as operating independently, I think the simple mixing models are adequate. And there, the most important issue, aside from the groundwater arrival time, is the dispatch of the wells. And that might be supported by the data archaeology.

And then, finally, and I think this would be a big contribution to the practice. Again, I've said this over and over and over again. But to apply methods of propagating your uncertainty quantitatively. Typically, Monte Carlo is the way people do that. It doesn't mean you have to run your groundwater model in a Monte Carlo framework. There's other ways to do.

I think it's practical, and I'd take a real hard look at that because it's very clear from our discussions there is a lot of uncertainty here. And again, thanks for the opportunity. I've very much enjoyed this. I'm very impressed with what you guys have accomplished.

DR. JOHNSON: Okay. Any reaction from the agency representatives before we close?

MR. MASLIA: Only to thank everyone for spending the time going through the material. Obviously, it was not a polished report by any means. But, again, to emphasize, we do take your recommendations and suggestions very seriously. It will, I believe, help guide us. We were at a stage where we needed, at least, some external input and guidance and just to thank everyone for their time and effort.

DR. JOHNSON: And in closing, one observation from the Chair. I've mentioned the term "cost benefit." And I think, as Ben and others said, I think you -- there's time now, and I think there's need now for the agency to step back and reflect and digest what you've heard over the past day and a half.

And I think you need to ask yourself, in the vain of getting data in which you have confidence, what benefit is it going to be toward that goal if other activities are done or not done? What's going to be the cost of some of these things you've put on the table? And perhaps, as a result of the last day and a half, some suggestions have been to perhaps reorder those activities? So take a hard look at the cost of what you're proposing to do in the future, factoring in the advice you've heard here from this panel.

And with that, I'd like to close by thanking, as the Chair, this panel. I've been in public health for about 40 years, and so I've attended lots and lots of meetings.

I've been on lots and lots of committees. Some committees, I've chaired. Some other committees, I simply chewed on as a member. But this is, certainly, in my experience, the most able and the most helpful committee of which I've had the privilege of being associated. So really, accolades to the panel.

I'd also like, on behalf of the panel, to thank the agency representatives: Morris, Frank, Bob Faye, and others who really in an exemplary way represented the agency and interacted with this panel and with the public representatives.

On behalf of the panel, I also would like to thank the public input and the public representatives here. And what was added was really important insights that we would not have had otherwise brought forward and were very valuable.

A special thanks to our reporter, who kept us all in line, starting with the Chair. So many thanks for your expert work. And lastly, many thanks to the administrative staff, Ann Walker and her colleagues, who have made much of what has been brought to you happen in terms of materials, arrangements, et cetera, et cetera.

So with that, using the prerogative of the Chair, I declare us adjourned. Thank you.

(Whereupon, the proceeding was adjourned at approximately 1:35 p.m.)

EXHIBIT 9

THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

convenes the

EXPERT PANEL MEETING

Analysis and Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point, Holcomb Boulevard and Vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina

APRIL 29, 2009

The verbatim transcript of the Expert Panel Meeting held at the ATSDR, Chamblee Building 106, Conference Room A, Atlanta, Georgia, on Apr. 29, 2009.

ORIGINAL

STEVEN RAY GREEN AND ASSOCIATES
NATIONALLY CERTIFIED COURT REPORTING
404/733-6070

C O N T E N T S

April 29, 2009

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-- "uh-huh" represents an affirmative response, and "uh-uh" represents a negative response.

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EXPERT PANEL

Analysis and Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point and Holcomb Boulevard and Vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina.

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HARTSOE, JOEL, USMC
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ROSS, RANDALL, USEPA
RUCKART, PERRI, ATSDR
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SCOTT, CHERYL, EPA
SIMMONS, MARY ANN, NAVY
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WARTENBERG, DAN, UMDNJ
WILLIAMS, SCOTT, USMC

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Glossary of Acronyms and Abbreviations

ASCE	American Society of Civil Engineers
AST	above ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
AWWA	American Water Works Association
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	community assistance panel
CD-ROM	compact disc, read-only-memory
CERCLA	Comprehensive Environmental Response, Compensation,
and Liability Act	
CI	cast iron
DCE	DCE:
	dichloroethylene
	1,1-
DCE:	1,1-dichloroethylene or 1,1-dichloroethene
	1,2-
DCE:	1,2-dichloroethylene or 1,2-dichloroethene
	1,2-
cDCE:	*cis*-1,2-dichloroethylene or *cis*-1,2-dichloroethene
	1,2-
tDCE:	*trans*-1,2-dichloroethylene or *trans*-1,2-dichloroethene
DHAC	Division of Health Assessment and Consultation, ATSDR
DOD	U.S. Department of Defense
DON	U.S. Department of Navy
EPANET or EPANET 2	a water-distribution system model developed by the EPA
ERG	Eastern Research Group, Inc.
gal	gallons
gpm	gallons per minute
HPIA	Hadnot Point Industrial Area
HUF	hydrologic unit flow
IRP	installation restoration program
LGR	local-grid refinement
MESL	Multimedia Environmental Simulations Laboratory, Georgia Institute of Technology
MGD	million gallons per day
µg/L	micrograms per liter
MODFLOW	a three-dimensional groundwater flow model developed by the U.S. Geological Survey
MODPATH	a particle-tracking model developed by the U.S. Geological Survey that computes three-dimensional pathlines and particle arrival times at pumping wells based on the advective flow output of MODFLOW
MT3DMS	a three-dimensional mass transport, multispecies model developed by C. Zheng and P. Wang on behalf of the

	U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi
NAVFAC	Naval Facilities Engineering Command
NCEH	National Center for Environmental Health, U.S. Centers for Disease Control and Prevention
NTD	neural tube defect
PCE	tetrachloroethylene, tetrachlorethene, PERC® or PERK®
PEST	a model-independent parameter estimation and uncertainty analysis tool developed by Watermark Numerical Computing
ppb	parts per billion
PVC	polyvinyl chloride
SGA	small for gestational age
Surfer®	a software program used for mapping contaminant plumes in groundwater
TCE	trichloroethylene, 1,1,2-trichloroethene, or 1,1,2-trichloroethylene
TechFlowMP	a three-dimensional multiphase multispecies contaminant fate and transport analysis software for subsurface systems developed at the Multimedia Environmental Simulations Laboratory (MESL) Research Center at Georgia Tech
TTHM	total trihalomethane
USEPA	U.S. Environmental Protection Agency
USMC	U.S. Marine Corps
USGS	U.S. Geological Survey
USPHS	U.S. Public Health Service
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
WTP	water treatment plant

P R O C E E D I N G S

(8:15 a.m.)

HOUSEKEEPING RULES

MR. MASLIA: I'd like to welcome everybody and thank especially the experts on the panel for coming to this two-day panel meeting and providing input to the Agency and to those working on the Camp Lejeune Health Study. It means a lot of us for you to provide us with your time and input and appreciate your pre-meeting comments.

And I'll just go over some house rules. You came in at the Visitor's Center. This is for lack of a better word an official federal facility or compound. So you are prisoners of Building 106, and my name I think is on all of your visitors' badges. I'm not sure if you want to claim that or not, but if you walk outside the building I'm sure I'll hear about it. So with that we'd like to ask that all of your activities remain in Building 106 if at all possible.

There is a cafeteria. Some of you passed in front of it as you came in, and there's lunch there. While we don't officially have reserved tables, we have set aside a row of about 25 or 30 seats that have reserved signs for the expert panel at the end of the cafeteria by the outside atrium as you walk past the cashiers all the way to the end. So if y'all want to sit together, that's fine. We'll make that possible.

And also, there are vending machines to my right outside the room here. Also, as I said, due to security it's advisable not to leave the building. We can't do it without one of us or ATSDR person and but for this evening or whatever, there's all sorts of fast food, ethnic restaurants up and down Buford Highway, which is a strip you came down, the seven-lane strip you came down this morning if you were awake to watch much of the scenery. Snack rooms as I said. The restrooms are to my left a couple of doors down.

We've got a number of people helping us. I just want to -- I'm sure I've left somebody off, so just let me know. But Liz ~~Burlsen*~~ [Bertelsen -ed.], who is from ERG, and has been in contact with most of our expert panel members. Jerome Cater*, Chris Fletcher*, Cathy Hemphill* in the back who brought us some coffee, Rachel Rogers* and Jane Tsu*. I don't think she's here.

Miscellaneous items: This is a sensor mike system, so you push the red button twice, and the red ring will come on around the top of the mike, and please speak into the mike. On the long tables here we've got four for five people, so share. You on the short table, y'all each have your own mike.

Please state your name for the first time -- we've got a court reporter -- when you speak into the mike or during the public session, when people come up, please state your name and affiliation.

This meeting is being audio taped, streamed live to the web and videotaped. It is a public meeting. As I said there's a court reporter recording everything, and that'll be part of the meeting report just like -- for those of you who were in the first expert panel meeting in 2005, the report that came out had two CDs with the verbatim transcripts. The same thing will happen here.

You'll, of course, get an opportunity to correct that or see a draft report obviously before it goes final to correct any information.

Turn off your cell phones to silence or vibrate and please no sidebars because it's difficult for the court reporter to record what you're speaking about on the side, and it may prove very important to us at ATSDR for those comments. So we'd like to hear it in public.

And that is it for housekeeping rules. Any questions?

(no response)

MR. MASLIA: At this time I'll bring up Dr. Sinks.

OPENING REMARKS AND INTRODUCTION OF CHAIR

DR. SINKS: Good morning everybody. My name is Tom Sinks. I'm the Deputy Director for both the National Center for Environmental Health and the Agency for Toxic Substances and Disease Registries, a long title. And I just wanted to welcome you here today. I am not an engineer. I am not an engineer. I'm an epidemiologist.

I have two of my mentors during my graduate school were actually converted engineers into epidemiologists of all things, and it may be why I got into the Environmental Health area. Because a lot of epidemiology is focused on physicians who become epidemiologists, the people from the health side who then go on to look at health issues.

And it's very important, at least in Environmental Epidemiology, for people on the exposure side to become involved in epidemiology because of an appreciation of how important it is to get exposure right. And if you have any appreciation for epidemiology, misclassification of either exposure or disease, is critical to the quality of your work.

And in general, if it's unbiased misclassification, it will always drive you towards not finding associations. So we are very, very concerned in Environmental Epidemiology that we get exposure right; hence, this is why we have you.

It's not unusual in situations where you have Environmental Epidemiology you're trying to look back over time that you have precious little information about exposure. And somehow you have to go back and try to figure out as accurately as possible what people were exposed to when you really don't have the information you would like to have, which is, gee, I wish I had some monitors on the tap water -- in this case, Hadnot Point from 1950 until 1985 -- so I knew exactly what these people were, and, gee, I wish I knew exactly how much they were drinking and how often they were showering, da-da-da da-da.

We don't have that information. We'd love to have it, but what we're going to do is use fairly sophisticated techniques to try to get back to the best information we can so we can do a good job with our epidemiology.

A couple things I want to say to you. First of all, I always appreciate Morris because he does such a great job. He wrote my opening remarks, and I'll pass these around for you if you'd like to see them because I don't plan to use them, but thank you, Morris. I'm sure they would have come out much more gracious than I will in person.

I want to make a couple of comments to you. For us, Monday -- no, Tuesday through Thursday is of all things a Camp Lejeune marathon. Yesterday we had our community advisory committee -- no, Community Assistance Panel, thank you, our CAP. Some of those members are here today. And the next two days we have this panel.

And one thing that I am very pleased with in terms of this project is the amount of openness and transparency that we're trying to put into this project. I think we can always try to do more, and if there are ways we can do more, we're interested in hearing that. But that's something that I think is somewhat unique about ATSDR. I'm very proud of it, and I think we are trying to do the best job possible on that.

Also, on this project and many of our projects we're very interested in not doing these solely intramurally. We're very interested in critical comment. Not just comment that says, hey, that's fine. Keep going. But a critical comment that says this is where I think you could do better.

Now in terms of being a scientist in this program and a supervisor, our job is to do exactly that with our staff. And we're not doing that if our staff are not being critical of ourselves all of the time. We should be doing that. We're hoping you will be doing that. You don't have to be too critical, but that's an important role for us.

And in Camp Lejeune, at least since I've been involved with this project, this is the third expert panel that we've held on Camp Lejeune. The first one had to do with seeking some advice from outside experts on additional epidemiologic studies. We had one similar to this on Tarawa Terrace, and this one today on Hadnot Point on exposure modeling.

And of all things, the National Academy of Sciences is writing a very large report we heard on Camp Lejeune. And we heard yesterday that the report that was scheduled to come out next week is now delayed again. So that's another piece of this.

So we're getting quite a lot of that. We will continue to get that. When we issue our reports, we'll put them out as public comment. We will get more comment then, but that's part of the process.

In terms of this project, I think you're probably very well aware of the charge. And I'll just say maybe simply we want to get the best information we can. Now, at the same time I really don't want to spend five years trying to figure out the best information we can. I really want to make sure we're getting the best information we can; we're doing it in a timely way, and we're proceeding along to get these projects finished.

Because, frankly, when I retire when I'm 70 -- because my youngest is six years old now -- when I retire when I'm 70, I hope I'm no longer in the business of Camp Lejeune. I know it will be something that has great interest to many people, but I hope we can get our projects finished, get the information out that needs to get out and get things done that need to be done at Camp Lejeune.

And so while you're looking at this, and you're scrutinizing this, I hope you recognize that this is not just an exercise in excellence. It's an exercise in an applied public health approach to an applied problem that people need answers to, and we really want to move ahead and get the best job we can done.

So with that I'll just close, and I hope you liked my opening comments whatever they were. And with that, Morris.

MR. MASLIA: Introduction of panel members.

DR. SINKS: I didn't realize you wanted me to do that, but you did give me this so I will introduce this. Most importantly, Bob Clark is from Cincinnati, Ohio, where I spent six years working for the National Institute of Occupational Safety and Health. I lived in Hyde Park right next to Graeter's Ice Cream. I could walk down there every afternoon, and I gained five to ten pounds.

Bob is a registered engineer and, I believe, a friend to epidemiologists. Currently, an independent environmental engineering and public health consultant. He retired from EPA in 2001. He's worked as environmental engineer at the --

You were a commissioned officer?

DR. CLARK: Right.

DR. SINKS: He was a commissioned officer working in U.S. EPA, which is actually a fairly rare thing. He was Director of the Water Supply and Water Resources Division at EPA from '85 to '99, and was appointed to a senior expert position at the EPA. He's authored or co-authored more than 350 papers and published five books. And I guess I'm going to turn this over to you.

MR. MASLIA: I was remiss in not stating, and I apologize to the experts and the audience. Those who have been in... We originally had James Blumenstock as our Panel Chair, which was on the original, and James, working for ~~ASTO~~ [ASTHO -ed.], got called up Monday morning to head their federal task force on the swine flu.

And so on short notice, Bob Clark has done a number of these panels, and I just want to assure for the record, that neither ATSDR, NCEH or CDC have any financial obligations or association with Bob Clark, and there is no conflict of interest, and we're appreciative of Bob's effort to step in at a moment's notice.

OPENING STATEMENT AND PRESENTATION OF CHARGE

DR. CLARK: Thank you, Morris, and thank you, Tom.

When James couldn't do it, well, they visually scraped the bottom of the barrel and came up with what they could find, and so that's me. So I will be the chairman this morning.

As all of you have been with the government or are with the government or affiliated with the government, you know there's a certain amount of bureaucracy that goes on. And one of the things we have to do, I have to read the charge so that we establish the fact that this is an official government meeting, so I'm going to do that.

This is the expert panel assessing ATSDR's methods and analysis for historical reconstruction of groundwater resources and distribution of drinking water at Hadnot Point, Holcomb Boulevard and vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina. The purpose and scope of this expert panel is to assess ATSDR's efforts to model groundwater and water distribution systems at the U.S. Marine Corps Base, Camp Lejeune, North Carolina.

This work includes data discovery, collection and analysis as well as water modeling activities. To assist the panel members with their assessment, they have been provided with the methods used and results obtained from ATSDR's previous modeling efforts at Camp Lejeune which focus on the area of Tarawa Terrace and vicinity. This panel is specifically charged with considering the appropriateness of ATSDR's approach, methods and time requirements related to water modeling activities.

It is important to understand that the water modeling activities for Hadnot Point, Holcomb Boulevard and vicinity are in the early stages of analysis; hence, the data interpretations and modeling methodology are subject to modifications partly based on input provided by members of this panel.

ATSDR expresses a commitment to weigh questions from the public and to respond to public comments and suggestions in a timely fashion. However, in order for this panel to complete its work, it must focus exclusively on data discovery and analysis and water modeling issues. Therefore, the panel will only address questions or comments that pertain to data discovery and analysis and water modeling efforts.

For all non-water modeling questions or statements, the public can contact the ATSDR Camp Lejeune Information Hotline at telephone ~~7-7-0-4-8-8-3-5-1-0~~ [770-488-3510 – ed.] or e-mail atsdrcamplej@cdc.gov. So that's the obligatory business that we have to take care of this morning.

One thing I want to be sure is we have a fair and open discussion. I certainly don't want to cut off any discussions or the opportunities for the experts to express their opinions, especially this panel. But we do have a very tight and specific agenda that we're going to have to try to complete. And so I'm going [to –ed.] hold fairly tightly to this so I want to warn you now that if I request that you terminate your discussion or your questions, it's not because I don't want to hear them; it's because we need to meet the tightness of our deadline. So I'm going to try to hold tightly to the agenda.

If there's additional comments, for example, if the web people, web-streaming people have comments, they can send e-mails into ATSDR to get their questions answered. Anybody here who has questions or feel like there's an issue that has not been well addressed can submit those questions or comments in writing. I think Morris can give you a contact point for that. We want to be sure that we have the maximum input, but we particularly, of course, want to hear from this excellent expert panel.

INTRODUCTION OF PANEL MEMBERS, AFFILIATIONS, AND RELATED EXPERIENCES

Just to give you a little more background on my background, we'll go around the table and introduce ourselves. I spent 41 years with the U.S. Public Health Service and the U.S. EPA, 30 of those years were as a U.S. Public Health Service commissioned officer. So I'm very familiar with some of the uniforms that I see in the room today.

I was detailed to the EPA when it was

created and ~~was,~~ [-ed.]for 14 years of that time, I was Director of the Water Supply and Water Resources Division in Cincinnati. I was actively involved in helping set the standards and develop the technologies that are utilized under the Safe Drinking Water Act for treating the kinds of chemicals we're going to be talking about today, so I'm very interested in this area. I spent three years as a senior scientist and since that time, I retired in 2002, I've been an independent consultant.

So let's go around the room. Randall.

DR. ROSS: My name is Randall Ross. I'm a hydrogeologist at the Robert S. Kerr Environmental Research Center, Ada, Oklahoma, for the U.S. EPA. I've been with EPA 22 years, I guess, at Kerr Lab working for the, what's now called the Applied Research and Technical Support Branch, providing technical assistance to EPA regional offices and hazardous waste sites in all ten regions over that time, mostly in hydrogeology, drilling and groundwater modeling-related activities.

DR. KONIKOW: My name is Lenny Konikow. I'm a research hydrologist, hydrogeologist with the U.S. Geological Survey in Reston, Virginia. I've been with the USGS for about 37 years, mostly in the research program and have been involved in developing groundwater flow and ~~solutransport~~ [solute-transport -ed.] models and applying them to groundwater contamination problems as well as water supply problems.

DR. GOVINDARAJU: Hello, I am Rao Govindaraju. I'm a professor in the School of Civil Engineering at Purdue University. My area of expertise is in surface and sub-surface flows and contaminant transport. I've been at Purdue for about 12 years now, and before that I was a faculty member in Kansas for five years.

MR. HARDING: I'm Ben Harding. I'm a civil engineer with AMEC Earth and Environmental in Boulder, Colorado, originally trained as what was then called a sanitary engineer, worked in advanced waste treatment for a number of years and then started to practice warm water resources and done a number of reconstructions of fate and transport of contaminants in water distribution systems. And I'm interested in risk assessment and treatment of uncertainty.

DR. CLAPP: My name is Dick Clapp. I'm an epidemiologist now at Boston University School of Public Health where I've been on the faculty for the last 18 years. Prior to that I worked as Director of the Massachusetts Cancer Registry and was deeply involved with the Woburn Childhood Leukemia Cluster and the water model that was created by a geologist at the University of Massachusetts in Amherst, named Peter Murphy.

And subsequently to that I worked in the consulting company and was hired as a consultant to the Ocean County Health Department in New Jersey where they were concerned about the Toms River exposures from hazardous waste sites that may have affected childhood cancer.

I'm currently a member of the CAP, and I, as a result of that, get paid per diem by ATSDR. I was here yesterday for the CAP meeting, and I've been for the last three years.

DR. POMMERENK: My name is Peter Pommerenk. I'm an environmental engineer. I am currently an independent consultant and used to consult on various Marine Corps and Navy contracts with Camp Lejeune, working on water treatment projects and water distribution projects.

DR. WARTENBERG: I'm Dan Wartenberg, a professor and Chief of the Division of Environmental Epidemiology at Robert Wood Johnson Medical School. And most of my research is on spatial epidemiology and GIS applications in epidemiology and also on disease clusters. And in 2000 I wrote the epidemiology section of EPA's reassessment of TCE, which I guess is still to move forward in terms of regulation.

DR. BAIR: My name is Edwin Scott Bair. I go by Scott. I'm a faculty member at Ohio State University in the Department of Earth Sciences. I have experienced six years with Stone and Webster Engineering Corporation. I worked with the USGS 16 years as a part-time employee.

And if I have a distinction at this table, it's being the only one who's lived at Camp Lejeune in 1952 when my father was called back into the Marines. My interests are in ground water hydrology, fate transport modeling. And one of my Ph.D. students, Maura Metheny, several years ago did a lot of work on the cancer cluster up at Woburn, Massachusetts.

DR. ASCHENGRAU: My name is Ann Aschengrau. I'm an environmental epidemiologist at Boston University School of Public Health. I'm a classically trained epidemiologist, and the area of research that I've been investigating for probably about 15 years now is solvent-contaminated drinking water. The research has been done primarily in the Cape Cod area of Massachusetts, which experienced exposure to tetrachloroethylene through the drinking water supply. I've also been investigating the spatial epidemiology of cancer and other diseases in the Cape Cod area, and happy to be here today.

DR. DOUGHERTY: My name is Dave Dougherty. I'm a consultant ~~on subterranean research~~ [at Subterranean Research -ed.] in Duxbury, Massachusetts. I'm trained as an engineer and my expertise is in groundwater. My career arc has gone from consulting to academia and back to consulting. I was a faculty member at the University of California Irvine and the University of Vermont. Back to Toms River, my first consulting gig was putting together a 3-D flow and transport at Toms River 25 years ago and has moved on to optimization perimeter estimation and long-term monitoring.

DR. HILL: Hi, my name's Mary Hill. I am a Research Hydrologist with the U.S. Geological Survey and have my educational background is geology and civil engineering. And I have specialized in with groundwater models, specifically integrating data and models, essentially how to do that best, what the uncertainty is, calibration methods, sensitivity analysis methods. And my book, actually a copy of my book is over there. It came out a couple of years ago. And I also, as part of that book, developed a set of guidelines for model calibration. There's a lot of talk about guidelines in this and what to use. Also, some years ago for a Proceedings article, I did a review of existing guidelines for groundwater model development and had submitted those. I don't know if they're around, but there were some questions about what guidelines might be available so that might be useful. Thank you.

DR. GRAYMAN: Good morning. I'm Walter Grayman. I'm an independent consulting engineer in Cincinnati and have been for the past 25 and-a-half years. My background is in civil and environmental engineering, but for the past, again, about 25 years I've been working in modeling of water distribution systems, hydraulic modeling and working with Bob Clark early in terms of developing water distribution system, water quality models. I did serve as a consultant for ATSDR on the Camp Lejeune work for a few years back when they were first starting it in terms of the field analysis modeling.

DR. CLARK: Well, thank you everybody. I'm sure we have a very highly qualified panel, and I'm looking forward to hearing everybody's comments. I'm sure they're going to be quite pertinent; it's going to be an interesting session, I think.

Morris, you're up next with your staff.

INTRODUCTION OF CAMP LEJEUNE EPIDEMIOLOGICAL STUDY TEAM

INTRODUCTION OF STAKEHOLDERS

MR. MASLIA: At this point Frank and I will introduce the ATSDR Health Studies staff and stakeholders as well.

Frank, I think you're up first so --

DR. BOVE: My name is Frank Bove. I'm a Senior Epidemiologist in the Division of Health Studies at ATSDR, been at ATSDR since 1991, before that with the New Jersey Health Department. And I'm co-PI on this work.

Perri Ruckart is back there. She's also co-PI, and she's an Epidemiologist in the Division of Health Studies. And Carolyn Harris, who's sick today, she's a Public Health Analyst who works on our budgets and contracts with contractors and so on. So that's the epi side of the picture.

INTRODUCTION OF WATER MODELING TEAM

MR. MASLIA: From the water modeling side, the study -- of course, I'm Morris Maslia. I'm a Research Environmental Engineer, and I've been with ATSDR and CDC since 1992, and I also spent almost ten years with the U.S. Geological Survey back in the days when we had money to do lansa^ [RASA (Regional Aquifer System Analysis) -ed.] studies and water resource we talked about.

Since the first panel, is interesting. We have the Agency has put resources in obtaining additional full-time staff. For those who were on the first panel, remember Jason Sautner was the only other full-time person with me, back there. Since then we've added Barbara Anderson in the back row, and Rene Suarez. And we also have Bob Faye, who's with Eastern Research Group, who was also with us for the first panel. And Dr. Mustafa Aral from the Multi-media Environmental Simulations Lab at Georgia Tech.

And at this point Frank and I would also like to introduce stakeholders, and if we miss anybody, please, if you want to stand up and introduce yourselves, but we have from Camp Lejeune and Marine Corps Headquarters, I see Scott Williams, who has been our point of contact both previously at Camp Lejeune and now at Headquarters. We've got Dan Waddill from the Navy. I see Joel Hartsoe from Camp Lejeune and Brynn Ashton, also, Thomas Burton.

And are there other people from the --

MR. GAMACHE: Chris Gamache.

MR. MASLIA: Chris Gamache, I know I'd miss somebody, welcome.

Then on the CAP -- oh, I'm sorry, I forgot Mary Ann Simmons, forgive me.

DR. BOVE: Mary Ann's also the DOD representative on the Community Assistance Panel. And Mike Partain, back there, is also a community member on the Community Assistance Panel. And Jerry Ensminger walked out just now, but he'll be back, is also on the Community Assistance Panel.

MR. MASLIA: Is there anybody else who -- I know we have a representative from EPA from Cincinnati.

MR. ~~BELGIN~~ [Beljin -ed.]: Milovan ~~Belgin~~ [Beljin -ed.] ^ ~~geologist~~ [hydrogeologist -ed.].

MR. MASLIA: And I've corresponded with him along with Dr. Ross for the expert panel. So welcome everybody. And at this point we're a little ahead of schedule which is good.

SUMMARY OF CURRENT HEALTH STUDY

Frank, let me pull up your and Perri's

presentation, and we'll proceed with the current health study, big picture, from Frank and Perri.

MS. RUCKART: Good morning, Perri Ruckart, ATSDR. Frank and I are just going to briefly describe our current health study at Camp Lejeune for you. We already introduced the project team.

Now, ATSDR has conducted or is in the process of conducting several health studies at the base, and we started by looking at the health effects on children or fetuses because they were seen to be the most vulnerable population on chemical exposures. In 1998 we published a study on adverse pregnancy outcomes. We evaluated potential maternal exposure to drinking water contaminants and the following outcomes: pre-term births, small for gestational age and mean birth weight deficit.

At that time we were only able to use available databases. There was no water modeling. We used electronic birth certificates beginning in 1968, and during 1968 to 1985, when most of the contamination ended, there were 12,493 singleton live births on the base.

And to assign the exposure we looked at base family housing records and linked those to the mother's address at delivery and usually the father's name. But we could not evaluate birth defects and childhood cancers because we're just relying on information from the birth certificates.

The results of this study showed that exposure to Tarawa Terrace water, which was contaminated with PCE, there was an elevated risk for small for gestational age among infants born to mothers greater than 35 years and mothers with two or more previous fetal losses. As far as the exposure to Hadnot Point water and TCE, there was an elevated risk for SGA only among male infants.

However, going through this water modeling process we discovered new data -- I'm sorry, we discovered that there was exposure misclassification because an area that was previously categorized as unexposed is going to be exposed. So once we have the water modeling results, we're going to go back and re-analyze the results from the 1998 study.

Now we also have a current case-control study, and I want to point out to you that here at ATSDR we do have peer review of our study protocols and the final study reports. I just want to mention that all of our work here has been peer reviewed.

So the current study is exposure to VOCs in drinking water and specific birth defects and childhood outcomes. This was a multi-step process. It involved reviewing the scientific literature to identify which defects and childhood cancers were potentially associated with the contaminants and that we could possibly pursue.

Because at that time period that we're looking at there were no registries, we conducted a telephone survey to ascertain the potential cases. It was very important to us to verify the diagnoses because we were using self reports. We did want to obtain medical records to verify what was self reported. And then using that information we're in the process of conducting a case-control study.

So this slide shows the outcomes that

we chose to further study in the telephone survey. We were asking about neural tube defects, oral cleft defects, the following conotruncal heart defects, choanal atresia, childhood leukemia and non-Hodgkin's lymphoma.

So through the telephone survey to identify potential cases of those outcomes among the births occurring during 1968 to 1985 to mothers who resided on base at any time during their pregnancies, that would be they delivered on base or they delivered off base but the pregnancy was carried on base, we identified about -- we estimated, I'm sorry, about 16 to 17,000 births, and the parents of 12,598 eligible children were surveyed.

That's an overall participation rate of 74-to-80 percent depending on which range you use for the estimated births. Because there is not a really clear handle on the births that were delivered off base, we have some best guess from the Naval hospital. That's why it's an estimate of how many pregnancies there were on base.

So through our telephone survey we were able to capture a sufficient number of neural tube defects, oral clefts and childhood cancers to proceed further with the study of those outcomes. There were 106 reported cases broken down as 35 neural tube defects, 42 oral cleft defects and 29 childhood hematopoietic cancers. And as I mentioned before, it's very important for us to verify, get medical confirmation of those cases. And that process has been completed.

So the way that shaped up was 52 confirmed cases out of the 106 we were able to get medical records confirmation for 52 of them, and 51 of those parents were interviewed. That's 15 neural tube defects, 24 oral clefts, and 13 hematopoietic cancers. Thirty-two of those 106 were confirmed not to have the reported condition. Eight refused to participate. We could not get, one way or the other, whether they have ^ [the reported condition -ed.] or not, they refused. Seven could not be verified or there was no medical record.

And believe me we tried. We took extensive measures. For those cases that were reported to have an oral cleft or a neural tube defect we offered them a visit with a doctor today for an oral cleft dentist so they could say with their evidence of an oral cleft if there was no medical record for the time or the same thing for the neural tube defect. But still, unfortunately, seven cases could not be verified one way or the other, and seven were determined to be ineligible. That could be because it turns out that the pregnancy did not actually occur on base or they were born outside of the timeframe and things like that.

So, as I mentioned, we conducted parental interviews and also included interviews of 548 controls. These interviews were conducted in the spring of 2005, and we wanted to get information on the maternal water consumption habits, the residential history on the base and up through the first year of life, maternal exposures during pregnancy and other parental risk factors.

And we conducted an extensive review of the base family housing records to verify the dates and location of where the mother was reported to have lived on base. We also used birth certificates and other information that's available to try to determine where exactly the mother was on base.

And Frank's going to discuss the data analysis.

USE OF WATER-MODELING RESULTS IN THE EPIDEMIOLOGICAL STUDY

DR. BOVE: I'm going to present what we propose for the data analysis. First of all, we're going to do separate analyses of each of these birth defects and so we'll focus on neural tube defects separately, oral clefts separately, and then we'll split it up between cleft lip and cleft palate and then look at childhood leukemia and non-Hodgkin's lymphoma together because of the small numbers of non-Hodgkin's lymphoma.

It may be difficult to also split cleft lip and cleft palate because there are 11 cleft palates roughly, and I think there's 13 or so cleft lips. So we're talking about small numbers throughout. So this is going to be the difficulty of this study because these are rare events, and doing a survey, phone survey, is not the best way to ascertain birth defects or childhood cancer, but it was the only way to do it at Camp Lejeune.

So next we'll evaluate the contaminate [contaminant -ed.] levels both as continuous variables and as categorical variables. We'll attempt to use smoothing methods to give us cut points for the categorical variables; however, again, because of the small numbers of cases, we may end up with ^, no medium and high for the categorical variable cut points.

Each contaminant will be analyzed separately. That assumes that there's one contaminant that's causing the problem, not a mixture that's causing the problem, and then we'll look at joint effects of mixtures.

So for neural tube defects first we'll focus on the confirmed cases and look at average and maximum contaminant level over the first trimester, over the period three months prior to conception to conception -- so that period as well -- and the average level in the first month of pregnancy since that's when the neural tube is closing.

For clefts we'll again be looking at average and maximum contaminant level in the first trimester. Again, looking at the period three months prior to conception to conception. Again, some of these are difficult to precisely or accurately define because we know when the birth occurs. We have some idea what the gestational age is and so on.

And then we're going to look at the second month of pregnancy because that's when the cleft lip and cleft palate are forming and are vulnerable to exposures. Although it may shade into the early part of the third month, so we may combine the second and third month as well.

And then for childhood leukemia and non-Hodgkin's lymphoma we'll look at each trimester separately. Then we'll look at the entire pregnancy. That's not on the slide. We'll look at the entire pregnancy, look at the average and maximum of the entire pregnancy.

Then we'll look at the first year of child's life. We only got information of the first year of child's life on residents, so we don't have information beyond the first year of the child's life although it may be possible to reconstruct that from housing records and not from the survey information if that is a recommendation. But we only have information on the first year of the child's life from the interviews of the cases of controls.

And we'll also look at, again, the three months prior to the date of conception to conception. Again, we're not sure when during pregnancy before the first year of life when the child is most vulnerable to these exposures that might cause leukemia or non-Hodgkin's lymphoma. And then finally, we'll look at the cumulative exposure over the pregnancy and first year of the child's life.

I thought you might like to see some real data. This is, we don't have Hadnot Point data, but this is Tarawa Terrace, those exposed who lived in the Tarawa Terrace housing areas. And you can see why we need monthly estimates because there is variability, quite a bit.

Some people move in and out. Sometimes the wells are shut, the main well at

Tarawa Terrace is shut down so that these months there's very little exposure to these months, very high exposure and so on. So I want to reemphasize why we need monthly exposure levels.

Now, we're planning two future studies, one on mortality, one a health survey. And for that monthly levels of exposure contaminant levels aren't as important as for this study. And we can talk about this future ~~studies~~ [study -ed.] if you want.

Data analysis, the typical way to analyze these data is using logistic regression. Again, I'll emphasize that the data is sparse for the cases so we may explore using conditional or exact methods. But again, with sparse data no matter what you do, you're limited by the sparseness of the data.

For confounders we'll use the ten percent rule including confounders in the model if they affect the ^dration by more than ten percent. And we're trying to keep the models as simple as possible given the sparse data. And then we'll explore the information we got from the survey on water consumption.

Now, I've never found this information that useful especially when people have to remember many, many years in the past, but we'll look at it anyway and see if it sheds any light on the situation.

Last slide we're going to talk, we're going to conduct sensitivity analyses to look at exposure misclassification varying sensitivity and specificity of our classification of exposure to see how that might affect the results especially with sparse data. They probably were affected quite a bit so we have to examine that.

Additional analyses, we have some cases and controls with a very poor residential history. This is another problem with the survey, people trying to remember their residences 20-, 30-some years ago or whatever. They forget. They're inaccurate. We have housing records that help to confirm some of that, but some people may have crashed with other people.

There are all kinds of housing arrangements that may have occurred on base, and so the housing records only go so far. They tell you where the sponsor lived, but not necessarily where the spouse and the rest of the family might have lived. And so we'll try to work with residential histories just to make sure all the cases that we interviewed and confirmed get into the analysis.

But we might also include some that haven't been confirmed yet and probably never will be confirmed because we just can't get the medical records for them. There's about seven of those pending that will never probably just determine whether they had the disease or not. We did an extensive effort to do that.

For clefts, for example, we actually paid for people to go to the dentist to get a confirmation that they had surgery for a cleft. And we tried everything to get the records for anencephaly, which is difficult, and spina bifida and for childhood leukemia we, again, made a big effort to confirm them. But again, seven cases that were reported in the survey we couldn't confirm yet. So we may include them in a secondary analysis.

Finally, we don't base our interpretations on P values. That's my thinking. We use these kinds of criteria. We can have a discussion of that if you want, but that's how we analyzed it and interpreted it. So, any questions for Perri and myself?

MR. HARDING: Ben Harding. If we go back to the table of the real data example for Tarawa Terrace, I'm not an epidemiologist, and I'm afraid that this might cause you a headache. But a question I have is, how could you use a table like this instead of having, for example, for child number one, I guess that's minus three months.

DR. BOVE: Yes, minus three months from date of conception all the way to the third month of gestation.

MR. HARDING: If those cells were, instead of having a single number in there, had either a range or an empirical CDF of values that were generated by a more probabilistic analysis of an exposure, how would that, would that make your analysis impractical, impossible, what?

DR. BOVE: Yeah, the relative position of each case and control wouldn't change with that so in one sense, no. The difference would be if we tried to make an inference as to at what level we see effect and what level we don't. And I think that this data is not good enough both on the water side or the epi side to make that assessment. Right now in this situation with environmental epidemiology and drinking water epidemiology, we still are not sure about the effects of these contaminants on these outcomes.

We have one New Jersey study looking at birth defects and we have a few studies looking at childhood leukemia like Woburn, for example, and then that New Jersey study that was looking at all ages but found an effect with childhood leukemia with TCE. So we're still in the early stages of trying to make the associations, not trying to define exactly what level of TCE or PCE we might see an effect.

So in other words, yes, we can plug almost anything in there, and it won't change the relative position of the cases and controls, and it will still be able to determine whether relatively higher levels seems to be associated versus relatively lower levels. Does that answer?

MR. HARDING: Yeah, thanks.

DR. HILL: Two things. I'm kind of uncomfortable with having numbers like this reported with three significant digits.

DR. BOVE: Right, I'm sorry.

DR. HILL: So just a general comment there.

DR. BOVE: Actually -- Morris, correct me if I'm wrong -- but I think we have more than three significant digits in the table and on the website, don't we? Right. So I actually reduced the number of digits.

But, yeah, I mean, again, it doesn't affect the relative positions.

DR. HILL: Right, it just affects the appearance of ~~decision~~ [precision -ed.].

DR. BOVE: Well, for 118, what would you put, 120 or...

DR. HILL: I would tend to round.

DR. BOVE: Round? Okay.

DR. HILL: I would tend to round. Mostly, it's conveying to people the precision of the number to my mind.

Okay, and then I had a question earlier on when Perri was talking. I thought what I understood was that in your initial assessment, you didn't have the results of the groundwater model so you were using some other estimate of concentrations at the wells to get, and then you used the groundwater model to refine that? Is that --

MS. RUCKART: You're talking about the 1998 study?

DR. HILL: Yes.

MS. RUCKART: Well, that was actually just based on crude exposure, whether they lived in an exposed area or not so at that time it was believed that one area was unexposed, and we got some new information that that area was exposed. So it was just based on yes, no, you were in an exposed area or not to take into account the water modeling at all.

So now, first of all, we found out about this error and then we are going to have more specific information from the water modeling. So it seems like a good idea just to redo that analysis.

DR. BOVE: For example, I think that there were 31 births we thought were exposed to trichloroethylene at Hadnot Point because that's the only area we thought. And that was because we thought that Holcomb Boulevard treatment plant was online before June '72. In fact, we thought it was online at the start of the study, which is '68. Of course, that wasn't the case.

So if you now understand that Hadnot Point served that housing up until June of '72, there's more than a thousand births and that changes things quite drastically for that study. And we didn't have this kind of data or the Hadnot Point data that we will have. So we want to go back and reanalyze it.

DR. HILL: And was the problem that you were using Holcomb Boulevard as your --

DR. BOVE: Unexposed group.

DR. HILL: -- as an unexposed group and now it's exposed. So, you could now -- I don't know if you can. I don't know how to do this exactly. But I assume you need to identify some other group as your unexposed group because you need a control group in your experiment?

DR. BOVE: No, the problem --

MS. RUCKART: Well, first of all, there's still going to be unexposed because people would have been exposed at different time periods, and there'll still be unexposed --

DR. BOVE: ^

MS. RUCKART: There are still unexposed. They'll just be less than there was like before there was 5,000 unexposed. There'll just be less, but there still will be unexposed from that study. But we don't have to collect any more data. We still have it.

DR. HILL: But the unexposed are amongst the housing units in the same area, but they're --

DR. BOVE: From '68 to '72, June '72, any part of the pregnancy that's within that area, all we have are people exposed to either Tarawa Terrace or Hadnot Point. Now, Hadnot Point, so for that period of time will have different levels of contamination but no births that are totally unexposed.

From '72 on Holcomb Boulevard is free of contamination except -- and we'll discuss this later -- for an interconnection that's used during the summer months. But we can take that into account. We'll take that into account in the current study, too. So from '72 onwards we'll certainly have unexposed to work from.

It's the before '72 that will be a little bit difficult unless part of -- but still, part of the pregnancy may have been off base. These people move in and move out. For that study they had to be born on base, but they could have moved on base in the seventh month of pregnancy, eighth month of pregnancy, so they're unexposed before that. So there'll still be some unexposed people even for the '68 to '72 time period, just not as many as before. Follow me?

DR. HILL: Yeah.

DR. BOVE: Let me take each period, '68 to '72 you have two water supplies, Hadnot Point and Tarawa Terrace, right?

DR. HILL: I understand that.

DR. BOVE: We don't know what the Hadnot Point levels are from '68 to '72. An important well comes online, what, '71, right?

DR. HILL: But the exposures are just based on where the people had residence, right?

DR. BOVE: Right.

DR. HILL: But they live in this community. They don't stay home all the time.

DR. BOVE: That's right. That's right. So we're looking at, we're emphasizing residential exposures. We don't have much information. I mean, people may wander all over base, that's true. We don't have an outside comparison group, outside of Camp Lejeune.

DR. HILL: And that's what I was curious about.

DR. BOVE: We will. We will for the mortality study and the health survey that we're doing next. And the reason -- well, two reasons why we didn't do it before. We thought there was a clean, unexposed group. So that study, but we can't really redo that study other than take into account we could take into account secondary exposure on base and call the people who were completely unexposed, those people who don't live on base until they -- during the period when they don't live on base.

For the future studies we're including

a comparison population from Camp Pendleton. Now, Camp Pendleton is similar in many ways to Camp Lejeune and unsimilar in other ways, but they both have hazardous waste sites on base, and the main difference is they don't have contaminated drinking water, at least as far as we know at Camp Pendleton. So that will be an outside comparison group for the future studies.

DR. HILL: Thank you.

DR. ASCHENGRAU: I just wanted to ask some more questions about the residential history. So did the people have to remember like a street address? What did they have to remember?

MS. RUCKART: Well, for the current case-control study, we had some information from this previous 1998 study as well as the housing records. So we would like give them a trigger. According to our records you lived at whatever, and we would just say the housing area. You lived at Tarawa Terrace during this time. Is this correct? And then they could say yes or no. And then that usually did not cover the entire period that we're interested in, three months prior to conception to first year of life. So then we would use that as our starting point and then ask them, well, what about before that. Where did you live, and then go back as far as we needed to and then up in time. And so, as Frank was saying, it's pretty hard to remember where you lived 20, 30, 40 years ago so then we did cross-reference that with the housing records, and then made adjustments. And then also with birth certificates or just any other information that we were able to process.

DR. ASCHENGRAU: So it's not like I lived at 371 --

MS. RUCKART: No, no, there's some --

DR. ASCHENGRAU: -- they don't have to remember that.

MS. RUCKART: No, the housing records would have information that was that specific, but we were just asking about the broad housing area. Our records show you lived at Tarawa Terrace or Hadnot Point or Hospital Point.

DR. ASCHENGRAU: So everyone living in that area gets assigned, or in a particular month, gets assigned the same value for their exposure?

MS. RUCKART: Yeah, we're not getting it down to the street level or anything like that.

DR. BOVE: But we did get, I mean, during the survey we did get the street name and sometimes street number from people. And from that we realized that there was another part of Jacksonville, North Carolina, that was called Midway Park. Midway Park is a housing area at Camp Lejeune, but actually, there's a housing area outside the base that's also called Midway Park.

And we found out that some of the people we thought were eligible, were actually living at the wrong Midway Park. So the survey helped, and they weren't in the housing records. That's why that triggered it to some extent. I mean, we had no record of these people living on base. So that was helpful because the survey clarified that.

DR. ASCHENGRAU: And then the last menstrual period, is that from like the birth records to estimate the conception or do you use the birth date and gestation to estimate the conception?

MS. RUCKART: We don't have information as part of the survey on ~~OMP~~ [LMP -ed.], or we don't have birth certificates for everybody. So that is why it's kind of, we don't exactly know the three months before. That's why we have those several different time periods we're going to look at, you know, minus three, date of conception to date of ~~conception~~ [conception -ed.], and it's not exact. We really just have when they're born.

DR. ASCHENGRAU: So you're estimating it when they're born, and then you're subtracting --

MS. RUCKART: Yeah, we can't figure it out gestationally or ^ [date of last menstrual period -ed.].

DR. GRAYMAN: Walter Grayman. Just to clarify, you seem to indicate that you weren't looking at the addresses within the areas. Is that correct?

MS. RUCKART: Yes, when we assign the exposure, we're just going to do it on the broad level, Tarawa Terrace, Hadnot Point, the various places they lived on base. However, as Frank was saying, as part of the survey they could report a specific address and then we can cross-reference that street to get the housing area. But we're not expecting people to be able to tell us the exact street. They could just say, oh, yeah, I lived in Midway Park or I lived in Knox Trailer Park.

DR. GRAYMAN: My concern really comes when you go onto the Holcomb Boulevard where we probably are talking about variation in terms of the concentration of the contaminants within Holcomb Boulevard which is different from the other two areas.

MS. RUCKART: Yeah, there is still different complexes or different housing areas within Holcomb Boulevard like Berkeley Manor or something like that. So we're not asking them were you served by Holcomb Boulevard. We'll be asking them for the specific, did you live in Berkeley Manor. Did you live in Hospital Point? Did you live in, you know, other areas served by Holcomb Boulevard.

DR. GRAYMAN: Thank you.

DR. BOVE: Yeah, we can distinguish the different housing.

DR. GRAYMAN: One other quick question on that. You brought up other activities besides residence. Did you look into work activities or is this not a very big issue back at that time?

MS. RUCKART: We did ask about that and can factor it in if we have enough information. And as Frank was mentioning, you know, the ten percent rule for affecting the model under estimate.

DR. BOVE: But very, very, very few of cases work controls had a job that involved solvents.

DR. BAIR: I guess my question follows with --

DR. HILL: What's the ten percent rule?

MS. RUCKART: Well, it's just kind of a rule of thumb, I guess, that epidemiologists use. So you have your crude model which would just be your outcome and your exposure. And you get a, let's say it just gives an odds ratio or a risk ratio. And let's say you get 1.5 just crudely looking at exposure and your outcome. Are these associated?

Then as you start adding in some other

variables like did you work with solvents or something like that, then if you add that variable also in with your exposures, you just would have let's say in this case three variables: your outcome, your exposure and your potential confounder, did you work with this chemical.

And if you just run that model, and you were to get an estimate that differed from, in my example 1.5, of more than ten percent, you would include it. But if not, you'd say, well, it's not really impacting our measure here so we're not going to add that. Because when you start getting too many variables it can make your model not run if you have sparse data. It doesn't really help you.

DR. BOVE: But some people use P values to determine whether you include a variable or not, and that would be really problematic in this study with low statistical power. So we try to make sure we capture as much of the confounding bias that we can given that there is also mis-measurement out of these factors as well most likely because of recall problems. But still we would have a better chance of including the confounder in the model that uses ten percent than if we use P values or some other rule.

DR. BAIR: I guess the question I have follows on one of Walter's earlier ones. Was there any assessment of exposure at mess halls or at daycare centers? Were all the residents cooking in their own residence or were there communal meals at some locations?

MS. RUCKART: All these things you mentioned could affect exposures, but we just don't have information on that. I guess we're going to assume like non-differential --

DR. BAIR: Well, did the mess halls have different water supplies than some of the residences?

DR. BOVE: Okay, the mess halls, we're talking now about the barracks then if you're talking about the mess halls, and you're talking about -- correct me if I'm wrong -- and so you're talking about bachelors' quarters, not family housing.

DR. BAIR: So families all ate in the individual residences because knowing my mother that would not be the case.

DR. BOVE: I can't say that they didn't go out and get a McDonald's or something during -- I don't think McDonald's was around back then -- but we're assuming that the major part of their exposure is in the home from consuming the drinking water and showering, which gives you an important exposure and a dermal exposure. So we're going to assume that.

I mean, there's not that much variability. We've looked at the data for showering and consumption of water. There really isn't much variability and they can't remember anyway, but I think that we're in good shape doing it this way. This is what we'd normally do in these studies. We really can't, I mean, you'd have to have a diary in order to determine all those different ways of exposure, and we just didn't do that.

DR. WARTENBERG: I assume you also do some sensitivity analyses so that if there, if there was an exposure estimates, you'll see what the impact would be on the --

DR. BOVE: That's right, we talked, yeah,

yeah.

DR. CLARK: Any more questions from the panel?

(no response)

DR. CLARK: Any questions from the audience?

(no response)

DR. CLARK: Morris, do you want to go ahead with the program?

SUMMARY OF WATER-MODELING ACTIVITIES

MR. MASLIA: Our schedule, which is good, which will leave lots of room for discussion and questions. And just back to a couple of housekeeping notes. I assume all the panel members see the booklet of slides that we prepared. I forgot to mention that. We do have some extra ones if people in the audience want to peruse them. We've got them in the cart here.

We also have the notebook that we gave out to the panel members if anyone in the audience would like to just peruse a copy. We do ask that you return it and keep it here because it is draft material, but Barbara may pass out a couple of copies if the audience would like to see it.

What I'm going to do is just give a general overview of the entire water modeling activities. I'm going to start very briefly on what we've done with Tarawa Terrace just so we're all on the same page for those who, panel members and members of the audience, who have not been with us since then. And then go into Hadnot Point very briefly. We have subsequent presentations and staff that will actually present very detailed information on Hadnot Point.

Throughout the water modeling activities, the epidemiological study came to us and gave us four goals and objectives to meet. And this is by order of preference, if you will. If all we could do was give them certain information, and at least wanted to know the dates of the contaminants that arrived at the wells.

If we were able to provide that information, then they would like to have the distribution of contaminants by housing location. That is, was it served by the Tarawa Terrace water treatment plant? Was it served by the Hadnot Point water treatment plant or the Holcomb Boulevard water treatment plant? Having that distribution they would like to have monthly mean concentrations, and I believe that's the numbers that Frank and Perri showed up on that table.

Is that correct, Frank? Those were the mean values. We obviously, if you see any of the reports we have ranges associated with those. I think Frank just showed mean values for an illustrated example.

And then, of course, we get into the subject of reliability, confidence, how confident are we, that is on the water modeling side, and the values that we are giving the epidemiologists. And just as an example, if you look at some of the supply well data from Tarawa Terrace of the wells, it may range from non-detect all the way up to 1500 parts micrograms per liter. And so the question is how reliable, when we give them a number, does it range that much or does it not range that much.

So getting back to this, and this will help, I think, clear up a little. We've got three housing areas, Tarawa Terrace and Knox

Trailer Park someone mentioned, served by both Camp Johnson and Tarawa Terrace. What's referred to as Holcomb Boulevard, and there's the Holcomb Boulevard water treatment plant, and the Hadnot Point area right here.

Initially, we assumed that Tarawa Terrace was completely exposed or continuously exposed I should say for the study period. And we assumed that the Hadnot Point area was continuously exposed for the study period. We also then assumed -- and I say we, that was the information that the epi study talked about, that Holcomb Boulevard was completely unexposed.

Based on some information and digging around, newspaper articles, some transfer of property documents that were provided by the Marine Corps, we estimated actually that Holcomb Boulevard really did not come online until June of 1972. Just for your edification that's based on one nice big picture in a newspaper showing a grand opening of the plant in August '72, and also U.S. government property transfer to the tune of $700,000 occurring in June of '72 which would be the treatment plant, meaning it was completed and online.

So that's our best estimate as to when Holcomb Boulevard, so that's the difference in time from '68 to '72. Obviously, Hadnot Point did supply contaminated water or water with varying concentrations of contaminants to Holcomb Boulevard.

DR. GRAYMAN: Morris, what is French's Creek? Why is that designated differently?

MR. MASLIA: It's just an area that's referred to at Camp Lejeune as French's Creek. It's on the same water distribution system.

DR. GRAYMAN: As Hadnot Point?

MR. MASLIA: Hadnot Point, but it's referred to as French's Creek, and we just, but it's the same distribution system.

We also have, and we met this past November, I believe, with former and current operators. You have a question?

MR. PARTAIN: Just [to -ed.] elaborate on Dr. Bair's question about the housing. My parents -- I'm one of the [Lejeune babies -ed]. I was born in January of '68. My parents lived in Tarawa Terrace, and the housing units there are self contained. It's like a neighborhood. You've got your kitchen, everything you need is there. The base is a self-contained unit.

My mother is French-Canadian, and at the time English was her second language. She didn't leave the base. Everything she needed was on the base, PX. The PX was located at Hadnot Point, the main side. All of her OB/GYN appointments were on the main side at the Naval hospital. The O Club, where my parents would go for their recreation, was on main side.

So we were exposed to both Tarawa Terrace water, which provided our family housing, and also Hadnot Point water, which provided the water for the O Club, the Naval hospital where I was born, and any activities they did on there. So these houses are just like you would go drive through a subdivision. It's not like a barrack or anything like that but family housing. Of course, when you're dealing with barracks, it's a totally different issue. I hope I clarified your question there.

DR. BAIR: Thank you.

MR. MASLIA: There's an interconnection valve here and a booster pump right here. And when Frank mentioned previously about intermittent mixing or interconnection, we had a meeting with former and current operators, ATSDR did, I think last November, and we also have some logbooks that have some entries into them.

And what it turns out as a general rule of thumb is that during the spring, which is dry in April, May, June, everybody's filling up the kiddy pools, sprinkling a golf course up here, and someone, they may need some additional water at Holcomb Boulevard. So they would turn on a 700-gallon-per-minute pump. At some point they switched that out to a 300-gallon-per-minute pump, and there's entries into the logbooks when they did that.

At the same time if this did not provide sufficient water, then they could go and open up this interconnection, which is referred to as the Wallace Creek valve, and water would flow that way as well into that site. So that's how you would get mixing of water, contaminated water, even after '72 in this area during April, May or June in that time period. And Jason Sautner will speak more about this on the second day about that.

And so that's a big difference than Tarawa Terrace for the question that we have posed because at Tarawa Terrace the last panel recommended -- and rightfully so because we didn't the testing because all the supply wells fed into a central water treatment plant, we could use a simple mixing model and mix, and assume, which we did, that the finished water concentration at the treatment plant was the same water that residents received from the treatment plant. So that's what's different about this situation.

MR. HARDING: Morris?

MR. MASLIA: Yes.

MR. HARDING: Ben Harding. If you go back to that slide, it doesn't make complete sense that you'd be able to do both things in a water distribution system, open the valve and use the booster pump. The use of the booster pump implies that the Holcomb Boulevard system was running at a higher grade level than the

Hadnot Point. And if you open the valve, if that were the case, then you'd expect water just to flow back into Hadnot Point. So I just want to put that question on the table, and maybe Jason or somebody later can address that.

MR. MASLIA: There's also ~~Joe~~ [Joel -ed.] Hartsoe here who probably has more expertise since he operated the system there that could answer us. Our understanding was -- and, Joe, please correct me. As I stated if there was insufficient supply from the booster pump, they would turn on, open up the valve.

MR. HARTSOE: The valve you're talking about ^ [is Marston Pavilion. -ed.] I don't ever remember opening that valve because of the watering of the golf course. It was always the booster pump. Then interconnections would only be opened if, that interconnection would only be opened if there was a major water break or anything like that. I don't ever remember opening that valve just to furnish water for the golf course area.

MR. MASLIA: There's also a two-week period in January of '85 when there was a fuel line break at the water treatment plant here, and BTEX compounds got into the supply here. So then they used the Hadnot Point water supply for about a two-week period. And there's actually some fairly detailed measurement, concentration data throughout the distribution system that we have. That's the other point to remember. Did that answer the question?

MR. HARDING: Yeah, it sounds like that valve was only opened under very rare circumstances.

MR. MASLIA: It is noted in the logbooks that we have when it, at least on there is notation that they opened up the valve, the Wallace Creek valve.

DR. HILL: So are you saying that the records you're seeing contradict what was said?

MR. MASLIA: No, not at all. I'm just saying when we have information or data, we prefer to refer to the logbooks. The logbooks specifically provide an incident that the Wallace Creek valve was open.

DR. HILL: And as far as you know, is that because some major main break or you just don't know?

MR. MASLIA: Oh, we don't know. It does not necessarily give those other details. We've actually transcribed the logbooks. Actually, the logbooks are on the DVDs for Chapter A, that three DVD set. They actually, if you're interested, we can point you to which files so you don't have to look through 20 gigabytes to find it.

But that's what we have gone through those, and that's one of the purposes when we had the meeting with the former operators so we could understand clearly because we did see entries mentioning a booster pump. We saw another entry mentioning a valve. And for awhile there we were not quite clear on the understanding of that. So I believe we're on the same page now, and we understand the operations we have seen.

DR. GRAYMAN: It would be interesting to maybe have a chart which would show on a month-by-month basis the number of hours that the booster pump was on and the number of hours that the valve was open on Wallace Creek.

MR. MASLIA: Jason does in his presentation tomorrow have a chart showing from the pump side the hours and so on, and he will present that.

DR. HILL: So there was this period of time where along Holcomb Boulevard there was this spill, and so they shut that water off. They brought water in from Holcomb Point, and during that time they did detailed monitoring of the quality of the water being delivered?

MR. MASLIA: Yes. I believe the state came in also and took some samples.

Is that right, Scott?

Yes, the State of North Carolina came in and there's actually sampling throughout the distribution system.

DR. HILL: I hadn't heard of that occurring, and it seems like that's a really nice opportunity.

MR. FAYE: That's discussed in detail in your three-ring binder report there. I think it's actually Table 12 or 13 of the Contaminant Data Report shows the analyses, the time of analyses, the location of the analyses. And there was the actual what we would call detailed sampling only occurred for probably a couple days, but then there was periodic sampling at a smaller number of locations for actually about two weeks.

And all of the data that we have regarding that incident and the sampling and et cetera, is on, like I said, Table 12 or Table 13, and actually may not have been printed out, but it's on the CD that was provided with the binder.

MR. MASLIA: I can pull that up. If you'd like me to pull that up right now, I can.

DR. HILL: Oh, no. I would suggest going on with your presentation. I went through most of those tables and marked them so let me look at those, but I didn't understand the significance of them.

DR. KONIKOW: Just one question on those ~~detail~~ [detailed -ed.] datasets. Could that provide an opportunity to test or calibrate your water distribution model?

MR. MASLIA: Absolutely.

DR. KONIKOW: Okay, absolutely.

MR. MASLIA: Yes, that's at least one thought that we have, but that kind of data we don't have otherwise. So, yes, Lenny, that's the lines, at least right now, that we're thinking along.

MR. PARTAIN: One important thing to note, I don't know if you pulled that dataset for the North Carolina testing in January of '85.

MR. MASLIA: Let's see if I can.

MR. FAYE: If you go to my hard drive --

MR. MASLIA: What table was that, Bob?

MR. FAYE: There you go. Go down to the tables.

MR. MASLIA: What table?

MR. FAYE: I think it's 12 or 13.

DR. HILL: It's 13.

MR. MASLIA: You want Figure 13?

MR. PARTAIN: Okay, that's it. Now, what I want to point out, these are different sample points along Holcomb Boulevard and Hadnot Point. The January leak that they're referring to that this dataset came from was the result, was taken after the Holcomb Boulevard plant had supposedly been cleaned because of a fuel spill.

Now, at this point in time, there was only one contaminated well operating that produced these results. The other ten, I believe it was ten contaminated wells had already been taken offline at the time of this reading. So you have one well producing those results all along different points of the distribution system within Holcomb Boulevard.

MR. FAYE: That's all discussed I think pretty thoroughly in the text of that report that discusses this incident and that was Well HP-651 that the gentleman was referring to.

DR. GRAYMAN: And that time period was when it was being supplied from Hadnot Point still?

MR. FAYE: Yes. And the issue there was that earlier during December of '84, I believe it was December 16th of '84, Camp Lejeune did a major effort of sampling all of their active supply wells because of their alert that they had, that there was several of the wells had been contaminated. And obviously, they were on a mission to find out which ones.

Unfortunately, part of that sampling effort, I believe, there were four of the bottles that were broken at the time. And one of those bottles was 651, so it was never recognized by anyone that that particular well was contaminated until these data came along. And then that was the last contaminated well that they removed from service.

MR. MASLIA: Yes.

DR. ASCHENGRAU: We just noticed that one of the sampling sites was the Berkeley Manor School, and that the TCE concentration's very high there. So I'm just wondering is it possible that some of the children in the study went to school there? 1985.

MR. MASLIA: Frank says that's a future study. The study goes from '68 to '85.

MS. RUCKART: The children in our study report, they're carried in utero, so they would not be at school. I suppose if the mother was a teacher at the school.

DR. ASCHENGRAU: What year was it? Aren't you going back to '68?

MS. RUCKART: Well, if the births occurred during '68 to '85, it's possible that the children did attend the school, but that would not be included in our study because we're just looking at exposures up to the first year of life. We are doing some future studies, and that will include as part of our health survey, dependents.

DR. ASCHENGRAU: Okay, but maybe we'll recommend that you go beyond the first year of life for the cancer outcomes.

MR. PARTAIN: You'll notice, too, that the hospital is in that dataset. I think it's 900 parts per billion or something like that.

MR. FAYE: And I think the relevance of this is that, as the gentleman pointed out, this was just one well that was pumping at the time. There were many other wells that were providing water to Hadnot Point by WTP at the time, and so the actual concentrations from 651 were substantially diluted, and you still got these concentrations.

And the point is -- I think I pointed that out as well in the text there of the report -- that you have as long as these contaminated wells were operated routinely, you obviously had contaminants routinely delivered to the WTP and this just happens to be the best example of that that we have.

DR. BOVE: One other point about this is that, yeah, the high reading at the school, but this was a two-week period. The school was free of contamination most of the rest of the time. But there are schools in Tarawa Terrace, and they got contaminated water as well so the child would have residential and school exposure. And we're going to be trying to capture this in the health survey, the diseases that developed after as they got older.

DR. HILL: But the school would also have been contaminated perhaps during those April through June time periods?

DR. BOVE: Right, we don't know. It depends on, yeah, this is Berkeley, yeah. We're not sure yet what parts of Holcomb Boulevard housing got the full brunt of that when they turned on the valve, and what parts didn't get the full brunt if they're going to be diluted of course. So these are questions we'll have to resolve.

MR. MASLIA: Scott.

MR. WILLIAMS: You may have to present to the panel that you have the well-cycling chart for that time period, so there's a lot of unknowns there. Morris has a well-cycling chart when all that sampling was going on, so you can actually see exactly which wells were on what days. We don't have the resolution for ^(off microphone).

MR. FAYE: Morris, I think this highlights the, probably the principal challenge from the ground up on this is to understand this may affect the groundwater as well, how these wells were operated. This is the same thing with Tarawa Terrace. This is a huge challenge in reconstructing that, and I think we ought to spend some time talking about how that was done for Tarawa Terrace. How it might be done for Hadnot Point.

MR. MASLIA: And I've actually got some Tarawa Terrace slides so maybe I should proceed to those and maybe we can --

MR. FAYE: Can I address that, Morris?

MR. MASLIA: Yes.

MR. FAYE: First of all at Tarawa Terrace our main, we didn't have a lot of specialized data in terms of the operations of the wells at Tarawa Terrace. We do have those kind of data for this particular aspect of the study for this study, and I'll detail that in my talk. But the point to be made a Tarawa

Terrace was our main approach was to make sure that we removed an appropriate volume of water from the aquifer at a particular time and for a particular time.

And the well capacities were just used to distribute that volume of water. We can actually do various tests and Peter Pommerenk has come up with a, described a whole series of concerns and tests that he would recommend for this particular study. And we actually have the data that we can accomplish that, and I'll talk about that in my presentation specifically related to well operations.

MR. MASLIA: So for overview, again, wanted to just make sure we were all on the same page and understanding that exposure, exposed, non-exposed and the time frame of each in which you have the valve and booster pump.

I thought it would be interesting just to give a generalized timeline so, again, everybody understands the relationship of different, the study, different occurrences of treatment plants or supplies coming online. And, of course, here's our current health study going from '68 to '85. Hadnot Point was the original water supply system on base. The base started around 1941, and it's presently still operating.

Tarawa Terrace based on information in the work details of the Tarawa Terrace reports, online from '52 to '87, and, of course, that was shut off after February of '87 due to contamination. And Holcomb Boulevard, as we said, came online in June of '72 and it's currently still operating.

It's interesting that the documented VOC contamination, that's where we have sampled data strictly from '82 through '87. That's all to our knowledge that exists in terms of specific contaminants such as TCE, PCE, degradation products. And so that is now, there's post-remediation or remediation data as they were doing RIFS reports.

But in terms of the water supply, that's what I'm referring to here, that's all we have. The historical reconstruction for Tarawa Terrace indicated that concentrations above the MCL, which is five parts per billion, for PCE in November of '57. And, of course, the water treatment plant was shut down during February of '87.

And at Hadnot Point, which is why we're all here today, again, this is what this meeting is all about, but again, the contaminated wells were shut down by '87. So, obviously, sometimes in this time frame it became contaminated. Lenny?

DR. KONIKOW: With the documented VOC contamination, was that in all three, from all three water treatment plants and all three supply systems?

MR. MASLIA: In '82 they not necessarily went to the treatment plants, probably in late '84, early '85 is when they actually started going to the wells and the treatment plant getting half singles, if you will. There's actually some inferences because of THM readings being affected by VOCs or chlorinated solvents in '81 and '80, but that is from '85 forward that that's at the treatment plants. I don't believe we have any supply wells prior to '84.

Is that correct, Bob?

MR. FAYE: Well, the question was related first to the WTPs. There's two tables in the report, I think six or seven or something like that, that actually show the, actually list the contaminant information that we have for both WTPs.

And I think to answer you question directly, Lenny, I'm not really positive there was VOC contamination noted through samplings at the Holcomb Boulevard plant during this time.

And, Morris, what was the question about the wells, the supply wells? What was that about?

MR. MASLIA: During this period, the sampling.

MR. FAYE: Yeah, that's all in the report as well. There's a large table in there showing the BTEX contamination and the PCE, TCE and derivative contamination at the supply wells and it covers this period. And I think that might be, I don't know. You'll have to look at the list of tables, somewhere between six and ten, something like that.

DR. HILL: The earliest year is '84.

MR. MASLIA: Yeah, the earliest year is '84.

MR. FAYE: For the supply wells, yeah, absolutely, yeah. The earliest is July, actually of '84, July 7^{th} of '84, I think is the earliest data that we have and then there's the '82 data relate to sampling locations within the Hadnot Point distribution system.

DR. KONIKOW: The Tarawa Terrace with the first arrival in November '57, if that was actually several years later, maybe even four or five years later, would that have any effect on the health study since the health study is '68 to '85? In other words would any inaccuracy in that first arrival --

MR. MASLIA: We actually did, Mustafa Aral did some well scheduling optimization and did different scenarios with different wells other than the ones that we calibrated for the model. And you could shift the time from '57 to '60, but during the course of the study it did not significantly affect at all the higher concentrations.

They all tended towards that level of that chart, the graph that shows in the finished water that all it shifted was, other than if you shut down, for example, TT-26. If you shut down TT-26, both the data and the model would show that your finished water went down to practically no contamination at Tarawa Terrace. But if you shifted the cycling so that it didn't hit or arrive or pass the MCL, say, as you said, 59, 60, 61, whatever, did not significantly affect the higher concentrations in the finished water.

DR. DOUGHERTY: Just to continue on that, was there sensitivity to the contaminant mass loading date as opposed to the water production schedule?

MR. MASLIA: The actual date of the introduction of the contaminant to the system at Tarawa Terrace?

DR. DOUGHERTY: Yes.

MR. MASLIA: No, there was not. That was -- and I guess I'll refer to Bob, but that was derived based on the deposition of the owners as to when they began operating the dry cleaner.

But, Bob, if you want to follow up on that.

MR. FAYE: Yeah, there was a legal, a deposition obtained from the owners, the Metts (ph), the Metts family I believe is the name that owned ABC Cleaners at the time. They described the onset of their operations. They indicated that they used PCE from the beginning of their operations and so we had a date, I think, of 1953 or '54, something like that, when the PCE was initially loaded to the subsurface as far as the modeling is concerned.

MR. MASLIA: We also had information just to bracket the actual value as to how much the Metts estimated they used during their process.

MR. FAYE: Yeah, they indicated that they continuously for the years of interest to this study anyway, continuously used between two and three 55-gallon drums of PCE every month.

DR. HILL: Mary Hill. So I understand how that the rest of the modeling concentrations would change as that beginning date changed, but in terms of the epidemiology study, and their efforts to try to get time connections, are their results impacted by that?

MR. MASLIA: No.

DR. HILL: I thought not. I just wanted to verify that.

MR. MASLIA: No, they would not be.

MR. FAYE: There's another question.

DR. BAIR: Yeah, it might be more appropriate for later on, but in terms of amount of contaminants going to the water treatment plants coming from the wells. The wells are constructed in a manner that commingles water between different aquifers?

MR. FAYE: Correct.

DR. BAIR: And I'm wondering in the Tarawa Terrace as well as the future modeling being done at Hadnot, how the quantity coming from each aquifer is apportioned relative to the total pump from the well because that makes a huge difference as to what's going to go to the water treatment plant. I mean, if you brought up 651, which was the worst well, that's open to three aquifers and there are screen blanks across two confining beds. So in terms, let's say it pumped 100 gallons a minute just for sake of discussion, did 70 percent come from one zone based on its permeability and thickness and 20 percent from another and ten from another? Because that's really going to impact what goes to the loading to the water treatment plant. So if that's in the mix, you know, I'll wait to hear it then.

MR. FAYE: Well, the concentration at the well is a concentration of the mass of the water and the mass of the contaminant from all of the contributing units. So it's a, we could break out the individual contributions from the individual aquifers, but I fail to see how useful that information that would be --

DR. BAIR: Well, you have to assign a pumping rate to each zone in the well, don't you?

MR. FAYE: ^ is the concentration ^(off microphone).

DR. BAIR: But in the flow model, the flow and transport model, if those are not apportioned properly, then you're going to get a different velocity distribution coming to one zone and another. And the velocity distribution affects the concentration.

MR. FAYE: Well, like I said, we could break out the individual contributions, but it's entirely mixed compute with the end concentration that the well delivers to the WTP, so I fail to see, yeah, we can do it just for academic purposes.

DR. BAIR: No, this is not an academic.

DR. KONIKOW: This is, you're using the models to compute the concentration coming out of the wells, and how you treat the wells in the model makes a difference is what Scott's saying. So the question is, how did you represent the pumpage in the model? Did you use the well package of ~~mod flow~~ [MODFLOW – ed.]?

MR. FAYE: I see.

DR. KONIKOW: In other words you have data that you used to estimate the monthly pumpage --

MR. FAYE: Right.

DR. KONIKOW: -- from each well. Some of that comes from the shallow system. Some comes from the deeper system. The concentration of those two units are not the same.

MR. FAYE: Where the well was in two aquifers in Tarawa Terrace which was basically what we had to deal with there was just two aquifers, I'm trying to recall. I think for the most part I just subdivided the assigned pumpage equally. I had no basis for doing it any differently.

DR. KONIKOW: What are you going to do in the new models for Holcomb Boulevard and Hadnot Point?

MR. FAYE: We would have to look at it in terms of the, like the Trans-Pacific [transmissivity -ed.]and American [word incorrect, correct word unknown -ed.] are different units, and try to apportion it as appropriately as we can. I, frankly, haven't thought about it a whole lot.

DR. KONIKOW: Because this, as Scott says and I agree with Scott, this could make a big difference in how you, how much pumpage you --

MR. FAYE: I agree if contaminant is isolated to one unit, and that unit is poorly pumped or vigorously pumped obviously, yeah, it's going to make a big difference. I agree.

DR. KONIKOW: Have you thought of using the multi-node well ~~passage~~ [package -ed.] because that will do a lot of that automatically for you.

MR. FAYE: Yeah, we have thought of that, and I think that's registered somewhere in the text there.

DR. GOVINDARAJU: Well, I just wanted to follow up on that but some of this was brought up at the discussion. Eventually, whatever the model does, what is ^ established in the well. So in the well water when it comes in from whichever aquifer, it gets mixed up. So the measured concentration is always a particularly average value.

MR. MASLIA: But basically, we've hit on Tarawa Terrace back and forth, which is fine. I thought I would just get back to the expert panel, the previous expert panel's, most people here were on there, and go over. There were five generalized recommendations. Some had sub-recommendations obviously for obtaining the groundwater modeling and sub-recommendations of doing sensitivity analyses, and dispersion fate and transport and so on.

But what I put together is just a table in Chapter A, which I believe was sent to you and it's on line and all that where we applied the recommendation and wrote the report in the manner so that anyone could pull, go to the expert panel report and see what the recommendation was and find a section in the report. If anyone wants a hard copy of this table, I could make that available.

But that's basically the approach, and hopefully, the approach coming out of this meeting is we'll have similar recommendations. When I say similar, probably more, but of that type that we can go down, and then the agency will implement as needed appropriately.

I thought I'd summarize the Tarawa Terrace -- and feel free to ask more detailed questions -- but in three major categories that the Agency feels that we achieved. And one was the understanding that the calibrated models for Tarawa Terrace are useful for the epidemiological study. Second, the concentrations that were measured in the 1980s, represent the high concentrations. There are no higher concentrations based on data and that was experienced over many years.

And finally, that using the models we would not be able to conclude when the contaminated water reached certain values, such as arriving at the MCL, arriving at the water treatment plant and water concentrations people were exposed to on a monthly basis for use with the epidemiological study.

DR. HILL: I agree with this, but one thing I've thought about is the fact that the concentrations are not higher in previous years. Isn't that partly because of how the source is represented in the model? And are there situations such as high recharge events or something, was it ever investigated as to whether there might be circumstances that weren't represented explicitly in the model because it's an averaged, kind of a long-term thing but that might be more smaller scale events that could increase concentration?

MR. MASLIA: We did assume for the deterministic approach that we had a concentration. I believe it was 1,200 --

MR. FAYE: Mass loading ranges.

MR. MASLIA: -- mass loading ranges --

MR. FAYE: -- concentration varied over time.

MR. MASLIA: -- yeah, mass loading range was

1,200 --

MR. FAYE: But to address Mary's question I think, yeah, they have ^ [massive -ed.] hurricanes there so you would get a dilution for a short period of time, but on the flip side, you get droughts that would increase concentrations for a relatively short period of time. So I don't know that we ever tried to address those kinds of cause and effect relationships in any of our modeling.

DR. HILL: And the one I was thinking of was that hurricanes might produce greater transfer of contaminants from the unsaturated zone into the saturated zone and which might show a ^ [relationship -ed.] of such.

MR. MASLIA: We did not address events such as those.

MR. FAYE: There was no continuous data to see if there were pulses or anything like that. We just didn't have that.

DR. HILL: I understand.

DR. KONIKOW: Just to follow up on that. Those high, rare, let's say, uncommon high recharge events might not lead to dilution, might actually lead to peak concentrations because it would have the opposite effect of what you would want. Because some of the contaminant is hung up as a separate phase in some of it, and so the faster it flowed through a water during high recharge events could dissolve a lot more, just bring a lot more solute.

Because one of the things that I noticed in the analysis of it is that the problem with mass loading rate is when you match that with the fluid recharge rate that you use, you wind up with source concentrations in the liquid phase that would be perhaps ten times above the solubility limit. So there's an inconsistency there the way the contaminant is loaded into the model at least by using the mass loading. Or maybe that's too much detail.

DR. CLARK: ~~Over here~~ [Dr. Bair. -ed.].

DR. BAIR: Yes, I was going to ask if in the future model you're going to put together that's transient, would there be spatial and temporal changes in recharge that can account for droughts and flood events and was that used in the Tarawa Terrace model, transient recharge, accounting for droughts?

MR. FAYE: We varied recharge only on an annual basis. That was our estimate. But to determine -- and we couldn't compute monthly hydrologic budgets. We just did not have raw data or examine the transporation date or anything like that. But what we did do was, we computed what we call a quasi or a gross hydrologic budget on a monthly basis for the period of interest using the climatological data that we had.

For example, we had pan evaporation data. We had rainfall data. So to estimate a month, this was an experiment just to test the sensitivity of the model to recharge. So what we would do, we would subtract the evaporation from rainfall and the difference we would assign as effective recharge. If it was negative, we would say recharge was zero for that month. Then we ran the model for all 528 stress periods with an array like that.

And then we compared the end-of-year changes in water levels using that approach versus the approach that was used in the calibrated model. And we found, and we did that in the western part of the domain where there was very little or no influence of pumping so it would be just a natural ~~relationships~~ [relationship -ed.]. And we found that there was very little difference in the year-to-year changes using one method versus the other. And that's described in Chapter C in detail, the whole approach.

DR. BAIR: Did you look at changes in velocities? Because there's a difference between focusing on water level changes during that and looking at velocities during that. And it's the velocities that are going to drive the contaminants whether they slow up during a drought, but during a drought you're probably pumping more water, groundwater or during a flood or hurricane event or a really wet year.

MR. FAYE: The pumping rates didn't change using the [recharge rates -ed.]~~,~~ from the calibrated model. Pumping rates didn't change using the quasi recharge rates, and we did look at velocities throughout the model. But basically that was just an effort to find out where we possibly were violating the ^

[Courant -ed.] condition, not for the possibility you were talking about.

DR. ROSS: I've got a quick question that has to do, I guess, with recharge as well. ABC Systems or ABC Cleaners discharged via septic system. This answer may be in the documentation, but was the base plumbed on a waste water treatment system or was there a septic system associated with each house at any period of time or how did they treat their waste water?

MR. FAYE: How did ABC specifically treat --

DR. ROSS: Not ABC, but the base.

MR. FAYE: Oh, the Tarawa Terrace. That was a sewerage system. Yes, septic tanks as an issue of recharge, I don't think that that was anything to deal with.

MR. MASLIA: We're about five minutes from a break. And as I told Bob, the reason the breaks are so ^ [critical -ed.] and they might want to have one is because of the video streaming. They have pre-programmed certain breaks in. So if we can go another few minutes and take a break and then just pick up, we can continue.

But while we're talking on it, this, of course, appeared in the Chapter A report. This is from the deterministic calibration that we did at TT-26, the primary. And as you see, as we have noted, when that shut down for maintenance here, of course, the finished water concentration, the water coming from the WTP, mixed with the WTP, also dropped.

And, of course, this was the probabilistic, we had two probabilistic analyses. The blue line here represents the calibrated finished water. This is just finished water concentration that I just showed you previously.

We ran one scenario where we used the calibrated pumping schedule that Bob talked about in the calibrated model unadjusted but then assigned probability distributions to all the other parameters as noted in the Chapter I, hydraulic conductivity and infiltration and there's contaminant parameters as well and that's the yellow band from here to here.

And then the pink band we tried to assign a statistical or an uncertainty property to the pumping so that it varied continuously, and that's detailed in the Chapter I report, Uncertainty, and that's the band, the pink band.

And I suppose what we observed is that the data, the measured data that we have, which obviously is in the late '80s, did fall in the confidence bands and was in the, for the water treatment plant, was in the calibration target, so I'm sure we'll talk a lot about calibration targets. There've been some good discussions in the pre-meeting notes about that.

But what I'd like to do --

And, Barbara, if you can get, I think it's the third or fourth poster. What I did I took this to the water treatment plant for both scenarios. And rather than calibration targets, I plotted it in terms of the 95 percent of the Monte Carlo simulations. So that's your confidence, the pink line going down there.

That's all the data that we have. This is all the data that's above non-detect. All these are detect measurements below detection limit either indicated as nondetects with no symbol or in this case for example, we've got a below detection limit with a value of I think about six micrograms per liter.

And here the actual measured data -- well, that's the 95 percent of the Monte Carlo simulation for those particular runs with scenario one where pumping was not varied from the calibrated and scenario two where pumping was varied from calibrated value assigned a statistical value properties.

MR. HARDING: Morris, if you could go back.

MR. MASLIA: Okay, let me back up here.

MR. HARDING: I just want to give you an impression. And my impression in looking at this was these seem too narrow. I would expect to see a lot more uncertainty. That's just, I want to give you my impression. I have some specific questions related to the sensitivity analyses, and they're things we can talk about later, but just...

DR. HILL: Mary Hill. They do look a little more reasonable on an ~~arid landscape~~ [arithmetic scale - ed.].

MR. HARDING: Yeah, but looking at just the arrival times, for example, very narrow.

DR. KONIKOW: Well, I think these are confidence bands assessed with a given conceptual model, with a given numerical model to look at the effects of uncertainty in just a few selected parameters. I agree. They're way too narrow in terms of what real uncertainty is.

DR. CLARK: I'm going to use my prerogative here as Chairman to say that we're going to take a break.

(Whereupon, a break was taken between 10:15 a.m. and 10:30 a.m.)

MR. MASLIA: Y'all get an A-plus for using a microphone except the people in the audience, the court reporter cannot hear you sometimes. So wait until you get the mike in your hand before speaking.

Bob, are we ready to begin?

DR. CLARK: Let's roll.

MR. MASLIA: We'll pick up where we left off, and I think just two comments I got cleared up. I guess the first one is there appeared to be some confusion about the valve and the booster pump. Let me bring the slide up. The booster pump is right here. That's the 700-gallon-per-minute or 300-gallon-per-minute pump that I said was noted in the logs. And it ran intermittently April, May or June. And Jason will also have some information on that when he makes his presentation from hourly information.

The shut-off valve, and I believe we refer so there's less confusion, as Marston Pavilion that's close to Wallace Creek 'cause this is all Wallace Creek. And that's where they had to actually go in by hand -- if you can travel the bridge here, you'll see it's down below -- and actually open it up by hand. So there are two different hydraulic devices so to speak. And that's where Joel said he did not remember opening it up once.

I think we've seen -- correct me -- once or twice in the logbooks, Jason, that they said they opened up the valve?

MR. SAUTNER: It really depends if you want to count the period in January to February of '85. It was open for a nine- or ten-day period there. Besides that it was opened maybe five times between 1978 and 1986.

MR. MASLIA: So just wanted to make sure we were all, understood that if there was any confusion. And then during the discussion as to apportioning over at Tarawa Terrace where wells may have been open to different zones at Tarawa Terrace as Bob Faye pointed out, were only open to two aquifers, and ~~tran-posivities~~ [transmissivities -ed.] were approximately the same for each. Obviously, that will be different for Hadnot Point. That will be taken into account. We do have the multi-node well package to use.

And then finally, Lenny, for my own edification, when we get here to make it clear that we did use the same conceptual model in running the two uncertainty analyses. In other words we did not change the conceptual model or change boundary conditions or anything of that nature or change how the contaminant source was applied to the model, a constant source versus a injection-type source. Just wanted to clarify, just make sure. I think that was Lenny's point.

HADNOT POINT/HOLCOMB BOULEVARD PRESENTATIONS AND PANEL DISCUSSION

So we will continue on over at Hadnot

Point. I'm, again, very briefly just going to show where we currently are from a project standpoint, and then we have follow-up presentations and discussions.

We're basically 95 percent complete with data analyses, the data that we have. That was the data that was presented in the notebook.

We're not 95 percent complete?

MR. FAYE: Yeah, for the IRP sites.

MR. MASLIA: Good, that's what I'm reporting on.

MR. FAYE: Good, say the IRP sites.

MR. MASLIA: The IRP sites.

DR. GRAYMAN: What are IRP and what are UST?

MR. MASLIA: The UST are underground storage tanks.

DR. GRAYMAN: And the IRP?

MR. MASLIA: IRP are the --

MR. FAYE: Installation Restoration Program sites and that terminology may not be exactly correct. Perhaps the folks from Camp Lejeune or the Navy can clarify that. But just for our own purposes of organization, that's how we've subdivided up the general data that we find.

MR. MASLIA: The data report, again, the draft is what we provided you. When I say 95 percent complete, it's not going through review or anything like that, but in terms of compiling the tables, things like that, state properties, statistical analyses 95 percent complete.

Groundwater flow and transport modeling, obviously, we have not gone very far on there for a number of reasons. One is we want feedback from this panel. We have to provide you with some guidance as to the direction we were heading, and we tried to do that, but not yet commit a whole lot of time and resource.

Number one, we needed the data analyses to be complete. And then also, again, obviously, we need input from this panel. And the water distribution system modeling, we do have calibrated all pipes modeled for both Hadnot Point and Holcomb Boulevard that is based on field work that we did in 2004.

We conducted some initial simulations,

what were referred to as interconnection scenarios. That's where we turned that booster pump on and off, the 700-gallon-per-minute, and Jason will report on that tomorrow and that.

As Bob indicated, this refers to the IRP sites. We have since March, we know we have at least 100 more reports containing some form of information, and we can discuss that. We have a session on the second day to deal specifically with the concept of, I guess, more information. You have an expanding universe or a universe with no bounds with information. Some of it's usable; some of it's not.

And the question is, is where do you put the bounds on that to complete, as Dr. Sinks said, to complete the study in some amount of time frame. Perhaps there's an opportunity to use the data from here, what data is there as a second set of data, calibrate or get some initial estimates from a model, and then test it against the second set of information.

This is an opportunity we did not have

at Tarawa Terrace, so that may lend itself to addressing some of the issues as far as testing the model against a second set of information. And we have allotted some time tomorrow, but we can obviously discuss it now.

DR. BAIR: Hi, Morris, with respect to the data you have here, this doesn't include the well packets. The three-ring notebook makes a point of showing, I think it's an example of Well 663, HP-663?

MR. MASLIA: No, I know what you're talking about. We received ten years of, the most recent ten years of, we refer to them as well packets. Those are handwritten notes that have been scanned in. And we are, this summer I've got a --

DR. BAIR: Intern.

MR. MASLIA: Yeah, with the last name of Maslia that's not busy for a month or two during the summer who will be putting them in into Excel. We've got the Excel templates set up and they go from '98 to 2008.

DR. BAIR: I mean, one of the things I was scrambling to find in all the information and on the CD was the depth of the well screens, the length of the well screens, the pumping rates of the well. Is there a central database that has that in it? That shows what formation each screen is in? the diameter? the length?

MR. FAYE: Well, I guess you just didn't scramble enough because there's definitely a lengthy table in the, on the CD. I don't know whether it was printed out in hard copy or not, but was it Table 5 that gives a complete description of the well, the well construction, the contributing aquifers, land surface elevation, the names, the a/k/a names. I think it's a fairly complete listing of the supply wells, the irrigation wells at Camp Lejeune.

DR. BAIR: I found that. What I couldn't find to tie into that was the pumping rate of that well or the pump capacity.

MR. FAYE: That's the capacity history information and that is in a separate package. I'm not sure if that was on the CD or not. But all the well screens and the other parameters that you mentioned were in that table.

MR. MASLIA: We can provide, as a member of the expert panel, a draft copy of that for you if that assists you with doing that.

DR. BAIR: I mean, so one of the questions I have, and I guess I'm just lumping it under data analysis, is there was, taking HP-651 as an example, they in another part listed a sampling depth in that well as minus 98 feet, and then listed TCE concentrations of 3,200, 17,006, 18,009. Was that a packed off interval so it just measured the UCHRBU unit or was that a vertically integrated sample?

MR. FAYE: No, all the samples were vertically integrated. I'm not sure where you -- we'll have to talk about that. That minus 98, that intrigues me. I'm not sure where that came from.

DR. BAIR: It's the middle of the upper screen of the three screens so it gets back to my comments about this vertical mixing and assigning appropriate pumping rates to each one of those in the model, but we can come back.

MR. MASLIA: Dave.

DR. DOUGHERTY: The one thing that was missing in the well construction table, which is C-3, are the details of it. Is it sand pack all the way up? Are there ~~detnite*~~ [bentonite -ed.] seals or a similar type of seals at certain depths? Or are these just conduits from shallow depth to the screens?

The other related thing was the cross-sections that were shown in the same Chapter C from the IRP investigations show much shallower depths than the screens. Are we going to see some information that shows additional geology for particularly the 651 area? That was the one that caught my attention.

MR. FAYE: Of the approximately 100 supply wells, I would say upwards of 90 percent of those we probably have the detailed construction information that you're talking about in terms of the gravel packing, the sand packing intervals, depth to ground, stub index, the whole thing.

We have that information. It was just a matter of, in terms of creating a table picking the, what I thought was the most salient information and including that. We can generate all of that information. That's not an issue at all. And if it turns out that that's critical, we can just add another table to include.

DR. DOUGHERTY: But the ~~ground~~ [grout -ed.] interval I think is a significant one because that [^ - ed.transmission zone, if you will, we don't know whether they're isolated by zones or if there's connectivity --

MR. FAYE: Almost all of those wells are constructed in terms of transecting the individual confined units. If they're deep enough, they're probably gravel packed across the confining unit. The confining unit is breached, and they're gravel packed across that or sand packed.

DR. DOUGHERTY: And the grouting was this ~~official~~ [surficial -ed.] --

MR. FAYE: Yes, this just on the supply wells, typical 30 feet, 50 feet, whatever.

DR. DOUGHERTY: So they are open, basically, gravel tubes all the way from 30 to 50 feet of depth down to the bottom of the hole?

MR. FAYE: That's right, and even at Tarawa Terrace, I think there were two wells, two of the older wells, where the bore hole was actually drilled substantially deeper than the finished well. And they filled the bore hole with pea gravel, the uncompleted bore hole with pea gravel. So, yeah, there are those construction issues. Like I say, we can generate all that.

DR. DOUGHERTY: That's the one that's pertinent to this and needs to be there.

MR. MASLIA: That's not a problem. That's a good question.

I think I've just got one more slide. This is just to give you really a sense of the magnitude and I think complexity. When we compare it side-by-side to Tarawa Terrace in terms of data availability -- we'll get into the model. The model is 25 times bigger -- but it's on the order of a magnitude more in terms of amount of data.

And right here I think the interesting is we've had our discussion, and as Bob has pointed out, we actually have supply well tests for Hadnot Point. We had none for Tarawa Terrace. So that just lists to give you sort of an idea of the volume of information that we've gone through thus far and gathered as well as some of the complicating issues up here with a model that large. Rene will be getting into that. And that's it.

The follow-up presentations, and actually I think we start with Bob, actually provide much more detail. If y'all want to proceed with that. I think we're just about right on schedule or I can answer some additional questions.

DR. CLARK: Morris, I have a question that has to do with the distribution system modeling the, you know, we discussed this issue of potential contamination of TTHM samples by VOCs. And it struck me that where you had that interconnection problem, where you actually had measured samples in the Holcomb Boulevard area from the Hadnot Point area, if you had comparable THM values, we could compare against those. Then you get a good comparison to see whether that relationship if valid or not.

MR. MASLIA: That's a good point. I mentioned that also if we could do that, then we could go back to the Tarawa Terrace early times where we have no VOC readings but we've got the THMs. And we see the THMs dramatically rising for a couple of years and at least give some additional confidence about that bound.

DR. CLARK: It should be possible to do that.

MR. FAYE: That might be very useful in the early parts of the period when we began actually to obtain data in the early '80s, so that might be a surrogate for that period.

DR. CLARK: And you should see the THM levels then go back down again as they take those wells offline so it would give a pretty good, it might track. It might or might not, but it might track pretty well.

MR. FAYE: The good part about that is that those data are fairly numerous, and they do span 1980 to well into the upper '80s period in time.

DR. CLARK: Well, they probably started collecting, I assume, on the base maybe about 1976? That's when the break, I think the requirements went into effect.

DR. DOUGHERTY: Nineteen eighty.

DR. CLARK: Thank you, Dave.

MR. MASLIA: That's something I think we want to go back and do not only at TT but also for Hadnot Point where, again, actual measured samples that we see are --

DR. HILL: Can I ask you a question? Are there any records, what are the records on the population of the base over the, from the '40s? How variable is that?

MR. FAYE: Table 2. Table 2 in the report.

DR. HILL: I'm sorry?

MR. FAYE: Table 2, Table 3, Table 4, something like that in the report. It gives the --

DR. HILL: The electronic table?

MR. FAYE: Yeah.

DR. HILL: Not this one. This one's --

MR. FAYE: It's one of the early tables in the, in your report there. It was probably on the CD, but it --

DR. HILL: Table 2 is Average Annual Rate of Treated Potable Water --

DR. CLARK: That's a different chapter.

MR. FAYE: No, it's in the background section. It's in the housing area where I discuss the population over, there's several intervals of time there that I discuss the population at the different base housing units.

DR. HILL: If you can't remember, we can't either.

MR. FAYE: It is the report that's in the three-ring binder. It's the Contaminant Data report.

DR. HILL: I was saying I was interested in dates, the table reference provides the resident population of the different housing areas, but I was interested in base population because some of the contaminant sources we're talking about, the activity level at those sources I would think would be proportional to base population. And in this site like the industrial area, for example, or some of the carpal areas in Tarawa Terrace, they are clean. But here there are different things that you would expect the activity level to be proportional, I would think, to base population. So just if that seems --

MR. MASLIA: Frank, was not the base

population the assumption for the epi study that was constant over most of the time?

DR. BOVE: For Tarawa Terrace we have housing records and we can make some estimates as to the population there based on that. Now, the units, we don't ^ [know the number of -ed.] people in those units. The same with Holcomb Boulevard. We know when the housing units are built, so we can do that. But the problem is main side ^ Hadnot Point. We have barracks, and we don't know how many people went in and out ^ barracks ^ [during -ed.] ~~Viet Nam~~ [Vietnam -ed.]. We do have ^ [information -ed.] from the '70s on based on computerized data, but before that we just don't know. And the barracks are --

DR. HILL: But you don't have sort of population values for --

DR. BOVE: The health assessment that we just went through has estimates of what the population ^ is today and the recent past. We don't know how many people went through those barracks during the ~~Viet Nam~~ [Vietnam -ed.] era and before.

We have computerized data -- and

Scott, correct me if I'm wrong -- We have computerized data from '71 on although from '71 to '75 we don't have their unit code so we're not sure who was at the base even then. From '75 onward we know how many people were at the base but we have family housing. So we have some information for -- we have Tarawa Terrace and Holcomb Boulevard were pretty, we can have good estimates. It's the barracks. It's the barracks that have trouble before '75.

MR. WILLIAMS: There are certain ways we can estimate it, but, no, we don't, we didn't do base ^ [census -ed.] or anything like that. There was a base master plan that came out like '87 that has 1983 data. Morris has all those where they actually did go to each water system to estimate how many people were served by that water system. It was very, they don't reveal the method they used, but you can tell by ^ [? -ed.]22,223 [? -ed.] people on this water system, and you can use that to estimate. You can say if there was this many people on these water systems and project that before '87 back to '57, you can get a crude estimate of how many people were served. And then you can assume the military persons would have had a two-year residency on average. Sometimes it was higher than that; sometimes it was lower than that. You can really get a crude estimate of the population. And that's how we came up with approximately 500,000, and that's probably conservatively high.

DR. CLARK: Let's move on at this point. I've got two more questions and then I want to move on to Bob's presentation.

DR. KONIKOW: Morris, on your last slide, on the availability of data I have two comments and/or questions or one comment and one question. One is that you're showing there's a lot more data available for the Hadnot Point area.

MR. MASLIA: We've got a hundred ~~USD~~ [UST - ed.] reports.

DR. KONIKOW: Well, you show there's more wells, more water levels.

MR. MASLIA: Oh, yes, yes.

DR. KONIKOW: So in terms of the, let's say, practicality of doing the detailed, deterministic models, I wanted to point out that if you look at the density of the data, it's actually much better in the Tarawa Terrace. It's about 105 wells per square mile in that area. Whereas, if you go to the Hadnot Point, it's only about 17 wells per square mile. So even though there's more data, it's more spread out, and that just makes it much more difficult to do the modeling and get the resolution that you need.

MR. MASLIA: Are you speaking from a deterministic standpoint?

DR. KONIKOW: From the deterministic groundwater model.

MR. MASLIA: Right, we'll address that. Rene will, but I would say probably 90-to-95 percent before we made up our minds to go with ^.

DR. KONIKOW: The other comment I have is that you're showing quite a few well tests, pump tests in the Hadnot Point area, and I'm assuming that these give estimates of transmissivity or something that correlates with transmissivity. And yet in the model, at least in the first steady state model, you're assuming each aquifer is homogeneous.

Can these data and all these tests be used to look at spatial variations in transmissvity and try to incorporate that information into the model to get better resolution and better matches on the head distributions?

MR. MASLIA: Yes.

MR. FAYE: Do you want me to answer that?

MR. MASLIA: Yes, go right ahead.

MR. FAYE: Yes, but the vast majority of those aquifer tests, Lenny, are for the Brewster Boulevard aquifer. So, yeah, which was obviously the, that's the aquifer that receives the contamination. So for that particular layer, probably for the layer representing layers, the layer representing the Tarawa Terrace aquifer, there may be enough data out there to provide some kind of gross detail resolution of the hydraulic characteristics.

DR. KONIKOW: Are you planning to do that?

MR. FAYE: Yeah.

DR. CLARK: One more question right here.

DR. ROSS: This relates to, I guess, variability in source streams. Perhaps it also relates to population changes over time. I expect during the ramp up to the ~~Viet Nam~~ [Vietnam -ed.] War there'd be more Marines passing through the base; therefore, ABC Cleaners would be cranking through probably more than two or three drums of perc [perchlorothylene or PCE-ed.] per month. Was there any consideration about that?

MR. FAYE: That doesn't seem to be the case. I mean, that was specifically addressed in the interrogatories during the interviews of the family and the owners. They had hands-on. I mean, that was their business. And you have to remember, too, now that there was a laundry, a major laundry, at the base itself. So they were possibly or probably dividing up the available work between them. So, but Mr. Metts was very specific, and he was asked that question specifically, and it was two-to-three 55-gallon drums of perc every month.

DR. ROSS: Did the base want them to use perc and what did they do with that?

MR. FAYE: They used barsaf* [Varsol -ed.] up to the early 1970s and then they used perc. And we do not have any records of their rate of use. At least we don't at the present time.

MR. PARTAIN: ^ [Where is the base laundry? -ed.] (off microphone).

MR. FAYE: Site 88, Building 25.

MR. PARTAIN: And there is a PCE ^ [plume -ed.] there.

MR. FAYE: Yeah, oh, big time plume.

DATA ANALYSES -- GROUNDWATER

DATA SUMMARY AND AVAILABILITY

My name's Robert Faye. I work for the Eastern Research Group and I support the Camp Lejeune Project here. For the Hadnot Point and vicinity project my basic responsibilities have been locating data, recognizing data that will be useful to the project, processing that data, creating databases, writing one of the reports that was in the three-ring binder there that you all received, The Soil and Groundwater Contamination Report. I apologize it wasn't completed, but it was 95 percent completed and there's only so many hours in a day.

This is a summary of available pumpage data that we have, daily operation schedules for Hadnot Point WTP individual supply wells.

We have daily operation schedules from November 28th, 1984, to February 4th, '85. Scott alluded to those data earlier when we were talking about the BTEX spill at Holcomb Boulevard.

As far as our corresponding pumping rates for both the Hadnot Point and the Holcomb Boulevard WTP individual supply wells, we have that data for a several month period here, from October of '88 to March of '89. Total gallons pumped, average pumping rate, average daily withdrawal and percent of time inactive for HP and HB WTP. The supply wells 1993, we have that data from that year. And as Morris was alluding to earlier, we have daily logs for wells pumped indicating operational status on and off for individual supply wells at both Hadnot Point and Holcomb Boulevard from January 1998 to June of 2000.

And these data to a large degree will allow us to address a number of the questions in terms of accommodating actual well operation scheduling in the HP/HB model that we're contemplating that you folks are commenting on here today. Peter Pommerenk in his notes address those issues in good detail, and I think these data will allow us to accommodate a lot of that, a lot of his concerns.

These are data that we have relative to either supply of water, water delivered or both for the WTPs. The first two lines there, Annual Delivery Rates, those are tables in the three-ring binder and the Soil and Groundwater Contamination Report that I wrote in Tables 3 and 4. I can't remember the names now, but they're all listed in there. Delivery rates from Hadnot Point, '42 to '98; Holcomb Boulevard, '75 to '98.

And then we have monthly rates of well water supplied or and/or treated by the WTPs, September '55-January '57. January '80 to December of '84, we have some overlap here; January of '82 to December of '93; January of '87 -- and these data do not all agree for the same months so we have to reconcile that.

And then we actually have daily rates of well water supply treated by the WTPs for this period, January '95 to May '99; January 2000 to December 2005. So you can see we have, at least as far as an annual situation, we're in pretty good shape. And through the whole period of interest that we would want to accommodate. And as far as the monthly rates not too bad either. And daily rates strictly for more modern times.

DR. KONIKOW: Bob, on the previous slide I'm still not sure. In your model you probably are going to go with a monthly stress period, right?

MR. FAYE: Yeah.

DR. KONIKOW: But with this kind of annual data how are you going to reconstruct monthly withdrawals from the wells to plug into the model?

MR. FAYE: Well, we actually have monthly rates of, we actually have several periods of time here, Lenny, where we have hours pumped, corresponding pumping rates --

DR. KONIKOW: That's all pretty recent. What about prior to 1984?

MR. FAYE: We'll probably use the same approach we did there in Tarawa Terrace where we apportioned a monthly rate according to the percentage of total well capacity. And that's exactly what we did at Tarawa Terrace.

The objective there, as it should be here, is to remove a specified volume of water from the system. So in that case the actual capacity, the actual pumping rate becomes just a surrogate for apportioning based on a total percentage basis. But we can also, using these data, address a lot of the operational concerns and interests that several folks have addressed in your notes including Peter, who really got into it in detail.

We can actually run tests and change our stress periods to 12 hours and run for specified periods of time where we actually have data to allow us to do that, to tell us to do that, and check the differences in water levels over a month to see what those effects would be. And by extension also into the fate and transport models, see how it affects the simulated concentrations.

DR. GRAYMAN: But if you go to the next slide, I mean, it looks like there's that 23-year period where you have absolutely nothing finer than annual, and that's the major era, major period.

MR. FAYE: Yes, and that was similar to the same situation we had at Tarawa Terrace. We didn't really pick up on monthly WTP deliveries or supply water until 1975, I believe. So we went from '52, '53 to '75. And what we did, we took like a ten-year period where we had, where we actually had those data, took an average, and then assigned that as a monthly rate back in time. We considered that was the best average that we had.

DR. GRAYMAN: Was there, I mean, to go back to Mary's question if there was any kind of a population or census data at least you could use that as a surrogate for water --

MR. FAYE: Well, we did. We, in an anecdotal way we did because it was Tarawa Terrace. There was a finite number of houses, and we understood that that housing was full almost all the time. There was a demand for that housing almost all the time for our period of interest. And it was subdivided into two bedroom, four bedroom, whatever they were, and that was a consistent thing for the period of time.

DR. DOUGHERTY: So one way of apportioning the stress is based on their portion of the capacity, but is there a portion of the record that's sufficient where you could look at the behavior of the operators in terms of how they operated the system rather than how the well screens had the capacity and use that as a surrogate rather than --

MR. FAYE: Yes, as Peter pointed out most of these wells were probably operated, well, he says 12-to-16 hours a day, which is fine. We can simulate that kind of a condition, not for our whole 1942-to-2005 period of interest or anything like that. But once we have a model that we have confidence in in terms of close calibration, quasi calibration, however you want to term, however you want to categorize it, we can run then these tests.

We actually have data that can assist us in understanding how the system was working operationally for individual wells. We can run specific wells for specific periods of time based on the data that we do have. We can turn other wells on, turn other wells off, that kind of thing, and actually test on an end-of-month basis how it affects, what differences there would be just using a monthly stress period or a 12-hour stress period, et cetera, et cetera. And that's fully reasonable, and we intend to do that.

DR. GRAYMAN: Bob, could you put up a figure if you have it, a figure of what the annual delivery rates were over those periods? Is there one?

MR. FAYE: I'm sorry, Walter, there is not, but there is in the -- I keep alluding to that report. There is a, there are two tables in that report, one for the Holcomb Boulevard plant and one for the Hadnot Point plant that shows the annual delivery rates for those periods that are up there.

DR. HILL: That's not one of the tables on the -- is it a table or a figure?

MR. FAYE: It's a table.

DR. HILL: And it's not the table on the --

MR. FAYE: It's like C-2 or C-3 or something like that.

MR. HARDING: They're Table C-2 and C-4.

MR. FAYE: Okay, there you go.

DR. HILL: A lot of years say N/A.

MR. FAYE: No, that's not true. There's only a couple years that say N/A.

DR. HILL: In the C-2 there's one, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13. And then 69 and 70.

DR. DOUGHERTY: You can ^ [estimate -ed.] from the neighbors unless there was some significant population change, you can ^ [estimate -ed.] because it's ^ [stable -ed.]. In the study period it's the first, before the first five years.

MR. FAYE: Okay.

MR. HARDING: If you look, it's reasonably stable and reflects the change that was made in, what was it, 1972, when Holcomb Boulevard came on line.

MR. FAYE: That's right.

MR. HARDING: If you take that into account it's really fairly stable.

DR. BAIR: And I think the first two years of Holcomb Boulevard we don't have any of that.

MR. HARDING: Just as a placeholder because it's way more important -- well, maybe I shouldn't say that. I'll leave the groundwater people to say how important the allocation of pumping to the different wells is. But I think when you start looking at the concentrations in the finished water, this becomes critically important on a fairly short time frame because we have a precision that's required here, the trimester, for some of this causation or whatever the epidemiologist calls this.

I'm trying to think of it. Association, there you go. And how the operators ran these wells is going to become really important. And so I'd like to have more discussion about that when we get to the water -- I think it's appropriate in the water distribution side of this discussion.

DR. BAIR: And that in turn is dependent on how the pumping rate is apportioned to each one of the lenses or layers that the well screens are across from, which in turn, is dependent on the confining beds in between them that are all given the same value of hydraulic conductivity ^ [in feet -ed.] per day.

MR. HARDING: Well, that will be physics down in the well hole, and then above the well hole there's a guy that flips a switch that turns on a particular well. And the way they make that decision is what, once we've figured out the physics of what brings us to an average concentration at the well head, it's that flipping of the switch that's going to determine what the concentration is essentially for the most part that gets to people's homes, and that's the part I'm talking about.

DR. BAIR: It's defining the relative permeabilities in the sediments that determines which plume, whether it's at this level or this level or this level contributes what rate and what concentration to the well bore.

MR. HARDING: I understand, and the interface between the water distribution modeler and the groundwater modeler, we just refer to wellhead concentrations in the above ground part of it. So once you guys have figured out the wellhead concentrations which relates to all the physics that takes place in the bore hole, there's another question which is when did the operator turn on the well and for how long? That's my issue.

MR. FAYE: Actually, it's even more complicated than that because there's --

DR. BAIR: Mary mentioned the three significant digits on that table earlier, too.

MR. FAYE: There's a routine operation that Peter constantly refers to, and correctly so. And then there's sort of an exceptional type of operation, and that's, and one example of that is this period of time in late January and early February of 1985 when a lot of the wells that were contaminated were taken off line. All of a sudden Holcomb Boulevard couldn't be used any more.

All of the water supply to that part of the base had to come from Hadnot Point, and they just turned those wells on and let them fly. So you have -- and so you have a situation where these wells were being pumped 24 hours a day, day after day. I don't know how frequently that kind of a situation occurred, probably not a lot.

But ancillary to that situation is for whatever reason most of these supply wells end up on somewhat removed from the center of mass of the plumes that were recognized in the middle '80s, middle '90s, whatever at a lot of these sites. So what happens is if you turn the well on for 12 hours and sample it, you'll get one concentration of a contaminant. If you turn the well on for 24 hours for eight days and sample it, you've moved a lot more of that mass from the center, mass of contaminant from the center of the plume toward the well, and you'll get a much higher concentration.

And, indeed, we see that in the data, and that's exactly what happens. So there's a matter of routine operation, and then there's a matter of exceptional operation so that adds another level of complexity to the argument.

DR. POMMERENK: I want to chime in on this. Just like you said, it makes a big difference for the contaminant movement of whether you operate a well like for a month continuously at a reduced flow rate or whether you operate it at a designed rate for 12 hours a day.

MR. FAYE: Right.

DR. POMMERENK: I think that the uncertainty associated with this needs to be worked out somehow and ^ [reflected in -ed.] the results.

MR. FAYE: Well, we have probably, what, two or three individual cases where we can actually test, use the model at some point when we have confidence in the calibration. At some point we can actually test that against actual field data for several wells which will give us some insight how the model's actually responding to that kind of condition. Right now that kind of a test and maybe some hypothetical tests would be perfectly feasible as far as I'm concerned.

DR. POMMERENK: I think at this point, I think in the near future you would have to develop at least some, a pilot study to just demonstrate what the potential uncertainties are, you know, operating in an idealized fashion versus what I perceive is more the realistic way of things, how things were done.

Another complicating factor is, of course, the fact that the total well capacity ^ [of the -ed.] well fields exceeded the required capacity for water demands that were at times 100 percent or even larger. So there were many more wells available than needed for day-to-day average operation. In fact, the State of North Carolina currently requires your water demand can be met with 12 hours of pumping, and I don't know how far back this regulation goes.

But so the result of this is that the operator has twice as many wells available as actually needed. So given the right permutation for those times, we don't know which wells were actually being used to meet the demands introducing additional uncertainty. Because you could have, you know, on any random day or even if you go into further larger periods, a set of wells that were less contaminated than in other weeks a set of wells was used that were more contaminated. So I don't know how you're going to address this kind of uncertainty.

MR. FAYE: I think we can get a large handle, our arms around that issue, not perhaps easily, but I think we have the information to do that, Peter, right here with this set of data. We have actually daily operations on and off for dozens and dozens of the supply wells that were active at this time during January '98 to ^ [2008 for -ed.] ten years. So there's a lot of statistical inferences in terms of operations. This 10,000 pages of data so that we can, there's a lot of statistical inferences that we can glean from that data.

And the good thing about this in addition, is that a lot of the wells that were active at this time replaced previously active wells going back 20, 25 years. So the inferences that we glean from this set of information, we can actually extend back in time to the early '70s, perhaps even late '60s and then maybe even beyond that if it turns out that there's some degree of consistency that we find to the way wells were operated back in the '50s or whatever with the other data that we have. So I think we can get our arms around that anyway from about 1970 up to the present time without a whole lot of trouble. I shouldn't say that. We can get our arms around that. It'll be a pain in the rear, but we'll get our arms around it.

DR. KONIKOW: Can you briefly describe how the well capacity data were derived? In other words you, basically, you assumed that the pumping rate was the well capacity information. And what I remember from one of the tables is that for an individual well for month to month it looked like the indicated well capacity could vary 20, 25 percent.

MR. FAYE: Yeah, and particularly over time because these wells, well, some of these wells were used for three and four decades. Now they were periodically reconditioned and whatever, you know, pumps repaired, bearings replaced, et cetera, et cetera, of course. But you do have a deterioration in, expected deterioration in the well capacity over a period of time.

And we have a lot of data indicating what that is. What that deterioration was and then as some operational thing occurred, what pump replaced, whatever, and the capacity goes up. To answer your question more specifically with respect to the well capacity test, typically, what you and I would call these tests would be a crude step drawdown test.

And basically they vary the head that the well is pumping against by discharge and check that pressure just to make sure that the well can meet its expected operational ranges. And that's essentially what they are.

They're step drawdown tests, and then typically, after the test there'll be a little note at the bottom of the test page that'll say left pressure at 100 psi or whatever it is. And that 100 psi then refers directly to a discharge that was used during the test, and that's the discharge that would show up in the Capacity Use Table that you're referring to at a particular, you know, October of 1978 or whatever it happened to be.

DR. DOUGHERTY: Just to go back to the operational uncertainty and how to reconstruct that, there's a marked change in data density in '98. And I assume a bunch of sensors went into the system. Was there a change in the operations going through a programmable controller or anything at that point which would suggest a difference in operation prior to those data?

MR. FAYE: I don't think so. They've been using a SCADA system over there for many years for better or for worse, but I don't know of anything that demark -- delimited 1998 in particular as an effort.

DR. CLARK: We're going to have to move on. We've got a lot of other material to present, so...

MR. MASLIA: Bob, can I just answer that?

DR. CLARK: Okay.

MR. MASLIA: The reason there appears, I say there appears to be more data density is because after ten years or ten years worth of records, the records are destroyed. So in other words '98 to 2008 represents the most recent ten years of records that are kept.

MR. WILLIAMS: The State of North Carolina requires you to maintain ten years of the data, and so I don't know that they're necessarily destroyed. They're just not kept after, when it turns into the eleventh year. So that's why we have --

MR. FAYE: That's your answer. Is that good? Okay, let's go on.

This is the slide that Morris stole from me, and I'll try to make him regret that. He's wrong here in terms of the slide, and where supply well tests at Tarawa Terrace.

And, Lenny, most of these were just exactly what I was talking about. These represent those step drawdown efforts that were made during the capacity use tests.

Let's see, what else do we have? Well, this is just, as Morris pointed out, this points out the great difference in the numbers of data that are available in this study. And as we just briefly discussed earlier, this represents what we call IRP data. This slide sort of resembles a credit card application. There's little, fine print down here talking about these LUST reports that have just recently come to light.

Timing was good on that because we were just about finishing up the IRP data. We couldn't have dealt with any more data if we tried. But anyway these represent the numbers of data that we have for the Hadnot Point and Vicinity Study.

And, Lenny, I would quibble a little bit with your density numbers. What you should really do is pick out two or four square mile areas where we have data, where the data actually occur at Hadnot Point, and you'll see tremendous differences in density in the areas that count. And I'll talk about that in a minute relative to Tarawa Terrace.

DR. BAIR: Bob, could you keep that on for just a second?

MR. FAYE: Sure.

DR. BAIR: Thank you. You mentioned that most of the 69 supply wells and 132 pump and aquifer tests are really these step drawdown-type tests?

MR. FAYE: No, not for these.

DR. BAIR: Not for the 132?

MR. FAYE: No, those probably represent completion tests by [the driller -ed.]^. It would still be, to a large degree they would still be step drawdown tests, but they would be a lot more detailed than a capacity use test.

DR. BAIR: So my question is are there or how many tests are there that are a bona fide aquifer test where you have an observation well, and we can extract from it a horizontal hydraulic conductivity from a specific zone, a ratio, perhaps an antisotropy within that zone so that it gives you some guidance for what to use as hydraulic conductivity distributions at each one of the layers. And where did you get values for the confining beds? Are those part of that set, too?

MR. FAYE: No, no, these would all be the permeable units. These would all be what we would call the aquifer layers in the model, virtually no data. We have a little bit of data at one site at Tarawa Terrace that we could refer possibly to, a confining unit, and I think that was like a half a foot per day or something like that horizontal.

But let me see. As far as the supply wells, you can forget antisotropy. Maybe ten percent of those had a single observation well so you can compute storativity from that, maybe ten percent of those. Now, the monitor well tests are a lot different. There are multiple, multiple observation wells for the most part, but the pumping rates are so low because it's contaminated water, and they're trying to deal with it as a disposal issue.

So the pumping rates are so low that the best information you can get from most of the monitor well data would be like a distance drawdown [curve -ed.]^. You don't get a lot of intervening time result at the observation wells.

Now, to flip that around there's probably several sites, I would say two or three where I was actually able to apply ~~a~~ ^[aquifer-test ed.] analyses, and actually compute a leakage for the intervening confining units. Also, there's quite a bit, in the supply wells there's a fair number of analyses that would lend themselves to like a Cooper-Jacob analyses, so it wouldn't be strictly a step drawdown.

DR. BAIR: Are those values, the variants there, put into the steady state model? Or is it still kind of a layered system with uniform values going across all the layers?

MR. FAYE: I didn't construct, I wasn't directly involved in the steady state model. Rene is going to address that. But I do believe that he interpolated the point data to the layer for that domain. The confining units are a whole 'nother story. They're sort of an arbitrary assignment right now. And one-tenth of the standard kind of heuristic type approach and one-tenth of the permeable unit value. But I think that'll be refined later on.

DR. BAIR: I'm feeling really confident about those three significant digits the more we talk. It's getting --

MR. FAYE: All right, I'm glad of that.

DR. BAIR: How about slug tests? Did they do slug tests in any well?

MR. FAYE: Ton, tons of slug tests. And --

DR. BAIR: Have those been processed?

MR. FAYE: -- here, you can see.

DR. BAIR: Sixty slug tests.

MR. FAYE: Sixty slug tests, yeah. We have processed those now. This probably means that there were originally somewhere between 150 and 180 slug tests.

DR. BAIR: You didn't believe?

MR. FAYE: I didn't believe them so I got it down. Sixty I can believe.

DR. BAIR: Thank you.

DR. DOUGHERTY: Bob, one quick question on the confining units. Are there data from the IRP program whether direct sampling of the fine grain materials or grain size analysis?

MR. FAYE: Lots of grain size analysis, yeah, many, many. And a lot of those were converted into a hydraulic conductivity value, but I didn't use those.

DR. DOUGHERTY: For fine grain materials --

MR. FAYE: For whatever that permeable unit happened to be.

DR. DOUGHERTY: Got it. Thank you.

MR. FAYE: But I'm very dubious of those, of that methodology, and I didn't use any of that here.

DR. HILL: You may not have used the values, but did you use the trends? Are there any trends evident?

MR. FAYE: I didn't look at trends in terms of percent fines at a particular point, percent coarse at a particular point. Haven't got to that point yet, but we can easily do that. My hunch is that on a macro scale it's probably not going to be much.

The trends are, these aquifers in terms of their hydraulic characteristics and in terms of their lithologies appear to be highly consistent until you get down to the what I call the middle Castle Hayne aquifer.

And then the lower Castle Hayne aquifer is a big jump downward in terms of the horizontal hydraulic conductivity. It's much smaller than the younger units.

DR. HILL: This is a report that I'm sure you've seen. It's the Cardinale.

MR. FAYE: Cardinale Report, yeah.

DR. HILL: One of the figures would suggest some trends. I mean, if you take out the highs and lows and kind of look at the trends so I was surprised to hear you say not.

MR. FAYE: I didn't say there weren't any trends. I'm just saying I haven't gotten to a point where I could investigate that situation yet. There may be a trend out there. I have to say though that I'm surprised that there would be based on what I know about the lithologies, but it easily could be. It could be.

DR. HILL: Well, okay, now, I'm surprised to hear you say that because one would think that there would be archaic channels that came through and that you would expect to see --

MR. FAYE: Are you saying trans-vertically or within a layer?

DR. HILL: It could be either, but I was thinking horizontally at the moment, but it could be both.

MR. FAYE: Yeah, there are, these layers, many of them have been, they were erosional surfaces. They were transgressed by streams. And then those channels were later infilled with channel sands.

But those streams from what I've seen in the Cardinale Report and from other reports that address that, these streams are not particularly large and so if you're, and so it's sort of a shot in the dark whether a particular sample was collected in an infilled channel or in a, for that particular horizon, a relatively undisturbed area. So that's just not something I can fully address in a meaningful way.

DR. CLARK: Robert, I think I'm going to have to move on.

MR. FAYE: Okay, you're the boss.

DR. CLARK: I don't know about that. I doubt that.

MR. FAYE: This, again, relates almost exclusively to the IRP sites that we talked about, and these are the sites that are addressed in the Soil and Groundwork Contamination Report that's in your three-ring binder. Again, don't ask me what tab because I don't know.

This shows basically the site names and the area of exposure based on the monitor well distributions at the particular sites.

And this is what I was talking about, Lenny. If you wanted to actually look at data density, this is what you ought to be looking at in terms of the areas of interest.

And this is what we call the landfill area, the northern part, Site 88, and the Hadnot Point Industrial Area. Those are the three major areas of groundwater contamination or at least the contamination of interest to us from the IRP sites.

This shows the density of the sampling points where we have samples for, that were analyzed for PCE, TCE and their degradation products. And that's pretty much exclusive. I mean, if they analyzed for PCE, they go through the whole enchilada of degradation products.

DR. BAIR: Excuse me, Bob. That map is showing wells, not aquifers.

MR. FAYE: Exactly.

DR. BAIR: Okay.

MR. FAYE: We'll get to the aquifer part in a minute. Bear with me.

DR. HILL: I'm sorry, also that's just PCE.

MR. FAYE: That's PCE.

DR. HILL: But there was, I thought at Building 820 in the Hadnot Boulevard area, just a little cluster on the bottom.

MR. FAYE: Right, it's right here.

DR. HILL: There was BTEX-free product there.

MR. FAYE: Just give me a chance, Mary. Give me a chance.

This is TCE, same idea. Those are the wells where we sampled for TCE. Here you go, Mary, that's where we show benzene. This is the site that Mary was talking about, 820. Of course, all of these concentrations I should have pointed out use a concentration range based on the size of the point that was used on the map.

And if Mr. Clark will bear with me

here, I'll go back and point that out. I'll point out Site 88 here, which is a site of major PCE contamination and also PCE contamination here and PCE/TCE contamination here as well as a lot of TCE contamination in the HPIA and major BTEX contamination within the HPIA as well.

This might address what you're talking about, Dr. Bair. This is our PCE concentrations, our PCE sampling points at depth along a section line -- this is very gross -- that runs basically from the New River over toward the landfill area, New River Site 88, Industrial Area West, Industrial Area East, and the landfill area. This gives you a notion of the depths that were sampled. So you're looking at, in terms of our identified aquifers and confining units, you're looking at that sampling that was actually all the way down to the middle Castle Hayne aquifer here.

DR. BAIR: Yes, I had a couple questions about that if you don't mind.

MR. FAYE: No, I don't mind at all.

DR. BAIR: Is the geology along A Prime consistent enough to draw some of the formation tops and bottoms and label that?

MR. FAYE: Oh, yeah, we actually have for each one of the units that's listed in, what, Table 14?

DR. BAIR: Yeah, that ^ [report -ed.]is really hard for me to digest.

MR. FAYE: Yeah, the data report?

DR. BAIR: It really helped me because I'm just getting used to this. If you would add some of the geology on.

MR. FAYE: Well, I apologize. We actually have contour maps of the top and the thickness of every one of those units that ^ [are in -ed.] the model.

DR. BAIR: And then the question I had is probably going to come up on this one, and I'm going to anticipate your next slide and your next slide. That is you have a lot of hits of PCE/TCE very deep.

MR. FAYE: Well, let's look at that for a second.

DR. BAIR: And does that go back to --

MR. FAYE: Those are the samples where we actually had a hit above detection limits. That's TCE at the same sites that are here, okay? And these are the places where we actually had a hit above detection limits. These are the samples.

See, you can see there's actually a fairly decent reduction from the total number of samples to the samples where we actually have a defined concentration. But the distribution with depth is pretty much the same, but these are the hit sites.

DR. BAIR: Can you go back one? I'm even more confused now. So the yellow-colored pluses and dots within the circles, those are --

MR. FAYE: The yellow crosses.

DR. BAIR: -- below your detection limit.

MR. FAYE: Those are below detection limits, right.

DR. HILL: Could we draw a distinction between reporting limit and detection limit? Because you've got a measurement at those pluses, it's just below, I mean, detection limit sort of implies that you couldn't even measure it. You have a value there.

MR. FAYE: No, that's not what it implies at all. That's the way it's reported. If you look on the tables again in -- god, I've got to repeat this a lot -- if you look on the tables again in the Soil and Contaminant report that's in your three-ring binder that I wrote, you will see that the analyses will say something like, there'll be like less than 0.5 whatever it is. Well, that 0.5 indicates the reported detection limit for that particular sample, for that particular analysis, and it means less than.

DR. DOUGHERTY: No, no, there's great variety from laboratory to laboratory on whether that means a method detection limit, a sample quantitation limit, which is a sample-adjusted method detection limit for media and interferences, or whether it's a reporting limit, which is a laboratory^ arrangement between a client and laboratory, where do I report. And the point is not to say that we know which of those it is.

MR. FAYE: Well, I do know which of those it is. I've looked at dozens of these reports, and I'm telling you that that is defined as a detection limit. Now, there is also a few quantitation limits. Now if the person who wrote the report didn't understand the distinction that you just made, then I can't address it. But those are reported as detection limits.

DR. DOUGHERTY: Are these laboratory reports or engineering reports?

MR. FAYE: They're what I would call site assessment reports written by consultants and they include the laboratory, they actually include, most of the reports actually include the raw data output from the laboratory. And that has a whole bunch of abbreviations that qualify the various concentrations and they say detection limit, and that's what I say here.

DR. BAIR: Bob, if you don't mind, I'd like to pursue this a little bit. If you were to add the geology on there, one of my questions in getting to, say, some of the yellow pluses and other things is, does that sample represent a 50-foot screen, a 20-foot screen, a ten-foot screen? Does the screen go across multiple aquifers?

And, if so, this could be telling you which are poor calibration targets for your model and which are strong calibration targets because you don't want the sample from a commingled well. You want to limit it to the shortest screens that correspond to your layering in your model.

MR. FAYE: That's right.

DR. BAIR: And then that gets back to Dave's question about the construction of the wells and whether there was grout in there or whether the ~~titecs*~~ [detects -ed.] or whatever small notations are, deep, whether that's just coming down the well bore. And I think that's critical to your setting up calibration targets.

MR. FAYE: Well, almost all of these wells that you see here that are represented, are monitor wells. I would say that the vast majority of them have a screen interval of between ten and 20 feet. That doesn't worry me a whole lot in terms of identifying a particular contributing unit except, it doesn't worry me too much for PCE because of the -- and the sampling procedures are generally well described, particularly after about 1990. So we know that they evacuated five casing volumes et cetera, et cetera, et cetera.

What it does bother me though is with the BTEX analyses because these are monitoring wells. The BTEX that's there is sitting in a, probably in that most upper cylinder, actually has ~~three-phase~~ [free phase -ed.] in a lot of cases in that upper cylinder. So rather than sampling a four- or five-foot interval, they're sampling the whole ten-foot or 15-foot interval. So, yeah, you have to qualify that somehow. I'm not sure.

Later on about 1998, 2000, they actually started to recognize that problem with BTEX, and they shortened up their screen intervals to about five feet. So those analyses are a little more reliable in terms of what was actually there.

DR. DOUGHERTY: Quick question on that. Do you know if their protocol was if they found ~~three-phase~~ [free phase -ed.] in the monitoring well, they did not sample?

MR. FAYE: No, no, what they did if they found ~~three-phase~~ [free phase -ed.], they adjusted their water level measurement and --

you know, I don't know. I know there's a --

DR. DOUGHERTY: 'Cause it may be censoring some of your data.

MR. FAYE: I think...

DR. DOUGHERTY: And at a number of sites where if they find ~~three phase~~ [free phase -ed.], they're not going to sample part five.

MR. FAYE: You know, just looking at it, they had a lot of sensitivity with respect to the water level measurement, but I believe you're right. I don't recall a lot of analyses at the sites where they actually found significant ~~three phase~~ free phase -ed.]. I think you're right. Yeah, that was part of their protocol.

MR. HARDING: So high concentrations are going to be underrepresented in some sense?

MR. FAYE: Yes, right. But the saving grace at those sites is we do know the thickness of the ~~three phase~~ [free phase -ed.] so we're in shape there.

DR. BAIR: Bob, before you move on, there's a high correlation between where you looked and where you found TCE, which isn't too surprising, but if we look at those deep occurrences there, and if you just go look at the section, it does go fairly close to two of the water supply wells there. There are ^ --

MR. FAYE: Oh, more than two.

DR. BAIR: Okay, and so the question is, maybe you can answer this, but I've thought we were talking about the monitoring wells. But the question is does the proximity to one of the supply wells lead to a --

MR. FAYE: Oh yeah. I think I addressed that in the report as well. And in particular with respect to the BTEX, which my understanding of the situation is if the BTEX is left to its own devices, it's just happy just floating up on the water table.

And when you find it 150, 200 feet in the subsurface near a relatively, in relative close proximity to a pumping well, why, you've got the vertical gradient -- now the vertical gradient's caused by that pumping. You've got advection, and that's what's forcing the BTEX way down into the subsurface.

And I do -- of course, the PCE being a ~~D-NAPL~~ [DNAPL -ed.], it wants to migrate vertically downward. But when you look at these depths, particularly in the landfill area, I think you're looking at a lot of influence from HP-651, which we talked about earlier.

DR. BAIR: And I was actually, I probably inferred it too much. If the supply wells are as Dave indicated, that you can get water moving along the outside of the annular space, and this supply well is off and 651 over there is on, you could be pulling contamination from shallow to deep through the annular borehole in one supply well going to another just because it can communicate hydraulically across that.

MR. FAYE: I think that happens and also as well -- no pun intended -- you get like 651 is right in here. I think, what is this, 653, 610. Six-ten is down here. You have these wells. They may not be pumping in a, at the same time, but they're moving that mass around at depth between each other all the time every time they're operating.

This goes back to, I think, what Peter was talking about in terms of how these operations affect the simulated concentrations that we would actually find, the actual operation 12, 16 hours a day versus some stress for a whole month, that type of thing. And we can test that.

DR. DOUGHERTY: Just a quick thing on this section since I can't put together the nearby supply wells with this cross-section.

MR. FAYE: Well, I can tell you there's a lot of supply wells here that surround the perimeter of the HPIA, and I'm saying at least a half a dozen or more that were active over time. And in the landfill area the most direct influence would have been HB-651, but there's probably three or four other wells in that general area or even immediate area that perhaps affected the vertical distribution.

DR. DOUGHERTY: Was this a cross-section showing all of those projected?

MR. FAYE: All of those what?

DR. DOUGHERTY: So all of the landfill area wells are projected onto this thing?

MR. FAYE: Yes, they are. You can see, you know, it's a gross, it's an informational slide.

DR. DOUGHERTY: That's fair once I

understand it. And again, just for information, what is the screen of these water supply wells?

MR. FAYE: HB-651 would have been and screened in at least two intervals below land surface.

DR. BAIR: I've got it right here.

MR. FAYE: Okay, there you go. I just hated to say you could look on table so-and-so.

DR. BAIR: No, I've got it. It's minus 93 to minus 103; minus 108 to minus 155 and minus 157 to minus 19 --

MR. FAYE: And those are intervals from land surface.

DR. DOUGHERTY: I have a different number from Table C-3 for 651. It's 125, 135, 140, 155 ^[, 189, 194 -ed].

MR. FAYE: In the table it's depth below land surface.

DR. BAIR: My only point was to demonstrate for others who are not so ground-watery (sic), roughly where the screens are in this cross-section tend to be 150 feet down so they're down below where we're seeing the hot spots, yet those are providing high concentration water to the treatment plants. So there's got to be some way to get from those hot spots down to there to the wellhead.

MR. FAYE: That's just the vertical gradient's caused by -- in my opinion, that's largely due to the vertical gradients caused by pumping at the supply wells and within the radius of influence of that pumping.

DR. HILL: You have five measurements at depth and of those two are hits. And if you think proportionately to what's above in terms of the proportion of hits you have two non-detects, it's actually pretty similar or perhaps a greater proportional concentration at depth. So the fact that you're not getting that many hits might just be because you didn't look. There's no indication in that data that the water in general at that stratum is any less polluted than what's above.

MR. FAYE: Well, that's exactly right. There's a lot fewer sampling points down here than there is up here, maybe by as much as a ratio of five to ten to one.

DR. HILL: Right, the ratio of hits is actually as high.

MR. FAYE: Well, yeah, okay, okay. And the obvious reason is they were looking for contamination at shallow depths, later on got kind of surprised they found it at a deeper depth, but they had a much greater density of shallow monitoring wells versus their deep monitoring wells.

DR. HILL: I just wanted to make the point that there's no indication on this data that it isn't as polluted at depth as it is --

MR. FAYE: That's exactly right. I would totally agree with that.

DR. ROSS: Were there no deep hits below the, what I call the DNAPL site, Site 88, or is the key just covering up what might be there?

MR. FAYE: I think, Dr. Ross, the key there is that there just were no deeper wells.

DR. CLARK: Can we wrap it up?

MR. FAYE: A few more to go, and that's why we're here, right? There's the PCE now. Those are the hits. Now, as Dr. Bair alluded, he anticipated what we were going to see here. You have the PCE contamination. This is every sample including the non-detects, and then here's the detects, and it shows the maximum and minimum concentrations that we found. And all of these questions that related to the previous two slides relate to this. Here's benzene.

There's the whole enchilada, and there's our hits again at depth. And here you're seeing that the HPIA where there was a massive benzene spill, a lot of surface contamination. Actually, now from the LUST reports we know that this contamination actually goes a little deeper down, around 150 feet. So there you see that.

There's our major plume systems that we've identified. Now this will change when and if we get into the LUST reports there's going to be a major plume of BTEX up here, probably another one right in here, definitely a big mess in here in the HPIA. So that will, we'll accrue a few more plumes when we look at the LUST data in detail.

Hopefully, this next slide says questions.

DR. CLARK: Jason, are you ready to go?

(no audible response)

DR. CLARK: Okay, Jason's up next.

DATA ANALYSES -- GROUNDWATER

WELL CAPACITY AND USE HISTORY

MR. SAUTNER: I'm just going to give a brief description of how we constructed the well capacity histories and I want to thank Bob ahead of time because I think a lot of the questions the panel will have ^ asked them in the ^. Louder? Okay.

Basically, just the well capacity history is essentially a timeline without lulls operated at the capacities from when they were put in service to the time when they were terminated or permanently taken out of service. Information we have for well capacity histories, we had over 100 supply wells that we were dealing with at the Hadnot Point-Holcomb Boulevard large distribution system areas.

Basically, we obtained a well packet of information for each supply well that contained driller logs, well capacity tests, well construction drawings, operation records, various other miscellaneous sources of information. We also had several other documentation sources examined.

We had well data lists, raw water supply lists, building dimension lists, operational records, water level tables, transmittal and correspondence letters, numerous CLW documents and various published reports. And on top of that we also obtained the daily logs for well pumps, which everyone's been discussing, as the 1998 through 2008 daily status of how wells were operated on or off.

This is just a figure of where the well locations are throughout both systems, throughout both areas. Now, here's an example of well capacity history. This is for HP-633. This is constructed for each of 100 or more than 100 wells basically just gives a date, capacity and operational status and a data source.

So for the date that we have, the date when it was put in service. We have the capacity at certain dates throughout when it was in service; the operational status and whether it was in service, out of service or when service was terminated, and then the data source of where that information came from.

And you can see where all these blanks are in capacities; we just simply didn't have a capacity given for that source of information. So that would be carried down in time, so that'll be carried down to the following empty block. This one here will be carried down to the bottom, too, and so forth.

The daily log for well pumps, simply just a scanned sheet for each month, for each well from 1998 through 2008. So it's a lot of information. There's I believe over 10,000 sheets. And the main two columns we're interested in are when the pump was on and when the pump was off. And as you can see for, this was just for January 1999 for HP-633, it was only on for the first seven days, and it was off the rest of the month.

And what we did was we used the ^ determine well capacity on monthly adjusted capacities. So from using these where we obtained the number of days it was operating each month along with the well capacity at certain times from the well capacity history, we created these tables.

This is just for all of 1999 so let's

focus on the first column or first row here first. This is January of '99. We know from seven days right here, add up the total number of days. We have a capacity of 205, which came from down here, the well capacity history.

From that we computed the gallons pumped per month. We know the total number of days in the month, from that we can get the adjusted capacity. So assuming that this well was pumped 31 days a month, instead of pumping at 205 gallons per minute, it would be pumping at 46.3 gallons per minute. And this could be computed for each well from 1998 all the way through 2008.

This is just an example of the number of days it was operated. The reason the time period is from '98 through 2000 is because the well was taken out of service or service was terminated in October of 2000. For several of the other wells we will have a full ten years of data on the number days that it was operated.

One thing that we're considering exploring doing is actually -- and this was discussed during Bob's presentation -- is actually taking our known number of days for a certain period of time and trying to sort historical trend back in time for a study period from '68 through '85.

There's different ways we're going to look into doing this, and we'll be using this trend, also using, we know our total average, our total annual rates from '68 through '78, '68 through '85 as well. This is a slide that Bob also showed showing you the available pumpage data. So basically, by using this '98 through 2008 daily data, we're going to try to back track and try and fill in the gaps between all these type of data time frames, taking '84 all the way back through '68.

And just to summarize it we had more than 100 supply wells. There's a lot of information to review in order to create a well capacity history for each supply well. And information for the past ten-to-15 years is more detailed than information for 50-to-60 years ago, obviously. And again, we're going to explore ways to find historical trends of how that well was pumping on a monthly basis using the detailed daily information as well as the annual information that we have.

With that I will give up to questions.

DR. GRAYMAN: Can you go back to slide number three? That variation in capacity, do you think this represents some changes in the, intrinsically in the wells or do you think there's some of that significant uncertainty between the tests?

MR. SAUTNER: I guess it would be really depending on, well, most of this information came from well capacity tests. They were fairly consistent in the way they conducted them. I'm not really sure as to what variation, what would be the cause of the variation.

DR. GRAYMAN: Without looking at the dates I mean you see a change from 221 down to 159, but that's an eight year period so that makes some sense.

MR. SAUTNER: Nineteen sixty-nine to '77.

DR. GRAYMAN: Can you go to the next slide? And there's a column over near the right where it says time checked. Do you know anything about the operation where they operated, they tend to be operated on a daily basis or was there a particular time when they checked it to see whether it was on or off?

MR. SAUTNER: I believe they -- this slide came from Camp Lejeune here -- I think they had a certain time of the day where they would send a [well -ed.]person out, and they would check the wells and report back. I'm not --

DR. GRAYMAN: When you say check, would they turn them on or off? I mean, did the wells tend to stay on for 24 hours?

MR. SAUTNER: I don't believe -- oh, yeah, that's, we did ask that question. If the pump was on, it was on one day. And if it was on the next day, it was on the complete time. So for day one to day two it was on for that whole 24 hours, yes.

MR. HARDING: I think this may, it raises this point. I know I've flogged this horse a lot, but there's a difference here between what you're going to do for the groundwater modeling and what you'll have to do for the water distribution modeling. Because while your stress period's a month in the groundwater model, the way that contaminants behave in the water distribution system during these interconnection events is going to be very dramatically affected by what pumps you assume are operating and the hourly, you know, flow rates.

In other words a pump can't run at an average of whatever it was. I can't remember the numbers but the average amount. It either runs on or it runs off. And if the contaminated well is on, it's on all the way, and then the contaminants can move out into the system during times of low demand or perversely in this situation, when the high demand comes on the golf course, that's when that interconnection opens up and that tends to have it move further in the system. So you can't use the same approach, I just want to caution, for both water distribution and groundwater modeling.

MR. SAUTNER: Right, and just to clarify, all of these supply wells pump directly to the water treatment plant. So we are going to be --

DR. GRAYMAN: They all pump directly to the treatment plant.

MR. SAUTNER: They don't pump into the system.

DR. POMMERENK: I think the wells that pump into a manifold collection system, there's a difference. They don't all pump against the same head. So depending on what combination of wells is on, the actual flow rate that is delivered by the well pump may vary as well. So it's just some added complication. I think one of the earlier figures you clearly saw that the wells had essentially streamed on a large water collection main. And depending on the size of the thing, I guess somebody would do a hydraulic calculation to see how well operation would affect the head ~~at each pump as it pumped~~ that each pump pumped -ed.] against, so just as an additional caution.

MR. HARDING: So another clarification, is there a booster pump, is there a storage tank and then a booster pump at the water treatment plant that then sets the grade line for the water distribution system?

MR. SAUTNER: Yes.

MR. HARDING: So there, and there's an unpressurized storage tank then at the water treatment plant and -- okay.

DR. KONIKOW: So if you go back to the previous slide, again, I agree. There are many sources that there are uncertainty in this, but what I want to look at here is filling in the gaps. Between your data points you had implicated that like from '69 we have 221 to 1977 we have 159. You would use a 221 the whole time.

MR. SAUTNER: Yeah, or one way to do it would be maybe to do a trend and step it down.

DR. KONIKOW: Which did you do? What are you doing or what should be done?

MR. SAUTNER: This is the information going to the generator and it hasn't been used as input.

DR. KONIKOW: So that's not in the groundwater.

MR. SAUTNER: Correct.

DR. CLARK: We have a swift comment from the audience.

MR. WILLIAMS: Yeah, I just wanted to clarify that the 24-hour pumping, which would only be indicative of the Hadnot Point wells, not at Holcomb Boulevard.

DR. CLARK: We're going to have to move on to the next presentation.

DR. GRAYMAN: Can he just clarify? Well, the Holcomb wells, how were they operated?

MR. WILLIAMS: Something less than 24 hours.

MR. SAUTNER: I think they were automatic, correct?

MR. HARDING: Did the Holcomb wells pump, did they pressurize the system or was it a similar situation where they pumped into an unpressurized storage tank and then were boosted into the --

MR. SAUTNER: It's the same situation.

DATA ANALYSES -- GROUNDWATER MASS COMPUTATIONS

DR. CLARK: Okay, Mass Computation.

MS. ANDERSON: I'm going to talk at you about the subsurface mass computation and make it very brief hopefully. This is a quick overview. I'm going to recap the site locations. I'm going to highlight some groundwater contaminant statistics and outline the purpose, scope and proposed methods for a mass computation and then finish with an illustration of a mass computation for TCE.

So you've seen this map a couple of

times already. I just wanted to recap again the IRP sites, the Installation Restoration Program sites are outlined in the dark red. The orange outline shows scenarios that we talk about a lot, Site 88, the landfill area and the Hadnot Point Industrial Area or the HPIA. That's where we're finding a lot of contamination, particularly the PCE and TCE contamination.

So I wanted to emphasize some relevant numbers for the groundwater contaminant datasets. Our available contaminant data span about 20 years from 1984 to 2004. We have over 2,400 groundwater sample analyses for PCE, TCE and their degradation products. We have over 2,600 groundwater sample analyses for benzene and related compounds.

And I've listed some maximum detected concentrations in groundwater there in micrograms per liter. Of course, the PCE level at 170,000 micrograms per liter, that's at or above the solubility limit depending on what reference you use. That detection was at Site 88 where we know there was some pre-phase product in the past.

So our primary purpose for contaminant mass computation is to provide really a starting point and a lower limit for a mass loading parameter when you do the fate transport modeling. The mass estimates will also be helpful in assessing plume stability over time, and we can look at those numbers to compare to other similar sites as well, but our primary purpose is for the mass loading parameter for the fate transport model.

For this work we're going to focus on PCE, TCE and benzene for mass computations. We're going to primarily compute the dissolved phase contaminant mass. We do have some data for some areas for the unsaturated zone and free product areas that we may address with some computation but primarily the dissolve phase contaminants. And we will be looking at multiple areas across the study site.

So this slide kind of outlines our general methodology, proposed methodology starting from the left there to select and prepare the contaminant datasets from the point data that we have. We're going to develop two-dimensional horizontal concentration grids that represent the horizontal distribution of contaminants using interpolation techniques to generate those.

And then we'll calculate the average contaminant concentration across these horizontal plumes. And finally, we'll calculate contaminant mass by combining that average contaminant concentration in a horizontal distribution with information we have about the aquifer porosity and the vertical extent of the aquifer where these contaminants occur. That's kind of a general depiction of our methodology.

DR. KONIKOW: So is the goal to estimate the mass in the system at one point in time or as an initial condition? Because contaminants are released over some long period of time. And so I'm wondering how does this relate to what you're going to put into the model?

MS. ANDERSON: Sure. I think that's part of the data exploration that we have to do. Obviously, there's a sort of a temporal distribution to the data that we have to look at and kind of slice it in different ways and look at what makes sense, and then look at those calculations and decide what makes sense to put into the model. So it's kind of a number of steps there that will be involved in the whole mass computation and then entering into the model. Maybe the next slide or two will explain that better.

DR. BAIR: I have a question, too. You're looking at aquifer thickness and the concentration in each one of the aquifers and then summing them for a grid block looking down?

MS. ANDERSON: There may be some other slides that explain that a little better, but yes, this process, I mean, essentially when we had the contaminant data -- and you saw in some of Bob's slides the vertical distribution -- obviously, when we derive horizontal representation of the distribution, we've got to look at a single aquifer and just only collect the data points for that aquifer, do an estimation, extend 3-D the calculation over that aquifer, and that would be a mass for that aquifer. Another aquifer would be a whole 'nother of that process repeated and then add --

DR. BAIR: Right, well, my question is that are you doing this just for the aquifers? Because the confining layers have mass in them, too.

MS. ANDERSON: I think, yes, that's a valid point, and we can look at --

DR. BAIR: And they are as thick as the aquifers in some places, and their porosity probably is not too different. So my question actually gets at porosity. Are you using a uniform porosity across everything?

MS. ANDERSON: Right now, the illustration I have here, I'm just talking about the porosity for one aquifer that we're looking at. But I think we do need to refine that and kind of look at different aquifers, different porosities if we have the data. Clay units, we have some data based on Site 88 investigations for porosity there.

So I think that's a valid question, and that's something -- it's really going to be data driven. Where we have the data and then what can we extrapolate from there and how can we extend that knowledge.

DR. BAIR: It also should be put into the sensitivity analysis, and that's the sensitivity of the source term and the release of the source term, the concentration and timing of the release of the source term.

MS. ANDERSON: Yeah, and I think as we explore the data and kind of do some of those vertical plots that Bob has shown in his presentation, we can get a better sense of where we have to go with the other steps, the other sensitivity analysis.

DR. BAIR: But that's my point is the plots that Bob showed are all biased towards the permeable intervals where they've done monitoring wells, and the contaminants exist in between sampled intervals, otherwise they wouldn't get down to the deeper parts.

MS. ANDERSON: Actually, I do have one slide where we can maybe explore that a little bit more and kind of talk about what you're getting at I think, but we're welcoming the input and how we should approach that.

DR. HILL: In step two considering the thickness you're using as the whole aquifer thickness that you're not making slices through it, it seems odd to me in step two not to do a 3-D interpolation of the data. I mean, there'd be no reason not to at that point, and then integrate, I mean.

MS. ANDERSON: Again, it's kind of data driven. There's a slide --

DR. DOUGHERTY: It's Surfer driven.

MS. ANDERSON: Surfer driven? We actually did look at some 3-D interpolation with GMS, and I think -- I haven't explored it yet -- but ^ with Surfer does some 3-D interpolation. And I think that it will be good to kind of run this method and then do some other comparisons with other tools to look at those types of interpolations.

DR. HILL: So when you do step two, obviously when we saw before, we had high concentrations and then low concentrations. What do you use as your point value in 2-D space given that you've had all this variation vertically?

MS. ANDERSON: Give me a slide or two.

DR. HILL: Sorry.

MS. ANDERSON: As Bob said, Mary, hang with me for a second. We'll get there.

So I just wanted to present a few

details about the data preparation and interpolation, which obviously we're talking about. We need to select the datasets and sort of group them based on some considerations. The horizontal distribution, and that's kind of picking areas across the study site that will isolate and do calculations.

The vertical distribution, which we discuss a lot. The sample altitudes and what we're going to consider as datasets for doing those horizontal distributions. And then the temporal distribution we need to isolate sort of or aggregate some datasets based on the temporal characteristics of the data.

When we do the interpolations, we'll have to look at multiple detections at the same location and kind of generate a single value. I think it makes sense, typically we'll be using the average value, but there may be some occasions where maximum values are appropriate for that.

The non-detects and the censored non-detects for the calculations I'm showing you here, I set those to zero. Now, we can consider different schemes for that if necessary, but by censored non-detects I mean the data that are less than whatever stated reported value, less than five, less than ten.

Non-detects, literally there are reported values that are just ND, and we have no reporting or quantitation limits to go off of on that data. So that's what I'm talking about, those non-detects and censored non-detects.

DR. DOUGHERTY: Just for those if you have a non-detect and a nearby close detect, do you somehow take into account that the non-detect may not be representative? I'm thinking about from the regulator side, of course, and from the other side you want to say well the other one's an outlier and it's a laboratory problem.

MS. ANDERSON: I think we're not to that point yet, but that's certainly a refinement that could be made. Initially, we're dealing with a very large dataset even when we isolate it to one location or area of the base. So that's certainly something we can consider and kind of refine that non-detects and censored non-detects to assign some values or discard data that we don't feel are appropriate.

DR. POMMERENK: Actually, with setting them to zero you would, you know, whatever your statistic is that you would use to represent the total mass and then you would underestimate the, that statistic was set down to zero so you may want to consider using some type of robust regression to -- you don't actually assign values to the non-detects, but you compute your statistic on distribution of values based on that there are values. We just don't know the numbers. And --

MS. ANDERSON: We have the ~~HASL*~~ [Helsel -ed.] text, and I think that that is something --

DR. POMMERENK: Yes, the ~~HASL~~ [Helsel -ed.] text will help you --

MS. ANDERSON: -- yeah, that we can consider after we do some baseline using this methodology. I think it would be good to sort of try to incorporate the non-detects in non-parametric methods and sort of try to do some analyses that way.

For the interpolation schemes kind of

looking at, we've explored some different options for that as well, but I think we'll probably just use the ordinary pre-game using standard default assumptions in Surfer Software. We did explore a little bit the autofit ^ [semivariogram -ed.] ~~gram~~, compared that to standard default assumptions in Surfer, and they seem to come out very similar for the mass computations, but that's something we can continue testing as we move forward. For the calculations that I'm showing here -- in our initial runs through this we're using ten foot-by-ten foot grid cell size.

So I kind of want to go through just a quick illustration, and it is just a slice, just a subset kind of illustrating the approach of the mass computation method. This is for TCE. This is the map that Bob showed as well showing the distribution of TCE across the study site. It's concentrated in a couple of different areas there.

We're going to focus for this illustration just on the landfill area. And this is the temporal distribution of data that we have for the landfill area. You can see in the middle there, there's the extraction well start up in October 1996. We have some data before that, a good bit of data after that.

For this illustration again I'm going to kind of look at this pre-extraction well start up database 1984 to 1993 and do some calculations with that. Certainly, we can run calculations with the first few years after extraction well set up or start up because there's very low flow with those extraction wells, and we may be able to use some of that contaminant data in a more extensive monitoring well network that was in place to do some mass calculations there.

DR. DOUGHERTY: Just to clarify, this is a remediation extraction well as opposed to a water supply --

MS. ANDERSON: Correct.

DR. DOUGHERTY: -- extraction well.

MS. ANDERSON: Yes. That's one, the remediation wells, the extraction wells were put in place in October 1996, when they started cleaning up the site.

So I'm going to focus on that earlier

data range there. And this is the vertical distribution of TCE in the landfill area just for that selected time frame that we're looking at, 1984 to 1993, so it's a little bit, it's like the slide Bob was showing, but it's a little more refined just to include the selected dataset.

I have included off to the left there just some general kinds of boundaries for the different aquifer systems: the Brewster Boulevard, the Tarawa Terrace aquifer and Castle Hayne aquifer system. And these are very general. They're kind of averages of top elevations and thicknesses across just the landfill area. So I haven't extended it across because there obviously are local variations. We're still dealing with a pretty large area so I just kind of added that guideline on the left-hand side there.

So you can see with this vertical distribution that we have data, contaminant data, just for two different aquifer systems, the Brewster Boulevard, the upper aquifer system Brewster Boulevard and then the Castle Hayne aquifer system.

There's really no data except for that one non-detect off to the left there for the Tarawa Terrace, intervening Tarawa Terrace aquifer system. So it's a constraint of the data for this time period. I think for later time periods we do have some data for Tarawa Terrace, that aquifer system.

But again, to illustrate mass computation, I'm just going to pick this one slice, this one horizontal slice of data in the upper Castle Hayne aquifer, the River Bend unit, and kind of run the calculation with that because I think that's how we'll have to proceed. Looking at grouping the data vertically, doing separate calculations for each and then kind of summing them, stacking them up.

So this is again, as I outlined in the general approach, we'll take that contaminant dataset, the data points, and interpolate them into a concentration grid, a two-dimensional horizontal grid, and that's what is shown there on the left, a traditional contour map, planar view. On the right I'm showing a 3-D wire mesh representation of the contaminant concentrations with the Z axis being TCE concentration in micrograms per liter.

So once we've established this concentration grid, we can use Surfer's grid volume utility to obtain both the planar area of the plume and also the grid, quote, volume, which I think this 3-D wire frame grid kind of illustrates the volume that I'm talking about; it's kind of these strange units of micrograms per liter multiplied by base area of each cell. It's essentially an area weighted concentration for each cell grid summed up to represent the volume of that concentration grid.

DR. HILL: Can I just ask a question?

MS. ANDERSON: Sure.

DR. HILL: I don't know that you can do this now, but it's really kind of critical where the points are that you're contouring, and they're not clear in that figure.

MS. ANDERSON: Yeah, the post points are not big enough there, are they? But that's something obviously we're, with our interpolation techniques kind of running interpolations and checking the post map to try and make sure it's a good representation of the data that we have.

DR. HILL: If those ^ aren't supported. It's just ^.

DR. DOUGHERTY: Clearly, they're supported by over-fitting, I suggest.

DR. CLARK: Scott, go ahead.

DR. BAIR: Barbara, my question would be if you look at the fishnet plot on the lower right, that would be one, two, three, four units that you're representing there?

MS. ANDERSON: Aquifer units?

DR. BAIR: No, just four horizontal units. There's a horizontal line going down from the peak and then there's a shoulder off to the left, and then there's another -- those are concentrations?

MS. ANDERSON: Yeah, that corresponds to the legend over there on the left --

DR. BAIR: Okay, so how many aquifer units are within that then? One?

MS. ANDERSON: Yeah.

DR. BAIR: Got you.

MS. ANDERSON: We're just taking that one slice of the upper Castle Hayne River Bend unit and looking at that.

DR. CLARK: Rao was next.

DR. GOVINDARAJU: I think I want to follow up on that next question. That is, this is going from 1984 to 1993, so this one unit you are computing is somehow over time, and time does not seem to factor in.

MS. ANDERSON: Right. I don't have a, we aggregated or I aggregated this data before the extraction well started up in 1996 because really if I plotted -- I have another plot and I didn't overlay it on here, but these numbers, the bar graph showed the total analyses we have, but the detections for each of these are the lower number, obviously. So if we want to just aggregate just 1984 to 1987 as one unit. There really aren't sufficient detections there to do an accurate interpolation. It would make more sense I think to use smaller time frames. But in this case there just weren't enough detections to really do a good interpolation so it's aggregated across that whole time frame. Is that --

DR. CLARK: In order to meet our streaming video guidelines we're going to have to wrap this up. So let's take just one more question and then, Barbara, can you wrap it up?

MS. ANDERSON: Sure. But maybe not, it's Lenny's question so I don't know.

DR. KONIKOW: So then the question is how do you go, you'll calculate a mass, but then how do you go back in time and use that to estimate what the mass loading rate is over the duration of the model? The Tarawa Terrace situation you had essentially a point source with a known location and a fairly constant over time disposal rate. Here I'm not sure how you're going to reconstruct the history of mass loading.

MS. ANDERSON: Yeah, I think that's going to be a challenge. I will say -- and Bob can chime in where he sees fit, but I think that for the landfill area I think Bob has, from his expert analysis of all the data that he's looked at, has determined that at Site 88 there was a dry cleaner, same as ABC Cleaners there was a base dry cleaner. And this landfill contamination is probably tied to disposal of filters from the, spent filters from the dry cleaning operation at Site 88, and there may be other sources. There may be buried drums, what have you, at the landfill area, but --

MR. FAYE: The issue, Lenny is basically, you know, you take what you get. We want to have a computation of mass prior to the onset of extraction. Yeah, and the data are over a particular period of time so, yeah, you had some concentration reductions because of degradation over that period of time, et cetera, et cetera, et cetera.

But I won't say the time is relatively immaterial here, but if we have this mass at this time, it basically gives us a minimum mass that we can work from. And what it is, I mean, it's basically, you know, you've got a flawed starting point or you've got no starting point. So, I mean, that's really what it comes down to. Of course, it's better to have a flawed starting point in my opinion.

DR. KONIKOW: You've had extraction wells over the whole duration of the system, but they were called water supply wells.

MR. FAYE: There again, sure there was mass removed from the system, but still we don't know what that mass was or we have a couple of concentrations that we could maybe make some estimates, but you'd have so much uncertainty you wouldn't assign a lot of reliability to that. But here again, I mean, it's not a perfect system. It's not a perfect analysis. But it gives us a starting point which is what we're after.

DR. CLARK: Let's give Barbara a chance to wrap up her presentation.

MS. ANDERSON: Sure, really after this I'm just illustrating how we can use, there's a Surfer utility to obtain both planar area and this grid volume and we can use that to easily obtain the average TCE concentration across this horizontal plume that was generated. There's a Journal article, Joseph Ricker* published in 2008 in "Groundwater Monitoring and Remediation" that kind of illustrates this if you want more information. But that's kind of what we were following with this approach. And then I just was showing the general equation there at the top and the parameters and values that I used for this illustration.

The first couple of values, the planar area, the average TCE concentration. Obviously, as I said, obtained from Surfer utility. Aquifer thickness. Here we're just using an average estimated thickness for the particular aquifer that we're looking at. And aquifer porosity we can look at effective or total porosity. We have some, I think, good values for that, 20 percent that was used in the Tarawa Terrace work and discussed extensively in one of the chapters in the Tarawa Terrace reports. The 40 percent total porosity just for this upper Castle Hayne River Bend unit, again, is from some site-specific data from Site 88 investigations. And we can refine this hopefully for each aquifer and each area that we're doing these calculations.

DR. KONIKOW: What did you use -- a couple more -- why did you use 22 feet for this system here when your earlier slide shows a box around it that looked like it was at least 35 feet thick where you encapsulated the data? And then the second question is why not account for the spatial variations, the elevations at the tops and bottoms? Why don't you use Surfer to get, why don't you consider multiplying all those concentrations? And why an average thickness? Why don't you use a thickness at each grid point?

MS. ANDERSON: I think we can do that as a refinement. We can import the extrapolation we've done with the model and GMS and kind of get actual cell-based aquifer thickness. And the other about the average that we've used here, I think -- and I noticed this in your comments you were referring to the Tarawa Terrace report which I think are a bit north of our location.

DR. KONIKOW: Just go back a few slides for this location. There, that looks like a vertical interval of 30 to 35 feet that you encapsulated the data yet you're using 22 feet. That's a pretty big percent difference.

MS. ANDERSON: That's the contaminant data. When you look at the actual extrapolation of any boring location or boring data that we have, and you look at the encapsulating aquifer system, we actually have a more refined sort of estimate of the thickness based on other data.

DR. KONIKOW: Are you saying that the data points here are --

MS. ANDERSON: Right, right. I think some of these data's a question of local variation.

DR. CLARK: Let's draw this to a conclusion so we can meet our deadline. So we'll pick it up at 1:30 this afternoon.

(Whereupon, a lunch break was taken between 12:37 p.m. and 1:30 p.m.)

DR. CLARK: Okay, we're ready to start up again. Video streaming is going to be online in a few seconds. Morris has got a few things he wants to do, wants to introduce Dr. Aral.

MR. MASLIA: Thank you for that morning session. This is the type of feedback we're looking for. We had some very interesting and informative and probing questions so we're going to continue this afternoon. Just a couple of housekeeping things before I introduce Dr. Aral.

If people would like to go out to dinner other than the hotel, there's a couple of restaurants in the area. One's a little bit more expensive, a nice French restaurant. I can see if they have room. We can talk at the next break and just see. Or if everybody just wants to do their own plans and maybe get together that's fine with me. Y'all may not want to eat with me, dinner. Actually, my wife would like to see me at home one day during the past two weeks for dinner. But at the next break maybe we can sort of formulate plans.

STRATEGIES FOR RECONSTRUCTING CONCENTRATIONS: PRESENTATIONS AND PANEL DISCUSSION

With that said, as we saw from this morning, a lot of data, a lot of information and how exactly to analyze it, how to make sense of what it is and how should we put it together so we can, if we want to, try to do a numerical model like we did with Tarawa Terrace. Questions you asked, Lenny, and pointed out, there is not a single source so where do we begin in that temporal distribution?

So after we had completed Tarawa Terrace and just looking at the surface of this, I asked our cooperator at Georgia Tech perhaps there might be a method either available or maybe we could look into developing one where we might be able to use some of the data that's captured, the contaminant data that's captured in either our supply wells or observation wells.

And would there be from a screening level a way to avoid or minimize having to transfer the data that we have in reports and analyses to then trying to categorize it for a numerical model. Just some of the issues on assigning supply well pumpages from the scheduling that we've got versus actually putting it into the model.

And so Georgia Tech and Dr. Aral have come up with a screening-level method. It was described in the notes, but Dr. Aral's going to describe it in more detail, and again, it is meant as a screening level, but it may be something very useful for us to either proceed with that initially or provide more information from that standpoint. So I'm going to turn it over to Dr. Aral, and let him proceed.

SCREENING-LEVEL METHOD

DR. ARAL: Thank you, Morris, and welcome back. When I heard this task from Morris, I said this is a difficult task. This is not easy to do. But then I'm sitting there and listening all of the critique that you guys are giving to the other approach, and I said my task is very simple because none of those critiques apply to what I am doing.

Our task is if we know what we know today, can we predict what has happened in the past? And then we are thinking about this at Georgia Tech where I work, and we thought, well, we do the opposite all the time as engineers. If we know what we know today, can we predict what is going to happen tomorrow? So let's look at that approach, and let's see whether we can get some insight and make some use of that analysis in predicting what has happened in the past.

So predicting the future and using the information from the future events is based on some control theory analysis. And I'm going to give you three simple examples where we use this approach and then try to extract some insight from this analysis to use to answer the question that we are trying to answer in this case.

For example, everybody has a car.

Everybody has a cruise control. You are driving down the highway, and you don't want to worry about the gas pedal. You just want to enjoy the scenery. What you do is you set your cruise control to a given speed, and you would like to watch the scenery after that. You assume that something in your car is going to adjust everything such that the system output is going to be that speed.

That's a custom control mechanism that is installed in your car. What it does it looks at the speed of the car, senses it, and then based on a computer program or a chip installed in your car, controls the system which happens to be in your case in the car, an engine, adjusts the carburetor, adjusts the system input which is the gas, so it maintains the speed. This is the simplest application of a control based analysis in our daily life.

Other applications are a little bit more complex. For example, we do, as engineers, reservoir management. We try to maintain a certain volume of water to supply the demand at all times by controlling the spillway gates. It is based on the same principle. In that case, of course, we have to predict the future.

We have to predict that there will be some drought season in the future or rainy season in the future, et cetera, such that based on that prediction we adjust the spillway gates. We release or retain water to keep the supply meet the demand. That's another application.

Another application is in power systems. We cannot store energy so we have to generate power at the time of use. We have to predict how many million people is going to turn off the switch in their homes and predict how many million are going to turn on and then estimate the demand at that time and then produce the energy required at that time.

All of those analysis is a time series-based analysis, and it's a control theory-based analysis. We have different ways of looking at this. We have intelligent control systems, optimal control systems, et cetera, et cetera, et cetera. This field is well established in engineering analysis.

Now what are the characteristics of

this system? In the examples that I have given the system information is known. We know how engine works. We know how to calculate the volume of a reservoir, et cetera.

What we don't know is how to maintain the system output. System input is fixed. It's today's information or yesterday's information. So what the controller does given this information on the system it adjusts the system behavior a little bit so that the output becomes what we want. So this is the basic idea of control theory based analysis.

Now, what we have here is the same system but in a reversed order in the sense that we know the system output. As you have seen this morning, there are numerous monitoring wells which are located at different locations in the site, which has been monitoring the site for the past 15 years. So the system output is known.

We don't know the aquifer properties; that's what we heard again this morning. We are trying to characterize the aquifer system.

Now, the question here is this yellow is the same yellow here, the system input. What should be the system input such that as it passes through the aquifer gives us what we have observed for the past 15 years. So this is a control theory-based analysis similarly, but the question is we are not going to predict the system output, we are going to predict the system input. That's the whole idea, and that's the only difference.

And there's one other difference and that's the following. We don't know the aquifer properties as well. We don't know how the system behaves. So this is a basic introduction to the idea, but I will go into details of the algorithm in a little bit more detail later on.

We are still in Camp Lejeune. We are looking at contamination sites at Hadnot Point or landfill area or other regions of the Holcomb Boulevard. And what we have done in the past is one of those sites, which happens to be the Tarawa Terrace area. The model that is used in this area is well calibrated, tested, applied, et cetera, and we have some existing models that we can implement in this study.

Now let's understand how the traditional way of looking at this problem goes. It goes as follows, and you have heard this all morning. Collect the data, develop groundwater flow and contaminant fate and transport modeling. That will hopefully give you some concentration profiles in certain water supply wells in the aquifer, create a mixing model, put it into water distribution system eventually giving you the exposure pattern at the site. So this is the traditional way of looking at this problem: data, to model, to mixing model, to water distribution system analysis.

Now, the purpose of the current study is a little bit different. All these steps that we have discussed this morning, and I have summarized here, takes a lot of time, a lot of energy. There's a lot of uncertainty as you have heard.

And the question we were asked to answer is if we know the field data, and this happens to be the Tarawa Terrace Area PCE

Contamination Database, can we skip all that intermediate steps or modeling of fate and transport analysis and jump to the final step of estimating the contaminant levels in the wells without using models or the models that we use traditionally? So that's the purpose of this study.

First of all we have to immediately identify what our limitations are. How we are going to overcome those limitations. So let's describe that. As Morris has said, this is going to be a screening-level procedure. We are not claiming that we will get exactly the same accuracy level -- and some of you are questioning that already -- exactly the same accuracy level going through the process of modeling. We accept that.

The other important difference is that the proposed method is not going to be applied to the whole area that you see here, which is Holcomb Boulevard and the Hadnot Point, but it is going to be applied locally in the following sense. We have talked about data clusters, density, data density this morning. So we are going to make use of that density and apply this method locally, to landfill area maybe, just look at that region.

Or apply it at some other source contamination where there's data, where there's monitoring stations, where there's monitoring data for 15 years, which we can use. That's the idea. So we can pick this method and apply it to different places. And as I have demonstrated in my report, we have also applied to Tarawa Terrace area creating a synthetic data to see how it works, and I'm going to discuss that today.

Other limitations, of course, quality and quantity of the data is extremely important. If we feel that at a certain site we don't have enough data, we will not apply this method. It's that simple. It doesn't work. So we have to wait for the site data analysis to be complete for us to implement this method at Hadnot Point or Holcomb Boulevard areas.

The other advantage of this is we can use this method at any of these small regions where we have some data to characterize different chemicals whether it be PCE, whether it be benzene or TCE, et cetera. If we have a fingerprint, we can use the method. If we don't have a fingerprint, we cannot use the method. So this is the starting point in our expectations in this method.

Let's also look at the technical details a little bit. I have to go back to the same procedures that we use in our traditional approach. What do we do? Well, we use groundwater flow modeling. This is the basic governing differential equation for that system. From this we get the ^ [velocity -ed.] ~~the~~ field in a multi-layer system.

We put that information into contaminant fate and transport, and then whichever method you use, finite difference, finite elements, ~~metal~~ [method -ed.] of characteristics, et cetera, this procedure lends itself to a matrix system to solve for the concentrations at the points of interest.

Time rate of concentration multiplied by some matrix M usually called in finite element terminology mass matrix, concentration times another matrix S, usually called the stiffness matrix, and then some loading functions whatever they may be.

So I would like you to remember this final outcome. If you go through this process properly, calibrate the model, and this and that, you end up at this stage which is not going to change after that point. This is your solution system.

This matrix equation represents the system itself after the procedures are properly implemented and the models are properly calibrated. So I would like you to remember this because I'm going to refer to this later on.

Let's also remember or look at the data that we may have at Hadnot Point. This is the general trend in the databases that we have seen so far in Hadnot Point area. Contamination starts at a zero and between T-zero and T-A, there is no monitoring of the site. There is no monitoring data, but during this period from T-zero to T-A, there is water supply wells operating at the different locations at different schedules at the site.

And then at time T-A the contamination events are discovered, water supply wells are shut down and the sites are being monitored. So we enter a period of no pumping of water supply wells and a period of observation. This is traditionally about three or four years from T-zero to T-A, and this is about 15 years from T-A to T-F, on that range.

And at certain sites we also have some internal points which is going to be very important for us in our analysis. Not at all points these internal observation points are available, but at certain sites there is some internal data points during pumping period. So keep that data structure in mind as well.

So what are we going to do? Well, as I have proposed, we are just going to skip all that modeling. We are going to look at the aquifer system as a black-box model, and we are looking at observation well concentrations or monitoring well concentrations, which are characterized in director X of T and X1, X2, X3, et cetera, are different monitoring stations which are recording concentrations over time. So X of T at the forward time, that is, after T-A is known at several monitoring locations. And we are interested in this time series change of this monitoring database as it happens over time. We are trying to understand that or trying to solve that.

Now, what does our aquifer system include, this black-box that I have drawn? It's not black but golden box in this case. Well, it includes everything. ^[Hydraulic – ed.] conductivities, different aquifers, advection, dispersion, diffusion, reaction, contaminant sources.

We don't know where they are, but we don't care because we are only looking at the monitoring locations. We are trying to solve everything at the monitoring locations. We are not trying to bring the contaminant from the source to the monitoring location.

What is an external forcing function that characterizes the behavior of this aquifer system that is the pumping rates at water supply wells which occurred between T-zero and T-A time period? And after T-A time period UFT is equal to zero. So those schedules we know, and actually so being characterized as you have heard this morning.

So our control theory based system is based on this black-box model, and we are trying to predict the time series evaluation of this XFT which is the concentration values at different monitoring stations at the site and not the whole Holcomb Boulevard, not the whole Hadnot Point, just landfill area, just another contamination site somewhere else in the site.

Now, this is the same matrix that I have shown you earlier. If you multiply the earlier matrix by M inverse, you get a matrix M instead of S and then as a load vector you get a matrix Θ, which is in front of this forcing function, UFT. So what is the size of this matrix M? It's an N-by-N matrix, N being the number of observation points. If we have five observation points, it's just five-by-five matrix.

What is the size of this Θ matrix? It's N-by-N. It's the number of observations times the number of pumping wells that we have at the site. UFT is the pumping schedules. X-dot is the rate of change of the concentrations at the observation points. X-zero is the initial value of the concentration at the observation point.

It's our assumption that if we look at the start time of contamination, whatever the contamination was, it's not going to be immediately observed at the monitoring station, so X-zero is always zero to start the solution. It will take some time for the contaminant to reach the monitoring well. That's my assumption.

So if we solve this matrix equation using our forward time integration -- and just using some symbolism here which is standard -- we can write the resulting matrix in the squared parentheses here as A and)-T times Θ as B, and our step-by-step solution becomes this. So starting from time zero at K is equal to zero, we can incrementally go forward in time to solve for the concentration profiles in five, ten, 20, 50 monitoring stations, however many we have if we know the matrices A and B.

But we don't know that. And that is the system matrices that we identify as A, and this is the forcing function matrix that we identify as B. So our task to solve this problem is very simple now. Can we determine, can we find a method to determine the matrix A and the matrix B? Well, actually, I'm introducing this as well, we can use a backward time integration process as well and look at the development of the matrices.

The outcome is basically the same. It goes backward in time from K-plus-one to K, but there are still two unknown matrices, A of B and B of B to subscript indicates that it's a backward system matrix. So backward, forward, the procedure is not going to change, and we can handle both of them.

Now, so our task now is to determine the matrix A and B. But let's look at this database. This period from T-A to T-F where we have all kinds of monitoring data is a period of no pumping. So if you look at our forward time integration scheme, U of K in that period is zero, no pumping. So our matrix becomes much simpler for that period.

If we have a time series of X of K, we should be able to determine the matrix A very easily. It's a least squares application, very straightforward. And this matrix A characterizes the aquifer properties at the monitoring location not in a region, at the monitoring location neighborhood. That's all we care. So we have determined the matrix A using a least squares method.

Now the next task is a little bit more difficult. We would like to determine the matrix B. A is already there. It will be always there because it's already solved. To determine the matrix B we use an optimization method in the following sense, that we describe the objective function first.

This objective function says that the difference between the simulated concentrations at observation wells at time T-A or the difference between the simulated values and the observed values should be minimized. This is our procedure, objective function of our solution for matrix B.

If we're going to minimize this difference in a least square sense again subject to the conditions that this is the time series solution of this monitoring well behavior, and if we know A already, then the only unknown is B. So this objective function through a minimization process determines the coefficients of B such that this task is accomplished as best as it can be accomplished.

So this is the optimization analysis that we use to determine the matrix B. Basically, we have used genetic algorithms to solve this optimization problem which incrementally adjusts the coefficients of the matrix B such that when we start from T-zero and start predicting the monitoring station concentrations, we end up as close as possible to the values of observation, observed values of concentrations at the monitoring stations at time T-A. That's the constraint here.

This method is that simple. We do these types of analyses as engineers routinely. This optimization method is not any different than what I have used earlier in other applications. Now, let's try to apply this to our Tarawa Terrace site and see how good we are.

So what we have done is we have used the calibrated models that we have at the site, Tarawa Terrace, input the same mass loading at ABC Cleaners, selected a smaller region -- as I said, this applies to a smaller region -- and generated a plume based on certain pumping schedules which we knew at the Tarawa Terrace area.

We used the pumping schedules at TT-26, TT-53 and TT-67. And this is the plume that we have generated over about 40 years starting from the contamination event that has occurred at time T-zero at ABC Cleaners. Then we have selected in our finite element match or if it's a finite difference, it's a center point as well, certain points where we have recorded the data. This is going to be our observation points.

So we know what this observation point, this observation point, et cetera, recorded. We have information on the pumping schedules of these three pumps with one difference. We have stopped the pumping schedule of these three pumping wells. This is the pumping schedule for the wells that we have selected at stress period, that is month 408, and let the simulation continue after that without any pumping at the site.

This is going to generate exactly what we expect to have data at Hadnot Point, a pumping period and no pumping period, and we will see what has happened to our concentrations. This is what has happened.

Contaminants start at time-zero and increase at these five nodes that we have selected as our observation period or as our pumping period. And then when we stop pumping at 408 stress period, some of the nodes are showing as a decrease in concentration like these, and the others are showing increase because the plume is moving. The downstream observation points are seeing more concentration over time as the plume moves downstream even if we have stopped pumping.

So this is our initial database. What we are going to do is we are going to blank that out. We don't know what has happened there. We are going to predict that part. We are going to predict that part using what, only the data points on this side. And also, we are going to predict that part using the concentrations at time T-A. Those are the values that we have used in our optimization model. We try to reach to that point. And I think I'm going to show you some of the results that we have next.

After we determine the matrix A using the data after the pumping has stopped, we wanted to see whether our matrix A behaves nicely. For these five locations, obviously, the least squares method works. We expected that anyway. So the simulated and the reconstructed profiles after the stoppage of the pumping works very well, and the matrix A is well-defined for this region of five observation points.

So that side is fine, but when we go back now we have to predict 40 years of system behavior when there is pumping. And initially I am showing you here the zero internal points case. That is, there is no internal points that we have used in this application. Obviously, this is not that good but the trend is there.

If we add some internal points, and in this case we are adding only eight internal points out of 34 years of database, and not eight data points on each line. It's just eight data points randomly placed, and here they are. As you can see, the objective function performs well. It just matches the internal data points between predicted and observed values very nicely.

So as you can see the data gets better, the predicted concentration profiles gets better in the pumping period. If we add just 15 points, this is what we have. So I'm very happy with this in the sense that there is such a method that we can utilize, and obviously, the accuracy of the procedure is improving as we include some internal points.

And I can do that over the weekend in terms of time associated with the task, and this is the 15 points that I have used in this case. I can look at the backward process. I'm just going to go through the slides very quickly. This is the verification of the matrix A sub B, and then, of course, this is the zero internal point backward solution.

And backward solution by that we mean we start from here and move backwards in solution to time zero, and then eight internal points and then 15 internal points. As you have noticed now, we have two procedures, going forward, going backward. These are independent procedures.

Then we said can we link them. Obviously, if we link them this method is going to use some information from one another, and it becomes an intuitive process. And if the process converges, then we have a very good method in our hands to apply at our site.

The way we are going to use the backward/forward solutions iteratively is as follows: We know internal points improve the solution, and we know from our experience so far the forward method works better closer to the time T-A. Backward method works better towards times zero.

So what we are going to do is we are going to assign some random solution points obtained from the forward solution close to the T-A time frame as data points in the backward solution. And then use the backward solution, get some random points from the backward solution closer to time T-zero, use it as internal data points in the forward solution. And if this converges, then we have a very good method in our hands.

So in summary, our next step is the use of forward/backward procedures iteratively to improve the solution, and we know also how to add confidence bands to the solution. We can give you plus or minus ten percent error, and we can propagate the field measurement error as well as computational error that we may have in our analysis and provide a band of accuracy interpretation over these databases. And finally, if all goes well, we are going to apply this to Hadnot Point area.

With that I will stop and answer any questions if you have any.

MR. HARDING: Yeah, I have some questions. This looks very interesting. It seems like this method will lump a discontinuous, inhomogeneous system into something more homogeneous that can make, you know, can help simplify, accelerate computational effort and things like that.

Two questions: A, you still will need pumping schedule if I understand this correctly. Secondly, where do the internal points come from? And this also seems to rely heavily on the initial condition that you applied here, that X at T-zero is zero. How do we know what T-zero is?

DR. HILL: Can I add one condition onto that so you can do it all at once? Also, your calibration in the non-pumping period require you to, you did it to simulated results from the original model, and so also comment on when you don't, obviously, you're trying to replace the model, and you wouldn't have simulated values. You would have the noisy measured values at that point. And it seems to me that's a problem, too.

DR. ARAL: The first question, this aquifer here is extremely heterogeneous, non-homogeneous and all that. But this aquifer here, which is the landfill area, we can very easily make the assumption that everything is homogeneous there. So that's not a big deal.

We are not proposing to apply this method to the whole region. We're applying it to a smaller area where we have monitoring data, and that is what we are trying to characterize. And we are going to apply this at different locations separately. So the matrix A is going to change. Every time we use this at a different site, based on the fingerprint that we have, the matrix A will change.

The matrix A will also change based on the characteristics of the contaminant as well. It's fate and transport. That's also included in the system behavior. If we have a PCE at this location, the matrix A is different than if we have a TCE at this location because degradation rates are different. The behavior of the observation points are different.

The other question was how do we synthesize the data? We are going to exclude obviously any data which we cannot predict a trend. The data that we can use in this analysis should give us a profile of some concentration over time. If it is an oscillating database, we will simply discard that monitoring database. We will not use, we will not model or we will not predict the concentration at that location. We will use another place where we have a better data. If we have none, we will not use this method.

The other question was --

MR. MASLIA: The observation internal points --

DR. ARAL: Okay, the internal points, we discussed this with ATSDR or ATSDR group. There are some sites at Hadnot Point and Holcomb Boulevard where there is some internal data which is available. And that doesn't have to be a time series data like the one that we discussed a minute ago, after the stoppage of pumping has to be a time, a one-time observation, which is fine. So we can use that internal data if available as a database to improve our solution as I have demonstrated in the case of Tarawa Terrace application.

MR. SAUTNER: Also T sub zero, Dr. Aral.

DR. ARAL: What did you say?

DR. DOUGHERTY: Also T sub zero.

DR. ARAL: Oh, T sub zero, okay. Remember, we are looking at the monitoring locations. The T sub zero is associated with the beginning of time somewhere out there which starts looking at the conditions of the monitoring well data. What we are assuming at that point is -- and that only appears in the forward time solution -- we are going to start this solution at a time where there was no contamination at the monitoring well.

That is our initial assumption. We are not saying year 1952 is the start of contamination. All we are saying is at 1952 there was no contamination observed. Let's start from there forward, move forward. Now, having said that, I want to point out one of my slides here, the backward solution.

Look what happens. We start from here and move backwards, and we end up with a zero concentration at this known point at a given time. The backward solution also interprets us the beginning of contamination, expected beginning of contamination at this monitoring location. That's an added information. I haven't even discussed that.

So we are not saying that we are starting at time zero as zero, but it's all zero from zero to 80 stress periods according to this analysis. So the use of backward solution has that advantage as well.

Yes.

DR. BAIR: I may be missing the obvious, which happens a lot, in the bigger picture this is giving you concentrations at monitoring wells. How does that help with the water distribution model? Can you make that link?

DR. ARAL: Of course. If we have concentrations at the water supply wells measured after time T-A, which we do have, we can include those as our monitoring locations in our database. So the matrix A is going to characterize the water supply well locations as well.

And then when we predict, one of these lines that you see here is going to be associated with the water supply well position. So now we know the contaminant profile at the water supply well, and then we can take it to the water distribution system after that. So the monitoring locations that I'm referring to always doesn't have to be monitoring locations, but it can be water supply well locations where we have data on concentrations between stress free period 408 all the way to, I don't know what, 600.

So that's a good question, but the information is in there if we have -- in other words, let me put it this way. We have to have concentration profiles observed at the water supply well locations to predict the concentration profiles before T-A. There are other ways to answer that question, but I don't want to go into that.

DR. BAIR: Okay, let's do it.

DR. GOVINDARAJU: Just a couple of points. In your last slide you said you were introducing Kalman filtering?

DR. ARAL: Yes.

DR. GOVINDARAJU: And so that is to basically take into account both error in observations and perhaps model error also. Is that correct?

DR. ARAL: No. We have a, it's again, when I use control theory-based analysis, we exactly didn't use the control based theory analysis. We have adopted some computational procedures to propagate random errors in data collection and errors in computation into our matrix analysis system to create bands of confidence levels. It's not exactly like you and I know in Kalman filtering analysis. Uses the similar concept, and we are using the name there, but we are not using the Kalman filtering approach.

DR. DOUGHERTY: So you're propagating a noise vector rather than using the system matrices so you're estimating the effect?

DR. ARAL: We are propagating a noise vector in the observation database into the system.

DR. DOUGHERTY: And then presumably for dealing with the system noise, you're applying the same sort of thing. You jiggle the matrix. You get an estimate for how much it impacts the vector and create a vector and drive the original system back.

DR. ARAL: Exactly.

DR. DOUGHERTY: I have a couple, I have lots of questions, but I'll try keep it focused. One was in the presentation you talk about the source strength as one of the input factors to the gold-box system, yet the source strength doesn't appear in the matrix equations, at least explicitly. So the question was, are there circumstances in which it needs to appear explicitly?

DR. ARAL: No, because the source is not at the monitoring locations. The source is somewhere else.

DR. DOUGHERTY: I understand that.

DR. ARAL: Right, so it is turning into the aquifer. It is moving down, and we are looking at what is happening at the monitoring locations. We don't know how much source there was, what the total mass is.

DR. DOUGHERTY: I understand, but in the same way you're using three pumping wells which are not the monitoring wells, so those things that are exogenous to monitoring are important to the system. So the question is still why does the source strength factor not appear in some way?

U is located spatially. It's not co-located with your monitoring wells, yet it's a factor in a linear system. So in the same way just because the source is some place else, it could still appear in the system.

DR. ARAL: It is. It is characterized in this matrix A. Wherever the source is, however it was, how long it discharged is being observed in the monitoring station, A or B or C, which is characterized by this matrix A. As I said from the beginning, concentration sources, aquifer parameters, diffusion, dispersion, reaction is a black-box in here.

DR. DOUGHERTY: I understand it's a black box. They don't appear in the stiffness matrix. They appeared in forcing function, which is what you reduced to be U. So I didn't want to get into that level of detail here. I don't think it's appropriate.

DR. ARAL: The only forcing function that we think is going to influence the profile of appearance of a contaminant at a monitoring station is the pumping that was going on nearby that -- we are not going --

Okay, let me back up a little bit. Here, when we use this method in this landfill area, we're only going to use the water supply wells in this little box. We are not going to use the --

DR. DOUGHERTY: I understand.

DR. ARAL: Right. So we are only going to look at the water supply wells near the monitoring stations, which influences the velocity field of the aquifer, which I think is important to characterize based on T-zero to T-A time frame.

DR. GOVINDARAJU: I think two points perhaps for clarification. What you are doing is you are using present data to predict past behavior. And let's say you focus on the landfill, and you only look at data in the landfill region. So there is an assumption that whatever let's say was happening in Hadnot Point before, the same pattern is occurring now also.

DR. ARAL: Okay.

DR. GOVINDARAJU: Because otherwise right now the analysis the way it's doing is not being influenced by what is happening at Hadnot Point. We're assuming that whatever concentration behavior we are observing, that is capturing everything. So that relationship changed over time, then it's going --

DR. ARAL: The answer is in this matrix. Once you calibrate the groundwater flow model and calibrate your contaminant transport model, you get your matrix system like this. Do you change that?

DR. DOUGHERTY: Yes.

DR. ARAL: How?

DR. DOUGHERTY: Because S depends on Q which depends on the pressure which is time-dependent.

DR. ARAL: It depends on q.

DR. DOUGHERTY: Little q meaning specific discharge. Sorry, I want to make sure I get it right.

DR. ARAL: But that happens to be in our system already in the matrix A, but the overall system that you have here, are you going to change aquifer parameters? Are you going to change the foundation coefficients? Are you going to -- you know, all of that is in there.

DR. DOUGHERTY: So it's a big linearization step to get from A to B.

DR. ARAL: My model is as linear as this one.

DR. HILL: It's not only a linearization step, it's a very strong lumping step. You're putting a lot in there. What that produces is a system that can't be cross-checked.

DR. DOUGHERTY: Well, there's nothing else to cross-check because he's using all the data.

DR. HILL: Yeah, you can't cross-check anything. You can't cross-check whether the hydraulic conductivities make sense. You can't cross-check whether the source strength makes sense. You can't cross-check anything. And also, the data you put in there, all the fits you showed, fit the data points perfectly, which always makes me nervous. So how do you deal with data noise as well?

DR. ARAL: First of all, cross-checking hydraulic conductors, it doesn't interest me in this case because I'm not using this differential equation to generate matrix A. I'm not using this differential equation to generate the matrix M or S. That's irrelevant. I really am looking at ten observation points characteristics for their behavior based on a database.

Now how am I going to propagate the error that I have in those observation points? The bands that I have described earlier is going to give us information. If we have field data error it will propagate in our solution. We will have computational error. It will propagate in our solution.

DR. DOUGHERTY: Even though your interests may not lie in matching conductivity values, the consistency between a data-driven system and a physics-based system are going to provide some measure of comfort to a lot of people.

So one possibility that might be considered is to take local scale flow and transport models, and so your original differential equation system, apply it to a measurement matrix so you basically are condensing the system down to the number of monitoring locations. And then comparing the condensed matrix coefficients to the coefficients that are derived out of this linear control system.

And I understand, I understand, but because you've got, they aren't going to be the same because to get to a linear control system you have to do, you do have to do some linearization. It's true, but it may help with some comfort to look at those, to look at a static condensation of the finite element matrix, you want to think of it that way, versus a control matrix.

DR. ARAL: The way you come up with the matrix A in a finite difference or a finite element method is completely different.

DR. DOUGHERTY: I understand.

DR. ARAL: But you should also ask the question to the person who's doing or choosing that path to give the comfort level of predicting the assimilated or observed values, right? And that's what you do. That's what you do. And in this case that's what we have done. We have totally used a different method to generate the matrix A or B, and we have confirmed the outcome that we have observed at the site are a match.

DR. CLARK: Richard is the next one in line, and [then -ed.] we're going to have to move on again I think. This is something that we may want to come back to if we have time this afternoon.

But go ahead.

DR. CLAPP: Yeah, this actually might be a question that jumps the gun. I'm actually wondering about at the bottom of the, at the end of this process how does this advance identifying finished water at a location where a child with a birth defect lived? What their consequence was or at least what their categorization was.

DR. ARAL: We have discussed that partially. We can use this method to determine the concentrations at water supply wells as a profile as well if we have information on concentrations. So once we have generated our profiles as solution, for example, if this is our water supply well data, if we are predicting this, our predictions will be used after this point the same way the other procedures would have used it going through groundwater flow, contaminant transport modeling.

DR. BAIR: It's a follow up. So if you do this at those three locations that are the local locations you indicated on the one map where the spots came out?

DR. ARAL: Any. Any location. Not three.

DR. BAIR: I thought you said you were using at the three where you had the most data and it couldn't be applied at areas --

DR. ARAL: We have not, we have not decided where we will use this yet. We are going to be totally data driven in that aspect. I am just giving you here some characteristic small locations that we may use.

DR. BAIR: Okay, so you could take that gold spot and move it all the way out along the line of wells that extends to the west where there's not much data at all?

DR. ARAL: The answer to that question is here. If there is no data, we will not use this.

DR. BAIR: Okay, so there will be water supply wells in the area we've talked about today where you can't apply this method.

DR. ARAL: Right. If that is the case --

DR. BAIR: So then what is used for the exposure assessment if this method doesn't apply? You still need a deterministic flow and transport model?

DR. ARAL: That's a good point. If we don't have, if there are water supply wells around here which we are using to contribute to the whole system supply or add to the system supply, then using water supply concentration profiles here is not going to add as much information for the whole picture.

DR. BAIR: So my question was how many water supply wells will be left out?

DR. ARAL: I have not looked into that yet. I don't know what the data structure is. We are just working on the method.

DR. BAIR: So it does mean that there will be two approaches to the same problem running in parallel?

DR. ARAL: Uh-huh.

DR. BAIR: Is that right?

DR. ARAL: That's correct.

DR. CLARK: Why don't we move on.

Morris.

MR. MASLIA: I may not have shown it, but somewhere in the notebook there was a flowchart, and it gave a double path. One was the traditional fate transport model, whether we use deterministic, probabilistic or grabber* estimation. The other approach was using this screening level model, and that would, depending on the data that you have available, would determine the approach.

STRATEGIES FOR RECONSTRUCTING CONCENTRATIONS: PRESENTATIONS AND PANEL DISCUSSION NUMERICAL METHODS

At this point I think we're going back to the traditional method that we had a lot of questions about this morning, but then the purpose of this is to at least generate some alternatives or get more input from you. So Rene Suarez started halfway as we completed the Tarawa Terrace modeling or as part of that, and we'll move into Rene's presentation.

MR. SUAREZ: Good afternoon. My name is Rene Suarez as Morris said. I am with ATSDR on the Exposure Dose Reconstruction Team and during the next few minutes I will be talking about the proposed approach to numerical groundwater flow and contaminant fate and transport modeling for the Hadnot Point and Holcomb Boulevard study.

The outline of this approach and kind of this presentation is groundwater flow modeling on the regional scale. Here we are going to develop and ^ [calibrate ed.] a steady-state model. We as well ~~we~~ [-ed.]are going to develop and calibrate a transient model for the groundwater flow. Then we will have to develop and calibrate groundwater flows for the local scale where we have the contaminants ~~of~~ [in -ed.] the areas of concern. And ^ [calibrate -ed.] contaminant fate and transport models for those ~~local~~ ^ [locally refined -ed.] models.

First of all I'll describe a little the Tarawa Terrace model. I know some of you were involved in the expert panel on this. The approach is very similar so I will just briefly describe the approach that was used for Tarawa Terrace.

In the yellow box we have Tarawa Terrace and what was used there was~~,~~ [-- -ed} we developed and calibrated a groundwater flow model in MODFLOW. It was a steady-state model. Then a transient model was developed. From that we developed and calibrated a contaminant fate and transport model using MT3DMS, which gave us the concentration over time for the area of the model.

Then we used a simple mixing model to estimate the exposure concentration using the flow data of the supply wells and the concentrations from the model. And finally, we verified ~~those~~ [the -ed.] estimated exposure concentrations in ~~that~~ [the -ed.] water distribution model that was ~~building~~ [built in -ed.] EPANET.

In this slide I'm showing the proposed Hadnot Point/Holcomb Boulevard model. And first I would like to point out the difference in areas of the Tarawa Terrace model that we have here in the yellow box and Hadnot Point and Holcomb Boulevard.

The area is five square miles for Tarawa Terrace, and I think Morris in one of the slides had 50, but the proposed [area is 84 square miles -ed.], I think that was like [, ed.] this is a more updated area. It's about 17 times larger for this model. The size of the total domain is 51,000 feet in the Y direction and 45,000 feet in the horizontal direction.

Some of the features of this model we have [are -ed.] a specified head in ~~data~~ [layer -ed.] number one of this model. That is representing New River here in this dark blue. On the right side, or the west side of this model, we have a no-flow boundary that mostly represents a topographic divide.

MR. MASLIA: Excuse me, Rene, can you speak up a little?

MR. SUAREZ: Yeah, sure.

We have a no-flow boundary on the ~~west~~ [east -ed.] side [which -ed.] is represented by a topographic divide. In some areas we have some general head boundaries where we have supply wells. We also have about eight small creeks that are represented by drains here in the model in green, and we have 100 supply wells in the area of Hadnot Point/Holcomb Boulevard.

In terms of the grid design that we are proposing, the model has been subdivided into 343 rows, 303 columns. This gave us square cells of about 150 feet per side. The model had been subdivided vertically into ten layers.

On the right side of this slide we have a table where we have the geohydrologic units on the left-hand side and the corresponding model layers on the right side. We have seven aquifers and seven confining units. The confining units are underlined in red. And please notice that the Brewster Boulevard is lumped into one model layer.

Horizontal hydraulic conductivity for the different aquifer was obtained from aquifer test analysis [. -ed.] for [For -ed.] the confining units. [-ed.] It [it -ed.] was assigned a constant value of one fit [feet -ed.] per day. Effective ^ [recharge or infiltration -ed.] was obtained from precipitation data, kind of the same approach that Bob described earlier that was used in Tarawa Terrace.

And elevation of the different layers, elevation for the, for layer one, the top layer, was obtained from ^ [digital -ed.] elevation model [and -ed.] topographic information and for [-ed.] the elevation for the other layers was obtained from borehole log data and geophysical data.

From here we proceeded to -- and please understand. This is the proposed approach, so it's not really like in the step of being calibrated or being completely built. So just keep that in mind while you're thinking there.

So the model was calibrated using that [kind of a -ed.] trial and error approach first, kind of a code approach [-ed.]. And then the PEST optimization is going to be or was run under this model, this steady-state model. Over here in the center we have horizontal hydraulic conductivity.

The layers that are currently missing are the confining units that were not included in the PEST optimization at this step. Research [? -ed.], two ^ [parameters -ed.] [Two recharge zones -ed.] were identified during the calibration process, [. -ed.] and [And -ed.] basically what we're doing is trying to review this subjective [objective -ed.] function in the PEST optimization. The objective function is just the sum of squared error. This is the observed heads, and this is the simulated heads. This simulation, [– ed.]the PEST optimization, [– ed.]took 78 MODFLOW simulations, and it took about two hours to perform that.

MR. HARDING: Can I ask you a question?

MR. SUAREZ: Sure, sure.

MR. HARDING: I guess I'm not a groundwater modeler. Why are you calibrating the recharge when you can make a reasonably good estimate of it and it's a time series?

MR. SUAREZ: Well, we're going to use both like we have in some starting points some precipitation data, weather data, but we still don't have, we only have like one weather station for that whole area and recharge definitely should vary in that area. So it's still going to be a parameter that we want to include in the calibration process.

MR. HARDING: You could get gridded precip.

MR. SUAREZ: You can get what, sir?

MR. HARDING: You can get gridded temperature and precip from the PRISM database on a four-kilometer grid, which is not super fine, but it's better than your weather station probably. Anyway, I disagree.

DR. DOUGHERTY: This is the net of what actually gets in the ground.

MR. HARDING: Yeah, you'd have to make that calculation, but you've got all the data to do it.

DR. HILL: But you don't. It's not something --

MR. HARDING: No, you don't.

DR. DOUGHERTY: Changes in soil moisture.

DR. BAIR: On a monthly basis, how much does that -- is that a problem? It's a pretty well drained area.

MR. FAYE: The only thing you've got are regional estimates of Blaney-Criddle stuff. You don't really have anything that you can pinpoint down to an area like this.

MR. HARDING: It's a starting point. That's where you start, but --

DR. DOUGHERTY: You've got the precipitation. These are pretty good estimates. They're interpolated from point [data -ed.]^. You've got temperature and dew point, you can use that in a physical-based equation to calculate ET. So then what am I missing about the rest of it? If the rain falls on the ground, where does it go?

DR. BAIR: Some's into ET, some's into plants, some's into runoff and some continues downward into groundwater.

DR. DOUGHERTY: And some stays in storage.

DR. BAIR: And some stays in storage until something happens to it, maybe in your 18 model.

MR. HARDING: Stays in storage in the surficial layers?

MR. FAYE: In the soil moistures.

MR. HARDING: Doesn't it make sense to use this information to inform this somehow? Because, I mean --

DR. DOUGHERTY: Usually something like that would be a starting point. You get a rough number and use a starting point.

MR. HARDING: Rather than just calibrating it. It seems to me you know a lot about it from the precipitation --

DR. HILL: So you'd expect it to be that value maybe, plus or minus a factor of maybe up to two, probably not more than two.

MR. HARDING: I'd be surprised if it was anything close to there.

Okay, go on, I'm sorry.

DR. BAIR: Rene, I have a question. Can you go back one slide?

MR. SUAREZ: Sure.

DR. BAIR: So if you look at iteration six, those are your best fit, right, the row going across from iteration six?

MR. SUAREZ: Yeah, well, I will call this it was the best fit without considering any specific information about the different layers and that, but, yeah.

DR. BAIR: So then if you look at model layer four, that's an aquifer.

MR. SUAREZ: Uh-huh.

DR. BAIR: And model layer three is a confining layer and five is a confining layer?

DR. DOUGHERTY: No, no, he said he didn't include any confining --

DR. HILL: He said estimated --

DR. BAIR: No, no, they're there. They're there in the model. Right, so my question is if model layer three has a hydraulic conductivity of one, and model layer four has a hydraulic conductivity of 1.2, and model layer five has a hydraulic conductivity of one, who's confining whom?

MR. SUAREZ: Well, these values were not really bounded like very specifically during the optimization process. That's why I'm presenting the approach. If we go to the green row, these values are more based on the aquifer test data. So, yeah, I expect these values to be higher during the optimization process.

DR. BAIR: And I apologize. It's just hard for me as a member of the panel to tell what's final and what's preliminary, so if I ask too many questions it's because my impression is this is the final stuff that you're presenting and not some preliminary work.

MR. MASLIA: Now, let me just again clarify. I tried to find a nice fit between giving enough information so we could provide the methodology that we want to use and not committing too many resources that we've gone down the path of trying to calibrate a model and then receiving feedback from the panel that's not going to work or you need to make some major changes because then in terms of resources and efforts we need to back track.

I didn't want to not show or present anything so again, especially on the numerical modeling part more so than the data analysis because it's really --

DR. CLARK: I think they're going to be depending on you to recommend --

MR. MASLIA: -- just an approach.

DR. CLARK: -- forward.

DR. HILL: Can I make one comment on this? Just that when, in regression when you have parameters that go to unreasonable values, generally that's indicating that there's some conceptual problem with the model. So instead of just putting limits on that to keep it reasonable, I would suggest re-evaluating your conceptual model.

MR. SUAREZ: Sure, sure.

DR. KONIKOW: Well, another related issue is why not, if you want to assume all the confining layers have the same hydraulic conductivity, why not at least treat it as one parameter? Then why not estimate that? Just make it part of the whole system.

Well, on a conceptual basis maybe this is a good time to discuss it, but maybe go back to the previous slide. And one of my major conceptual concerns is for the flow and transport model lumping those four upper units into one model layer. This seems like a major conceptual flaw.

Somewhere in your report it said that you had field evidence that that upper clay unit was very substantial in retarding the movement of the DNAPLs and had a significant effect on the contaminant ~~transporting~~ [transport -ed.], yet here you're lumping two aquifers and two confining units into one model layer, which means you're going to smooth out all the influence of the heterogeneity, and a very significant heterogeneity, in layering on contaminant transport.

And this is the unit into which the contaminants are introduced and you're losing all the controls by this lumping. I just don't see conceptually how this can be justified.

MR. SUAREZ: Well, one of the plans is to subdivide that when we go to the more localized model because this is --

DR. KONIKOW: Well, you -- I don't think when you go to the localized -- if you're using MODFLOW, maybe Mary could say something about this. I don't think in the localized models you could change the vertical, the model layering, can you?

DR. HILL: Yeah, you can.

Are you doing this to avoid dry cells?

MR. SUAREZ: Yes.

DR. HILL: Yeah, don't.

MR. SUAREZ: Well, it's one of the reasons -- let me explain. We don't have to the extent that we're proposing this model the, basically the interpolation scheme that we're using to interpolate those layers. Now you get a lot of layers that kind of like kind of disappear, appear and disappear, and it's kind of difficult to at this moment I'm not presenting at this moment just to have a structure that makes sense.

DR. HILL: Use the Huff* [HUF (hydrologic unit flow) -ed.] package and assigned, and use defined thickness layers using your contoured water table for those layers. And get in the ballpark in terms of hydraulic conductivity.

DR. CLARK: Rao had a comment he would like to make and then I think we need to let Rene continue his presentation.

DR. GOVINDARAJU: This is Rao from Purdue. I think along the same lines my feeling is even if you get the conceptual model correctly, and you just let the optimization run its course, it may give disparate value the confining layers which are less than the aquifer conductivities.

I think once you think a conceptual model is correct, you must do a constraint optimization. If the assumption or the belief is that the confining layers are about one-tenth of the conductivity of the main layers, then you should, I suppose, impart that knowledge to the optimization routine.

DR. KONIKOW: But is that knowledge or is that just an assumption?

DR. GOVINDARAJU: That's an assumption.

DR. HILL: Well, I would say it's knowledge. It just depends on how you want to use that knowledge. And one way to use it is to apply it as constraints so that you constrain what values your parameters can take. Another way to use that knowledge is to say, okay, I'm not going to apply this as a constraint. I'm going to see what fits my data best and if those values are unreasonable, I'm going to sit back and say, okay, if I have enough sensitivity, if I have enough, if my targets or observations --

DR. CLARK: Let's let Rao go on and, ~~I mean~~ [then -ed.], let's let Rene go on and present his --

DR. HILL: I was almost done.

DR. CLARK: Okay.

DR. HILL: -- then go ahead and if my observations provide enough information to estimate those things, and they provide a lot of information, if my estimated value is wrong, it implies a problem with the conceptual model. So it's just how you use that information.

DR. CLARK: Let's let Rene go on and finish his presentation.

MR. SUAREZ: I will point out something maybe related to that. So just to show [how -ed.] the calibration was from that preliminary model as we mentioned we were using, we used PEST. One of the things we also are considering [is -ed.] UCODE. The root mean square for this model was 5.46, and on the right side we have a plot of the simulated versus observed water level values. The values in red are monitor well data, and the values in blue are supply well data.

And please notice [in -ed.] this slide, overestimation of the supply well data because this was just to kind of like try the method. Because this includes all the data, one thing that when you go and check on case-by-case of the observed data, some of the observed data that I include I shouldn't have included in because it was being subjected to draw-down effect, and at this time we're not concerned with pumping. So there's a lot of refinement that I have to go and select what data I will include into the optimization process.

DR. DOUGHERTY: Quick question, and all these are equal weights?

MR. SUAREZ: What?

DR. DOUGHERTY: You're using equal weights on all of the data?

MR. SUAREZ: Yes, right now, yes.

DR. DOUGHERTY: So you're not using the measurement error differences?

MR. SUAREZ: No, at this moment, no.

So this just showed the results from that preliminary model, and we have a head difference of about four feet from east to west. This plot also showed the head residuals. We have in blue less than minus five feet, in green minus five feet to five feet, and in red, larger than five feet. One of the ~~common~~ ^ [comments -ed.] about data density that ~~we're~~ [we were ed.] talking before, although this model is really large, actually the area is very concentrated, and it's hardly difficult to calibrate the models in some areas that we don't have data, and at this step we're just trying to build a regional model and then we'll have to calibrate that model. But then we'll have [, ed.] I will say[, -ed.] plenty of data to calibrate those local models.

Just comparing the Hadnot Point/Holcomb Boulevard and the Tarawa Terrace model side-by-side I just want to point out what I would think is the two major difference in terms of building these two models. We have fairly [large -ed.] difference in [the -ed.] size of the model. That will include steps that were not contemplated, were not in Tarawa Terrace. Like here we will have to build a regional model and go to more refined local models.

Also, we have a lot more data that is good for calibration, but it will also make it more complex. So we will need to ~~do,~~ [-ed.] use optimization process for this model. And that will include a lot of effort in calibrating the steady state transient models for each one of the regional/local models and the contaminant fate and transport.

DR. HILL: Excuse me. Those observed the concentrations that you have listed there, do they include the non-detects?

MR. SUAREZ: No, these are locations. If you look at this I may not have made the difference. Locations where we have data in terms of contaminant --

DR. HILL: It is important to use the non-detects as well, and UCODE provides a formal mechanism for using non-detects.

MR. SUAREZ: Sure, sure. I saw that in your notes. And definitely that's something that we'll contemplate.

So we can proceed with the discussion. What I want to do is summarize ~~like~~ [-ed.] the approach, so you can see in perspective of the amount of data that we have at this moment and amount of data that we may need to check within the documents that we still haven't really realized that we have.

We are going to build our numerical model, and we gave some information of a preliminary numerical model that we have built. We are going to run a steady state model. We also gave some preliminary information on that. We are going to run this model using MODFLOW-2000 and PEST for calibration. We're going to do that as well with the transient model, same situation. Then that's for the regional model.

From there we're going to go to a more localized model where we're going to choose some areas where we need refinement. And when I said refinement or local areas, the bulk of our contamination is located, for example, in this picture, the landfill area and the HPIA area, Site 88, we'll need to build local models for them.

We will have to evaluate the effects of pumping on those because we have a lot of supply wells and not all of them are pumping on the same times. So we'll have to evaluate the effect of pumping on those boundaries. And from there we'll have to run our transport models in those local grid refined models ~~or ^ models~~ [-ed.] using MT3DMS, the same approach that was used in Tarawa Terrace and PEST or UCODE for calibration.

From here we can start the discussion.

DR. BAIR: Rene, with respect to the calibration, is there any time, money -- they're kind of both the same anymore -- to get a velocity data that you could use to help calibrate? You have a lot of head data, but it would be nice to get, and I know it's not easy here, stream flow gain or loss so you can get some discharge data, a flux out of your system. Or some tritium/helium age dates so you can do some backward particle tracking to check to see if the physics of your model matches the chemistry of the tritium/helium to give you confidence in some of the velocities.

MR. SUAREZ: I'm sorry, you're combining something about money or I was just thinking --

DR. BAIR: No, the money was just a comment for the people way up there. That's for the people in the corner. You're on a time frame and time costs money and this would be getting more field data. So can you put in a couple monitoring wells out in that area where you don't have a lot of data?

MR. MASLIA: Let me address that specifically because that's what I picked up on the field data. Can we gather more field information, which we could gather in a shorter span of time compared to the effort of doing a full-blown calibration here. And that would really depend on discussions from our agency management and the Navy or the funding party. And could it either meet our existing time schedule or extend it less longer in time.

And that was one of -- I'm glad you asked that question because it fits right into, and maybe it was not clear why we went to Dr. Aral and his group at Georgia Tech to try to come up with an alternative method. After we finished Tarawa Terrace we saw the effort that went into it. And regardless of if you think the confidence is not large enough or narrow enough, you have a model that produces reasonable results.

And we saw the effort that went into it. Looking at what we had, just looking at the data that we have, it became apparent right away is what can we do to come up with some initial answers, not throwing out the baby with the baby carriage at the same time, but either using it as a starting point to help augment or help us jump start that or as a check.

As somebody said if we're going to spend another year or two years, you still have the question of how confident are you in those hydraulic conductivities or how confident are you in a much, much larger model. And so I made the decision to see if we could come up at least with a screening-level model, you know, something to put our teeth in.

I think your suggestion we need to talk about and think about could that Dr. Aral's method then also be combined in conjunction with maybe a small field effort to give us a method and some information to more rapidly get to the point of where we now want to distribute the --

DR. BAIR: I mean, I guess what I was getting at, Morris, is there a couple obvious areas where you need data? In the north part of your model area where you don't have many water levels, there aren't many pumping wells up there so a current water level would actually give you some guidance for applying backwards in time.

I also think you need to look at some of the confining layers in more detail, not only their lateral continuity but their permeability because they're restricting the contaminants flowing downward. And assuming one foot when the aquifers are ten feet per day, you know, a difference of a factor of ten isn't much of a confining layer. It's just the heterogeneity within most aquifers.

So I just thought it would be your time, Rene -- and I didn't mean to scare you with that and somebody else's money, but I just thought if there's an opportunity to discuss that, that there are some -- I don't think it's expensive. It's time that I got the impression that's pushing you.

And I personally would much rather you see take the extra year to get the answer right or closer. And it reminds me of that Jack Nicholson film with Tom Cruise where they were in the Marines and there was that -- what was the name of the movie? A Few Good Men, yeah.

And I show that, a clip in my class, and Cruise is on the stand and Nicholson says, "You can't handle the truth." Well, I turn that around and say, "You can't afford the truth." How much of the truth do you want to pay? And in the bottom line when you're done would have spending 25,000, 50,000, 100,000 more dollars to get more of the truth and lose a year, is that going to be beneficial. And that's not a decision for the panel. That's a decision up there. So that's my two bits.

MR. FAYE: Dr. Bair, how much differentiation in time can you get from the age-dating analyses that you're talking about? What was it, a helium/tritium type?

DR. BAIR: Well, I use this with one of my Ph.D. Students up at Woburn, and we used the tritium/helium dates to help calibrate our flow model. So we, too, were forecasting backwards in time, and what we were interested in is if our steady-state model or our transient model prior to turning on the wells, wells G and H.

Now that the wells were off in 2002, when we did the sampling, could we replicate those velocities in our model that we measured in terms of the groundwater ages in 2002. So they're two different times, but neither of them are transient at that moment because neither of the wells were on. And that gave us a comparison of physics-based travel times and chemical-based travel times. And it turned out to make us feel comfortable.

So I think what everybody's looking for here is for your models to demonstrate a level of professional comfort among all the different professionals in the whole room. And if tritium/helium helps you or some other technique helps you --

MR. FAYE: But what is your tolerance on those ages? I mean, is it like of you get an age of 1950, does that mean it was somewhere between 1940 and 1960 or, I mean, what's the tolerance there on that?

DR. BAIR: I have my Woburn presentation in here. Kip Solomon* did those for us at the University of Utah, and he puts an error bar on every one of those. So the error bars there are less than a year, slightly more than a year. And then we compared it to the error bars on our reverse particle tracking, which accumulates a conservative age.

And our error bars there were putting particles all over the well screens and tracking them backwards to the water tables. So we were looking for our variation in backwards travel times to be within Kip's plus or minus. And we did it pretty well except for the deepest wells that were closest to the metamorphic bedrock where they get a helium signature from the decay of some of the minerals in the granite.

So that's esoteric, but I think you need a little more field work.

DR. CLAPP: I was just going to ask Dr. Bair, actually, my impression is that that additional work in Woburn hasn't changed the results of the case-control study. And in terms of how it's implied or applied in epidemiologic study it may be been --

DR. BAIR: It's done subsequent to the case-control.

DR. CLAPP: Right, I understand, but would it have mattered in terms of the case-control study as an outcome?

DR. BAIR: I've shown our results to the Massachusetts Department of Health people, and they wished, they told me they wished they had had this when they had done their work. What my student was able to do is what you're asking yourselves to do is to come up with a month-by-month exposure concentration for each one of the water districts in Woburn.

Woburn has a very mixed system so the water distribution model was much different. And we're able to come up with bands of what the concentration would have been during gestation, during the first year, seven years, et cetera. And they didn't have that. I don't think most epidemiologists are used to getting that type of information. So it's something groundwater people haven't been able to provide with much confidence until the last many years. But, no, it didn't change them. They had already published it so Costace* and Condon*...

UNIDENTIFIED SPEAKER: (Inaudible).

DR. BAIR: I don't know. They would have had to have different approach because I, we can give exposures. I don't know if in terms of parts per million, micrograms per liter.

DR. CLAPP: They were looking at ranks and I doubt that the ranks would have changed much to be honest.

DR. WARTENBERG: Why didn't they re-do it if your data were available?

DR. BAIR: What's that?

DR. WARTENBERG: Why didn't they re-do it, their analysis?

DR. BAIR: I don't know, budgets.

MR. BOVE: I'll tell you one thing, if they have all the data it can't cost that much.

DR. BAIR: One of the problems we had there was statistics of really small populations so there are 28 children who developed leukemia in Woburn over that period of time, '68 to '84. Seven of them were involved in a lawsuit.

It's the lawsuit testimony that gave us the birth dates and the gestation periods. The other 21 sets of data are sealed by the State of Massachusetts under a nondisclosure agreement. So I have seven. I wish, you know, I tried bribery. I tried lunches, tickets to the Ohio State-Michigan game, everything and couldn't get those released.

MR. FAYE: Dr. Bair, let me ask another question. Most of the wells that were contaminated are destroyed now. They're not available for sampling, so what would an alternative be if we're lucky enough to have like a monitor well along the flow path or --

DR. BAIR: Yeah, you would want to use monitor wells along a flow path, and that's what we used more as a pre-pumping wells, G and H, potentiometric surface and particle tracking for was to determine a long flow path and then sample wells at distance along that flow path and then at depth.

DR. CLARK: Morris had a question.

MR. MASLIA: Yeah, a question. Combining two thoughts here, wells G and H at Woburn, I'm thinking they may, assuming you've got the data, there may be an opportune moment here to test out Dr. Aral's method on some real data.

DR. KONIKOW: I have a couple things, but one, you know, I think there can be some value to doing age dating, but I do think you have to be careful. This system has been so heavily pumped. Things have been mixed up so much in this system.

You have boreholes that are open to multi-aquifers. You have flow down the annulus. Getting an undisturbed, natural, a sample that reflects an actual travel time through the system under natural conditions. It may be difficult. It may be impossible. I don't know. I'm not saying don't do it. I think there is value of getting those age dates. But the band of uncertainty about your ages may be wider than the geochemists will tell you on the basis of the lab analyses.

Another point if we jump to the transport modeling -- well, let me go back one step. Again, on the age, the point I was trying to make there, whether or not you do the age dating and get the samples, I want to follow up on something that Scott suggested and reinforce that the use of MODPATH to simulate advective transport.

Even though it doesn't give you concentrations, can give you for such a low computational effort and low computational cost a lot of insight into how fast things are moving, where they're going, what the effects of transient flow are. Extremely valuable to improve your conceptual understanding at almost no cost. I mean, this is really relatively easy to do once you've developed a reasonably good transient flow model. And it's just a logical step to do before you go to the, all the headaches of transport modeling. And so I would really encourage you to add a few days or a few weeks to the timeline to get a lot of insight from the MODPATH.

MR. MASLIA: That's what we added. People would love it.

DR. CLARK: Mary and then Walter and then we need to get back on our video streaming again.

DR. HILL: Two things. One is you also mentioned stream flow data, and Cudgels'

[Codgels -ed.] Creek -- I don't know if I'm pronouncing that correctly -- is entirely within the model and there's, actually, you have several streams that are entirely within the model and many of them go under roads which provides perhaps when the road was constructed, they might have done some kind of analysis about stream flow that you can use to get a low flow measurement. You might have a fairly large, a small weight, a large variance on that. But it's extremely important to have some kind of flow data to compare your model against.

MR. FAYE: The USGS in North Carolina does have their standard regression equations with soils and drainage area and whatever for estimating average flow conditions and things like that. Probably in the upstream reaches of these streams that would be a possibility. The downstream reaches are all tidally affected, and Wallace Creek is tidally affected big time. So we could definitely take some shots at estimating a long-term average, low flow or average flow, whatever.

DR. CLARK: Walter, go ahead.

DR. GRAYMAN: Just briefly, just actually going back to what Ben was saying. I wasn't quite satisfied with the closure on the recharge issue. Within PEST do you set bounds on the, do you give it an initial recharge value and then set bounds on it and allow it to --

MR. SUAREZ: Yes, an initial value and you can set your bounds --

DR. GRAYMAN: I think we may be getting a little bit into an interface issue. And I'm talking about here an interface issue in terms of professions between surface water hydrologists and groundwater hydrologists. And then I think Ben is probably the only one here who's probably kind of the official surface water hydrologist.

MR. HARDING: ^.

DR. GRAYMAN: Well, but we're all hydrologists. I'm not sure that we really explored that as much as possible because I tend to agree with Ben. At least surface water hydrologists feel they can fairly well accurately estimate what the amount of water, at least entering the upper zones of the soil than maybe what groundwater hydrologists feel surface water hydrologists can do. I'll leave it at that.

DR. CLARK: Let's wrap it up then. We have, it's our break time, and we reconvene at 3:30 at which time we'll hear questions from the public.

(Whereupon, a break was taken between 3:15 p.m. and 3:30 p.m.)

MR. MASLIA: Panel members here because there's a decision or a thumbs up or thumbs down approach for the panel to -- because it's really your decision as panel members. So I'll just wait 'til all our panel members are here.

According to the schedule, we're supposed to have another half hour of discussion and then go into the public presentation part. We have allotted two hours. Right now there's a 30-minute presentation by a member of the CAP, Jerry, as well as a presentation-slash-statement by a member of the Department of the Navy, Dr. Dan Waddill.

What we're proposing was brought to my

attention by Scott Bair is he's got a prepared presentation for other purposes about Woburn that may have some important information for us in terms of what we're doing here at Camp Lejeune and I would be interested in it from a professional standpoint if nothing else, and it may, in fact, generate more questions.

So what I'm proposing is that we move the public presentation to start now. Do the public presentations and then we should have sufficient time for Scott to make his presentation and then we can follow that with additional questions. Is there any issue? Does anybody on the panel have an issue with that adjustment to the schedule?

Walter?

DR. GRAYMAN: Can we move Scott's to right at the end, the last thing?

MR. MASLIA: That's after the public presentations.

DR. GRAYMAN: Okay so the stuff you were talking about --

MR. MASLIA: Well, no, not his but it may add more information that we want to take into account to, and so we would basically end the day with maybe a longer discussion period than that. So is there any, is that okay with everybody?

DR. CLARK: Is that a problem with the, Dr. Waddill and Mr. Ensminger?

MR. ENSMINGER: No.

MR. MASLIA: So if that's the case we're into public presentations.

PANEL CHAIR ACCEPTS STATEMENTS AND QUESTIONS FROM PUBLIC
(REPEAT STATEMENT OF PURPOSE OF PANEL)

DR. CLARK: According to protocol I'm supposed to read the charge again to the panel so that everybody will know that this is a public meeting and what it's supposed to accomplish. So in order to follow protocol I'm going to do that if you'll bear with me.

This is an expert panel assessing ATSDR's methods and analysis for historical reconstruction of groundwater resources and distribution of drinking water at Hadnot Point, Holcomb Boulevard and vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina. The purpose and scope of this expert panel is to assess ATSDR's efforts to model groundwater and water distribution systems at the U.S. Marine Corps Base, Camp

Lejeune, North Carolina.

This work includes data discovery, collection and analysis as well as water modeling activities. To assist the panel members with their assessment, they have been provided with the methods used and the results obtained from ATSDR's previous modeling efforts at Camp Lejeune which focus on the area of Tarawa Terrace and vicinity. The panel is specifically charged with considering the appropriateness of ATSDR's approach, methods and time requirements related to water modeling activities.

It is important to understand that the water modeling activities for Hadnot Point, Holcomb Boulevard and vicinity are in the early stages of analysis; hence, the data interpretations and modeling methodology are subject to modifications partly based on input provided by members of this panel.

ATSDR expresses a commitment to weigh questions from the public and to respond to public comments and suggestions in a timely fashion. However, in order for this panel to complete its work, it must focus exclusively on data discovery and analysis and water modeling issues. Therefore, the panel will only address questions or comments that pertain to data discovery and analysis and water modeling efforts.

For all non-modeling water questions or statements, the public can contact the ATSDR Camp Lejeune Information Hotline at telephone 7-7-0-4-8-8-3-5-1-0 [770-488-3510 – ed.] or e-mail atsdrcamplej@cdc.gov.

REPRESENTATIVE OF CAMP LEJEUNE COMMUNITY ASSISTANCE PANEL (CAP)

And with that, why, we can begin the public presentations and we're going to hear from Jerome Ensminger first.

MR. ENSMINGER: Good afternoon. My name is Jerry Ensminger. I am a member of the ATSDR's Camp Lejeune Community Assistance Panel, and I've been involved in this incident since August of 1997. Over these past 12 years I have viewed thousands of documents related to this situation and what I have discovered is both disheartening and disgusting.

Department of the Navy and United States Marine Corps officials and representatives have in the past and continue right up to the present to misrepresent and deny the facts. They have done this by making false and misleading statements, providing incomplete or false data and by withholding key data that is crucial to the findings of truth in this situation.

I don't expect any one of you to take my word as proof of these serious allegations I'm making against these supposed honorable government entities. That's why I've provided all of you with some of the actual historical documents which came directly from their files so you can witness the deception with your own eyes.

Now, I want to take you through some of these documents, and you have them in a binder there in front of you, and I've picked out some key documents. And these are only a few examples of what went on here.

But the first document is a letter dated 3 February from 1986 from the United States Environmental Protection Agency Region Four. And it states, "Dear Sir: On November 1st, 1985, Messrs. Mathis and Holdaway of this Agency met with Facilities Engineering Staff at Marine Corps Base Camp Le Jeune."

Okay, I want to skip down to the second paragraph, what's highlighted on your document. "Both Messrs. Holdaway and Mathis became aware that there was evidence from sampling as early as 1983 or 1984 of diffuse contamination of the groundwater with unspecified organic substances, and that as a result of detection of unspecified volatile organic compounds in raw potable water samples, certain potable wells at Hadnot Point were taken out of service. In consideration of the fact that the major portion of the resident population of Camp Le Jeune is dependent on Hadnot Point well field as its potable water supply, the parties in the meeting agreed that any potential contamination of this resource should be investigated as expeditiously as practical. It was also established that there was no contamination detected in treated potable water..."

Let me say that again. "It was also established that there was no contamination detected in treated potable water distributed at Camp Le Jeune, however the extent and sensitivity of analytical procedures for specific organic substances was not fully discussed."

This was 1986. They found contamination in the potable water at the tap in Camp Lejeune as early as 1980. Let's go down to the second page of that letter.

It says, "This Agency is concerned that a potential for human exposure to hazardous substances and hazardous wastes via the Camp Le Jeune water supply may exist due to the presence of such materials in the groundwater in the general vicinity of the potable well field. The existence of such a potential exposure would warrant consideration of this area for inclusion on the National Priority List, with an attendant increase in the expediency of investigation and remediation." Now, the EPA didn't believe them and that's why they recommended this to go on.

Now, this next document comes from a technical working committee which was the predecessor to the Restoration Advisory Boards for the EPA. And they had members from the EPA. They had members from the state environmental regulatory agency there. They had members from the local community there. They had members from the LANDIV* [LANTDIV - ed.]. And this is a court-recorded document, and the gentleman by the name of Bittner was the City Manager for Jacksonville. And they were discussing the contamination in the Hadnot Point system at this point.

And Mr. Bittner asked the question, "What kind of tests were you getting when you were running those contaminated wells in terms of water quality?" He says, "I imagine it would be pretty much diluted but you were still probably getting some readings if you ever took a scan."

Mr. Bob Alexander who was the environmental engineer for Camp Lejeune answered his question. He said, "We had very little, if any data, before we realized our ground water was contaminated." I mean that is an out-and-out lie.

So Mr. Bittner follows up. "So there's no record of it in terms of what you were pumping." Alexander, "We had some tests--like at the Tarawa Terrace area--before we realized that ABC Cleaners was polluting our wells there. We had some tests and ended up with some measurable concentrations. But they were almost at the detectable level. When you're taking out of the Hadnot Point area 35 wells that had been servicing that system, probably a well would only run for about two days. It would only be about five or six wells running, so we had a rotating cycle of operating on those wells. It would be practically impossible to say what wells contributed what compounds on any given day. You'd have to backtrack from the residence time in the reservoir and all that to see what wells were going two days ago."

So Bittner says, "And, basically, Bob, there's no record of that." And he says, "It would be practically impossible to track that down."

And then Ms. Cheryl Barnett, who was a representative from ~~LANDIV~~ [LANTDIV -ed.] up in Norfolk, Department of the Navy, who is by the way now a high ranking official up there with their environmental branch, Barnett pipes in and says, "There were no requirements, you know, the requirements to test your finished water for VOCs; it's a new requirement. It's a new EPA drinking water requirement, so there was no prior testing program before. It is just purely in the course of this investigation that we discovered that problem to begin with and since that time they've been monitoring the finished water effluents, but it was never a requirement."

Now, that statement, "it was just purely in the course of this investigation that we discovered that problem to begin with..." This is a person that was trusted with our environmental health. She is a high-ranking official now in the Department of the Navy's environmental program. I want you take a look, and she was talking about the confirmation study when they discovered this contamination.

This letter was written on 10 August, 1982, by Grainger Analytical Laboratories out of Raleigh, North Carolina. The chemist up there and the part-owner of the laboratory saw these samples, saw the interferences in the TTHM testing that they were doing, and they took it upon themselves to isolate the interfering chemicals and quantify them. And they wrote this letter to the Commanding General of Camp Lejeune.

Previously all samples from site TT and HP, which is Tarawa Terrace and Hadnot Point, "presented difficulties in performing the monthly Trihalomethane analyses. These appeared to be at high levels and hence more important from a health standpoint than the total Trihalomethane content. For these reasons we called the situation to the attention of Camp Lejuene personnel. Results: The identity of the contaminant in the well field represented by samples 206 and 207 was suspected to be Tetrachloroethylene.

And at Hadnot Point it was Trichloroethylene. If you'll go to the second page of that letter, there's where they broke it down. Those were the results that they got from those samples. Sample 120 was Hadnot Point tap water, 1,400 parts per billion.

Whenever the fuel leak took place at

the Holcomb Boulevard water system in January of 1985, they called the state in to do split samples because they thought they had all their contaminated wells offline already anyhow. Guess what? They still had one, one contaminated well online, Well 651 at Hadnot Point. They had shut the Holcomb Boulevard plant down and opened the valves up and put them back on Hadnot Point water to flush the system out, to flush the fuel that had leaked out of a backup generator line into their treated water storage tank.

These were the samples, these were the results of the samples that the state took. Now, this was dated, well, you can see the date of the analysis, February of ’85. Now these people sat in these meetings subsequent to these tests, these analytical results and those initial letters that I read to you, and lied. I mean, this was one contaminated well that was creating these results in February of ’85, 1,148.4 parts per billion at the elementary school in Berkeley Manor housing area.

If you’ll go down to your next

document which is a TTHM test. When the TTHM regulation was coming into effect, the Department of the Navy contracted with the Department of the Army to have their environmental hygiene team come to Camp Lejeune and other Naval facilities and do, start doing TTHM tests for their water systems. You can see this one was dated 29 December, 1980. The first test that they did was in October of '80. You can see what they wrote down here at the bottom, heavy organic interference. You need to analyze for chlorinated organics by the GC/MS method.

Go to the next one, January of '81. You need to analyze for chlorinated organics by GC/MS. February of '81, water highly contaminated with other chlorinated hydrocarbons, in parentheses, solvents. Yet these people sit in meetings and say they didn't know?

ATSDR, you know, while they've had their own faults throughout this process, has had one devil of a time trying to get information from these people. There has been stonewalling, you name it. This is a letter written on September 2nd, of 1994 from ATSDR to what was known as the Navy Environmental Health Center then, complaining about Camp Lejeune, about the Marine Corps and Department of the Navy, about getting documents and data.

ATSDR identifies and obtains documents needed for evaluation to develop the public health assessment by discussing the public health issues with the installation and having them send us documents where the information can be found. As you are aware, we have had much difficulty getting the needed documents from Marine Corps Base Camp Lejeune. We have sent Marine Corps Base Camp Lejeune several requests for information and, in most cases, the responses were inadequate and no supporting documentation was forwarded. That was September 2nd of 1994.

Go down to these e-mails. Ms. Kelly Dreyer, who worked at Headquarters Marine Corps, was put in charge of the Camp Lejeune water contamination issue. ATSDR had been provided incorrect water system data for not only the public health assessment, but for a study that was being done on small for gestational age in adverse pregnancy outcomes. They never told ATSDR that the Holcomb Boulevard water system wasn't constructed until 1972.

ATSDR went through this entire process thinking that those, all those housing areas on the other side of Wallace Creek on the main part of the base, three major housing areas: Midway Park, Berkeley Manor and Paradise Point were always on that clean Holcomb Boulevard system. Well, the study period for ATSDR was 1968 through 1985. Well, the Holcomb Boulevard plant wasn't built 'til '72.

When I first saw that study, and it came out -- well, it came out a long time ago, but the first time I really looked at it in depth, I said what the devil's going on here. They only had 31 babies identified in that study as being long-term exposed in utero to trichloroethylene, TCE. I said that can't be right.

I called Dr. Bove up -- I didn't call him. I sent him an e-mail. And he sends me an e-mail back and he goes what the hell are you talking about. So I picked the phone up and I called him, and I said you had I don't know how many thousand housing units over there, I said, that was, I said, the Hadnot Point water system wasn't constructed 'til '72. I said you only identified 31 babies in this study as being exposed to trichloroethylene, and I said, all those housing areas were on Hadnot Point water all those years. He goes oh my god.

Now when the Marine Corps was asked why they didn't provide the correct data whenever this e-mail was sent to them by Kelly Dreyer, who was the project manager for this thing, Tom Townsend, who is a retired major and lives in a cave out in Idaho -- he doesn't really live in a cave, but he likes to say that. He's like a hermit.

But he wrote over a thousand FOIAs. He lost a son and also his wife, and he was very diligent in writing Freedom of Information Act requests. And Tom Townsend identified this. And Tom Townsend you've got to understand, everything he writes, he does it by hand on a yellow legal pad, and that's his official correspondence. He don't type.

He doesn't use a computer, and that's how he sends his stuff out.

The Marine Corps said they used, they saw that he had copied ATSDR on his initial letter pointing out this incorrect data. So they surmised that ATSDR was going to use his letter pointing out the wrong, the incorrect water system data as their notification. They said this in a press interview with Dan Rather and an AP article.

Well, you saw what kind of trouble ATSDR had on 2 September in 1994. Here's a letter from December 9th of 2005. "ATSDR has experienced delays in obtaining requested information and data pertaining to historical water-quality sampling data and site remedial investigation reports." And they were told.

"ATSDR staff is attempting to meet the project completion timelines discussed with Marine Corps staff in August. To do so, we must be provided all documents that relate to base-wide water issues immediately. The Marine Corps is responsible for the identification and timely sharing of all relevant documents relating to the base-wide drinking water system. This includes documents that ATSDR may not be aware of as well as documents that are in possession of DOD but may no longer be located at the Camp Lejeune base. Discovery of this documentation must not rely on specific requests from our staff, but on our shared goal of ensuring scientific accuracy of our study and DOD's responsibility to provide the information. ATSDR staff can coordinate with the United States Marine Corps staff to determine the appropriateness of any document as it relates to our study. We request that your staff verify and confirm the existence of the documents listed in the attachment. We also request that your staff identify for us any other documents that may be useful to ATSDR for its water modeling analyses," and it goes on and on.

Yesterday we find out, we had our Community Assistance Panel meeting, that there's another whole file of documents related to underground and aboveground storage tanks, some electronic portal from a contractor. I mean, this never ends.

These are a few examples of the misinformation, disinformation, half-truths and outright lies that have been told by representatives of the Department of the Navy and the United States Marine Corps. There are many, many more. They have provided inaccurate data to the ATSDR, they have misrepresented the levels and the extent of the contamination to the media and to the public at large. They have, and they continue to misrepresent their negligent behavior which created the conditions that led to the drinking water contamination aboard the base.

Their negligent behavior was they just ignored it. They had warning after warning after warning. They were told by I don't know how many different analytical laboratories in I don't know how many analytical samples and results that they had a problem with these contaminants, and they never tested their wells. They never tested the individual drinking water wells until they started in July of 1984 knowing full-well they had a problem.

The Marine Corps' representative, who

did the interview for Dan Rather's story last October, was a Lieutenant Colonel Mike Tencate from Headquarters Marine Corps. He's a lawyer. He sat right there and told Mr. Rather that whenever they discovered that they had a problem with their wells, they took them offline. Mr. Rather asked him, he said where do you get your water? He said from wells. But you never tested them? You knew you had this stuff in your tap water, you never tested them? He repeated his answer again. Whenever we discovered that it was in the wells, we took them offline.

They tried to make the excuse that they thought they had AC-coated pipes that was creating this stuff in the water. Trouble is they never went back and even checked what the construction materials of their own water system was to verify or deny that claim. Morris, in his water modeling, has shown that there was only AC-coated pipes in one water system, and that was Holcomb Boulevard. The two highest contaminated systems had none in it, Tarawa Terrace and Hadnot Point.

And in my statement here it says in a

recent interview with Dan -- I already went over that. As soon as they discovered he said they took the wells offline. Well, the sole source for drinking water at Camp Lejeune are deep ground water wells. Exactly where did the authorities at Camp Lejeune think this contamination was coming from or emitting from. It wasn't coming from the supply wells. Perhaps they had some rogue water treatment plant operator at the treatment plant pumping these chemicals into their treated water, right?

The truth is that base officials knew about it by August of 1982 that the well fields for Tarawa Terrace and Hadnot Point were the source of the contamination aboard the base's water supply system. Instead of decisive action, excuses were made, the base supervisory chemist offered a suggestion that some of the contamination could be coming from asbestos coated pipes in the systems. Well, the only instances where any contamination was discovered in that system was when the base operators were opening in the clean Holcomb Boulevard system, was when the operators were opening and closing the isolation valves which interconnected the Holcomb and Hadnot Point systems.

And, you know, there are some very pertinent questions which need to be asked here. Why didn't the Department of the Navy and USMC officials research the construction materials of the contaminated system back in the early 1980s? The main question would be why did it take more than four years to sample the supply wells? In that, that question has been asked multiple times and no one can get a straight answer from the Department of the Navy or the Marine Corps.

It was my understanding that this expert panel was requested by the Department of the Navy. It is my opinion that they are hoping that this forum will kill the Hadnot Point water system modeling. In fact, I believe they would like nothing more. If science is ever going to have a better understanding of the effects of these chemicals have on human beings, it is imperative that this effort continue. If the victims of this tragedy are ever going to fully understand what they were exposed to or what caused the death of their loved ones or their illnesses, this water modeling effort must be seen through to its completion.

And my involvement in this is my daughter, Janie, was the only child of mine that was conceived while her mother and I lived at Camp Lejeune in one of the contaminated housing areas. When Janie was six years old, she was diagnosed with acute lymphocytic leukemia. I watched Janie go through hell for two and a half years before her ultimate death.

And from the date of her diagnosis until the date that I found out about the contamination, I did what any normal parent that had a child, who lost a child to a catastrophic long-term illness would do. I wondered why. And it was fourteen and a half years until I was walking in the living room with a plate of spaghetti to watch the evening news and the Public Health Assessment had come out. And one of the local TV stations picked up on the story and did a blurb on the evening news.

And I was -- I just walked into my chair. I was standing there and the reporter said the contaminants that have been found in Camp Lejeune's drinking water from 19 -- they erroneously said from 1968 through 1985 at that point -- were linked to childhood cancer, primarily leukemia. I dropped my plate of spaghetti on the living room floor, and it was like God had opened the sky up and said, Jerry, that nagging question that has been with you for fourteen and a half years, here is a possible answer to it, not a confirmed but a possible one.

And I started making phone calls and started digging. Here I am. That was August of 1997, and I've been asked when I'm going to give this up. And I've made the statement to the press and I made a statement indirectly to the Commandant of the Marine Corps. I said I'll give this up when you do what's right by our people or when you pat me in the face with a damn shovel and blow Taps over me, that's when I'm going to quit. And I mean it. Thank you.

DR. CLARK: Mr. Ensminger, we thank you for your statement. Would you be willing to take some questions?

MR. ENSMINGER: Certainly.

DR. CLARK: Does the panel or anyone in the audience have any questions or comments?

MR. HARDING: Bob, I have some for Mr. Ensminger. I suspect I know the answer to this, but I'd like you to address it directly because one of the charges that we have is to ask if the timeline of this study is sufficient. And you've heard, you've been here the whole time. You've heard all of the discussions about the technical difficulties and the complexities of this and some discussion about whether it can be done by, what is it, December. And I wanted to know what you and also your sense of the rest of the stakeholders you're associated with think of a longer time to get an answer if the answer could be better.

MR. ENSMINGER: I, personally, and I know some people that said, you know, that there's been enough time spent. Those people aren't really as deeply involved in this, but anyone who is deeply involved -- and Mike Partain is another victim back there.

He was born at Camp Lejeune. His father and mother lived there, and he was conceived there and born there. He ended up with being diagnosed with male breast cancer two years ago. We've also identified ten other cases of people at Camp Lejeune, either dependents or male Marines who had breast cancer.

But to answer your question, I know science takes time; good science does take time. And I have no qualms at all with taking more time to ensure a good product, and that's my answer.

DR. HILL: Just a quick question, the excerpt from CERCLA 47, do you have a year for that?

MR. ENSMINGER: A year? Yeah, it was May -- no, I'm sorry, August of 1988.

DR. HILL: Nineteen eighty-eight. Thank you.

DR. CLARK: Any more questions or comments from panel or audience?

(no response)

MR. ENSMINGER: Now, to go back to that other question about how much time it's going to take. What I do take exception to is the dragging this thing out by the trickle of documents. And every time something new comes out it kicks this thing to the can further down the road, and that pisses me off. I mean, I should say it frustrates me. Dr. Sinks does not like some of my mannerisms. I'm me. I'm a retired former Marine. I was a drill instructor and I am what I am and you get what you see.

DR. CLARK: Anyone else have comments or thoughts, questions they'd like to raise for Mr. Ensminger?

MR. HARDING: I just have a comment to the panel. Just many of you may be aware of this, but there was a, if you will, an epidemic of TCE contamination events discovered in the fall of 1980, and I guess Bob might know this. I think it was a regulatory requirement at EPA that this testing for THMs be done.

And I've seen other documents just like this. And it, literally with the GC trace on it with an arrow saying, you know, possible TCE contamination. And this is how, I know it was true in Phoenix. I think it was true in Redlands, California. I can't remember, a number of the cases that I've seen where this October of 1980, there's a lot of this that went on.

DR. CLARK: It turned out that when we were working on the THM methods that they were very good for capturing VOCs at the same time. And it was kind of a confounding and puzzling effect. But the point that Mr. Ensminger makes is absolutely valid. And I do have a question.

First, Mr. Ensminger, you identified correctly, I think, the fact that the THM samples had VOCs in them. Did you look at anything other than just the three samples that you --

MR. ENSMINGER: Oh, yeah, there's many more. I mean, there's, we've got a whole file of the TTHMs from the Army Environmental Hygiene team and then the Grainger Laboratory that wrote the letter. We understand that they were told by the Department of Navy to quit quantifying the amount of chemicals, the interfering chemicals, they were finding.

So they put on there by it with an asterisk that this chemical was still being found in that water system and tetrachloroethylene was still being found in the Tarawa Terrace system. They quite quantifying it, but the actual analytical results, there's many of them, and they're in the files.

DR. CLARK: Did you do any looking at samples at a given location over time, for example, after those wells had been taken offline to see if there'd been changes in the THM values?

MR. ENSMINGER: I really didn't see that many TTHM samples after the fact. I don't know. I haven't seen them. I'm sure they're somewhere.

DR. CLARK: They would be required to submit them to the state, but that's something --

MR. ENSMINGER: The State of North Carolina is like, you know.

MR. PARTAIN: Jerry, that had that TTHM problem, too, at the air station.

MR. ENSMINGER: Yeah, they had a problem over at the air station with TTHMs. They exceeded the MCLs at the air station. And they had salt water intrusion over there.

DR. CLARK: Probably brominated compound. It's probably getting brominated compound.

MR. ENSMINGER: Yeah, that's what it was.

DR. ASCHENGRAU: I just want to follow up with you or the ATSDR folks about that file that you said was, came to light yesterday.

MR. ENSMINGER: Yeah, Morris had that on one of his slides this morning.

DR. ASCHENGRAU: So has it been given to ATSDR for review to see if there's any useful information in it?

MR. FAYE: That's your call, Morris.

MR. MASLIA: Bob's punting to me. Actually, in a series of e-mail communications between Bob, myself and the Marine Corps we became aware of it the beginning week of March of this year. And we did ask, it's, as Jerry pointed out correctly, it's housed at a website, web portal, by a consultant to NAVFAC, Katlan Associates, Katlan Engineers.

We have been given a password and access to that. Bob initially downloaded over 100 documents. We have -- not pages, documents some of which are hundreds of pages long -- and that's why I referred to it as information because we've done an initial catalogue of that. We've got that on an Excel file.

And that's when I was discussing earlier today that perhaps one way to use this in the most efficient manner as the universe of information is expanding and trying to stick on some timeline, whatever that may be or the panel recommends, would be to view this as a second, quote, independent set of data that we might cull from those documents. Develop a model, calibrate to a set that's already been described here that Rene and Bob and Barbara have described, and then perhaps be able to test or give ourselves more confidence on running the model with this second set.

That would do two things. One, it would not completely ignore this other data. It would keep us going down the path, but it would also answer questions that we, as people have pointed out that with Tarawa Terrace we did not have the opportunity to because the data just weren't there as a second set of information. So that's thrown out.

Consider in your recommendations, if you would, for the panel members. But that's our thinking right now is that is a possibility. Obviously, you have do nothing with it, which I don't want to go down that road, or incorporate it with our current data, which we know how long we've been, what, since June of 2007, Bob?

MR. FAYE: Probably a year and a half.

MR. MASLIA: A year and a half already on data analysis and going through these documents and stuff like that. So if the panel would, I think we would appreciate some feedback on that.

DR. ASCHENGRAU: And then there's really no way of knowing right now if there are still yet other undiscovered sources of information?

MR. ENSMINGER: Well, we know that there's some key stuff that's missing from the files. I don't know if -- one thing I forgot to mention was that there's an Associated Press article out today, ATSDR withdrew the entire Camp Lejeune Public Health Assessment yesterday.

DR. HILL: What does that mean?

MR. ENSMINGER: It's invalid. Benzene was left off of it. And we found, Mike Partain, who's my brain back there, he's been a godsend to me. We've been going through all these CERCLA documents and putting two-and-two together, and we discovered that the contractor that was doing the confirmation study at Camp Lejeune in 1984, in their plan of work and safety, work and safety plan for their contract in early 1984, agreed to a monthly progress report on their efforts to, on the confirmation study on all the contamination sites on the base to start in 1984.

We found the progress report for May, June and July. And in July the first samples were taken of monitoring wells and water supply wells that were close to the contamination sites. Oddly enough, we don't have any more progress reports for that confirmation study. They ended at July. So when they would have got started getting the results back, the August, September, October, November reports, they're missing from the files.

But we did find a report of the analytical data. We can't even find the confirmation study report. The Marine Corps absolutely refused, they disagreed with the conclusions. I've got this in writing. And absolutely refused to release that report to any outside agency, but they did agree to release the analytical data.

We found the results from the July sample from Well 602, which was right by the Hadnot Point fuel farm, and it had high levels of benzene in it in July. Do you know when the well was taken offline? 30 November. You can't tell me this company didn't alert them that they had high levels of benzene in that well when they found it in that analytical result. That's why we can't find the progress reports for August, September, October, and November.

DR. ASCHENGRAU: So I do think it does fall within our purview to make a recommendation that all of the relevant information should be given to the research group and that would affect our other recommendations for the modeling, et cetera.

MR. ENSMINGER: That would be appreciated.

DR. CLARK: Morris wants to say something.

MR. MASLIA: Yeah, I want to clarify for those who are on the panel who are not really familiar with the Health Assessment process. What Jerry just mentioned that the Health Assessment for Camp Lejeune, it's the 1997 Health Assessment, was pulled.

In a series of discussions, as Jerry said, one of the factors were -- and this is in one of the tables, I think Table 8 or C-8, C-10 in Bob's report -- you'll see benzene levels 720, 380 and so forth. That was completely omitted from the Health Assessment. That's point one. Yet, a year later, the 1998 Health Study coming out of Frank's division, mentioned benzene contamination of 700. So obviously, the data was not put into the Health Assessment.

Other issues, as have been pointed out previously, was the start-up date with the Holcomb Boulevard plant was incorrect. There have also been issues of, I guess when ATSDR was moving offices, some of the original references to support the Health Assessment cannot be located.

MR. ENSMINGER: Not some, all. They can't even provide the supporting documentation for the thing that created the document. How in the hell can you make a stand, stand on a document and stand behind it when you don't have the supporting documents that it was created from? It's worthless.

MR. MASLIA: As a consequence, yesterday our Division Director and Tom Sinks told the CAP that the Health Assessment, the 1997 Health Assessment, was being removed from the website. It's still, as any document would be, in hard copy if someone requests it. But if they request it there'll be a caveat or some letter with it explaining that.

And, of course, then they would wait until we finish the current study investigation for Tarawa Terrace and then also the Hadnot, Holcomb Bridge area to do whatever Agency management decides what approach they want to take. So I just wanted to clarify that for those who are not familiar or with the Health Assessment itself.

DR. CLARK: Walter, you wanted to make a comment?

DR. GRAYMAN: Yeah, this morning there was at some point, there was a graph shown in which it showed that there's a lot more data available from 1998 to the present time. And the explanation was that, and I can't remember whether it was federal or state law regulations that the utility hold onto the records for ten years. Is there something that can be done to ensure that that period is extended so we don't start losing data that becomes ten years old and then is lost?

DR. CLARK: I'm assuming that that's probably a state agreement in conjunction with EPA, but I don't know that.

MR. ENSMINGER: It's a CERCLA requirement. And it's required to be maintained for 50 years on any site that's declared a ~~super fund~~ [Superfund -ed.] site. And there's all kinds of stuff from Camp Lejeune missing. Now they keep saying they have this seven year, in-house requirement to purge their files. I hate to tell them, but they're in violation of the CERCLA laws.

And, you know, Morris and Bob Faye had an experience up at the State of North Carolina's archives when they were trying to find all the operating permits for the water system at Camp Lejeune. And they went in there, and they found everything from the beginning of the base, to the opening up of all the different water treatment plants, the water distribution systems, and it went from 1941 to all the way up to, what, 1968, or no, '68? And then from '68 all the way to 1990 or '91, the file folder was there. Everything was gone. And then from that point to present everything was there. You tell me.

DR. CLARK: Any more questions of Mr. Ensminger?

(no response)

DR. CLARK: Comments?

(no response)

DR. CLARK: Well, thank you very much for your presentation. I think --

DR. CLAPP: I was just going to say the same thing the Chair just said. I'd like to thank Jerry for his service and his presentation.

DR. CLARK: Well, I think he reminds us that there's a human dimension to this study that we have to keep in mind. I think we, it's very easy, as you can, if you remember from the previous discussions today, to get lost in the science and the wonders of that aspect of what we're doing. And we'll have more of that tomorrow, but there's a human, real tragedy in some sense, involved in this situation.

MR. ENSMINGER: We have a website we created for the victims of this thing, and it's www.TFTPTF, that's the abbreviations for The Few, The Proud, The Forgotten-dot-com. And I'm going to tell you, people contact me all the time. You would not believe the cases of non-Hodgkins lymphoma, the cases of leukemia, liver cancer, kidney cancer, bladder cancers of former Marines and sailors and their family members that are coming to our website.

It's horrible, and I'm fearful, when we finally do find out the truth in this thing, when we uncover it, we're going to be uncovering one grave at a time. I hope not, but I believe that's what's coming. And I have one more thing to say. You saw the examples of the lies. You've got them right there in your hands. There's only one reason to lie, and that's because you're guilty.

MR. PARTAIN: I'd also like to invite the members of the panel, on the website there is a historical timeline of events that's referenced with actual documents. Most of them are available on the website. We can pull a document up and read that. It's under the historical document section.

It's rather long boring reading, but it at least gives you an idea of what happened. And that goes from basically 1950 to 1989, and I'm currently working on the second half of that project, 1990 to the present day. And there's also on the discussion board on the website there is a discussion called Betrayal of Trust and Honor, which is an historical discussion.

My degree's in history -- I'm a former teacher -- you'll see I can read the stuff. And it's all referenced to historical documents, too, and that will give you an idea of what was going on. Jerry mentioned in his presentation about Cheryl Barnett saying that we didn't know until this study. Well, the study she's referring to is the confirmation study of 1984.

DR. CLARK: Thank you very much.

DR. GOVINDARAJU: Actually, could you please repeat that website again? I wrote it down.

MR. PARTAIN: It's The Few, The Proud, The Forgotten. If you take the initials, Tango, Frank, Tango, Peter, Tango, Frank-dot-com, TFTPTF.com.

DR. CLARK: Mary.

DR. HILL: So there's been mention of health effects that are further along in life than some of the ones that are formally being considered here. And I assume there was some investigation into those and there wasn't enough data to support that, but I just wanted to -

DR. BOVE: No, no, no, no. That's our future studies, which we can talk about at some point if we -

DR. CLARK: I suspect we'll end up discussing that further on as we get further into the discussion. I have the same reaction that you do.

Any more comments, questions on this particular, on Mr. Ensminger's presentation?

(no response)

DR. CLARK: Okay, to continue on --

MR. HARDING: Bob, just a comment on what Frank said and Mr. Ensminger, I wasn't completely clear that there were going to be follow-on studies, but it just raises the point again that this, that the key to all of that is going to be the exposure information. And so it's important that that be done as well as it can be. And I want to encourage, and this will be something I advocate in the panel, that ATSDR really focus its efforts on the things and maybe we can help them do that, that are most important to getting that information.

DR. CLARK: Very good comment.

Anything else?

(no response)

<u>REPRESENTATIVE OF DEPARTMENT OF NAVY</u>

DR. CLARK: We'll let Mr. Dan Waddill from the Department of the Navy ~~to~~ [-ed.]continue and I guess conclude our public discussion.

DR. WADDILL: Well, my name is Dan Waddill and I'd like to thank you all and ATSDR for this opportunity to address this expert panel. I work in the Navy's environmental clean up program as the head of the Engineering Support Section at NAVFAC Atlantic. My group provides technical support for Navy and Marine Corps sites across the continental United States and Alaska.

My educational background is in modeling of groundwater flow and contaminant transport, and I've been involved in numerous applications of these models at sites, Navy and Marine Corps sites. Last year I contributed to Navy comments on the ATSDR water modeling report for Tarawa Terrace, and I believe you have copies of those comments and responses.

I would like to say that the Navy and Marine Corps fully support the scientific effort to determine exposure concentrations and their effects at Camp Lejeune, and in particular, we support the work of this expert panel, and we do thank you for your efforts. As you move forward with your discussions today and tomorrow, I'd like to ask you to consider three issues related to the groundwater modeling efforts.

But before I do that I'd like to explain how I'll use the words accuracy and precision in my comments because I think that will help clarify what I'm talking about. In the way that I'll use it accuracy is the extent of agreement between model output and measured data, and accuracy would be estimated by comparing the model to the real world.

For example, at Tarawa Terrace we would compare model-simulated PCE concentrations with measured PCE concentrations and that would give us a sense of model accuracy. Precision is the extent of agreement among various model runs, so precision would be estimated by comparing one model run to another as we do, for example, during Monte Carlo analysis.

So to get to the first issue in the existing charge to the expert panel, Section 2B asks which modeling methods do panel members recommend ATSDR use in providing reliable monthly mean concentration results for exposure calculations. And we certainly think that is a good question for you to consider.

In addition to that I'd like you to consider a more preliminary question which is, or issue, which is whether or not modeling at Hadnot Point is capable of providing reliable average concentrations on a month-by-month basis. And in other words can we expect the model to distinguish concentrations from one month to the next with a degree of accuracy that would be useful for the epidemiological study or is monthly simply too fine a resolution for the model to achieve.

And why do I ask you to consider this issue? Well, we know that the modeling efforts at Tarawa Terrace and Hadnot Point both face a fundamental difficulty caused by the limited availability of real-world concentrations. The models are being asked to reconstruct historical concentrations back to the '40s or '50s, but prior to the 1980s there are no measured concentrations of PCE, TCE and the other contaminants.

For Tarawa Terrace ATSDR determined, and the Navy concurs, that there is not enough measured PCE data for a meaningful model verification step. And since measured PCE concentrations are available only in the 1980s, model output from the late '70s or early '80s back to the 1950s cannot be compared to actual PCE data.

And we know that we have to ask the model to fill in data gaps. If we had enough measured data, we wouldn't need to model at all. We'd just use the measured data. But the question is, is 30 years, is that too big of a gap to be filled in by a model on a month-by-month basis.

To evaluate model uncertainty probabilistic analysis was used at Tarawa Terrace, numerous model runs compared against each other. So that gives an idea of model precision and the uncertainty based on model precision. And this is good information. It's a standard modeling technique, standard approach. And it gives us a sense of how tightly clustered that model output is. But it doesn't necessarily tell us if that cluster of output is centered around the real result. Is it hitting the real-world target?

For Hadnot Point the situation is similar in that the model would need to extrapolate concentrations back in time over roughly 30-to-40 years. As we've discussed already, the overall situation at Hadnot Point is that it's significantly larger and more complicated than Tarawa Terrace was.

So the second issue I'd like to look more closely at model uncertainty, as I mentioned before at Tarawa Terrace, probabilistic analysis was used to examine uncertainty with respect to model precision. And this work occurs in the model world. I would also like to examine how the model compares to the real world and that would help us better understand uncertainty with respect to model accuracy.

And obviously there are long stretches of time without real-world concentrations, you know, they're just not available for comparison. But we do have those in the 1980s, and those comparisons were made for the Tarawa Terrace model during calibration. So that degree of fit that was attained during the model calibration gives us a sense of the uncertainty that we might expect with respect to accuracy of the model.

For the earlier decades when we can't compare the model to real-world concentrations that accuracy is somewhat unknown, and I guess I would ask you to consider whether we would think the model would be more accurate in those earlier years than it was in the '80s or might it be similar.

And so just to sum up, I think it's important to consider the model precision, model accuracy, and to consider how the uncertainty in the accuracy can be assessed and conveyed to the model users. That would include the public as well as the epidemiologists.

Just as an example, you know, this morning when Dr. Bove showed the table of monthly model-derived exposures, the panel, you all asked, commented on the three significant figures. And there's a comment that it might be appropriate to show a range of values instead of a single value. And I certainly think that these are good suggestions, and it would be helpful to know what that range would be as we move forward.

And just as an illustration, and I'm picking these numbers out of the air, if we have a value of 90 micrograms per liter, does that fall within a range of 60 to 150 or is the range more like 30 to 300 or is it 10 to 1,000. It would just be useful to have this kind of information passed along to the users of the model.

And the third issue is related to the second one. I'd like to look more closely at model calibration. The existing charge to the panel asks whether there are established guidelines for applying calibration targets and what the calibration targets ought to be, and again, I think this is very useful and appropriate.

Given that approach though I'd like to ask the panel to consider also how the model results ought to be interpreted when the calibration targets aren't met. And maybe that's not a good way of asking that question.

I thought perhaps a better way and a more general and useful way to ask that question would be simply how do we assess and convey to model users the performance of the model during the calibration process. And I think this is important because it will shed light on model accuracy and the uncertainty associated with accuracy.

So just to sum up I'm asking the panel to consider three issues. First, given the limited availability of measured concentrations and the site-related difficulties and uncertainties that we've talked about, would modeling at Hadnot Point be capable of providing reliable average concentrations on a month-by-month basis?

And second, in addition to considering uncertainty with respect to model precision, how should uncertainty with respect to model accuracy be assessed and conveyed to the model users?

And third, how do we assess and convey the performance of the model during calibration? And issues really two and three could really be lumped together into one main concern that would be that model users be given a clear understanding of the model uncertainty.

And, you know, I've been working with Camp Lejeune for a year and a half or two maybe, so I certainly don't understand all the issues associated with it. But I can say that the Navy goal for this expert panel is simply to get your best recommendations for the best science that could come out of this result. And I know that you have a difficult job. This is a difficult site, and we certainly thank you for your efforts.

DR. CLARK: Dr. Waddill, would you be willing to take a few questions?

DR. WADDILL: Yes.

DR. CLARK: Do we have questions from the panel for Dr. Waddill?

DR. GRAYMAN: It's more a comment than a question. One danger when you talk about ranges for values is if the perception is that that range, that every point within that range is equally likely, and I would suggest maybe rather than a range of values, a likely distribution of what the values are going to be so the points at the end are probably less likely than the ones nearer the middle.

DR. WADDILL: I would agree with that and really, I'm not asking you to, I'm just asking you what sort of recommendations might you have. I'm not trying to endorse a range.

DR. CLARK: Do we have any more? Mary.

DR. HILL: Just one thing. In talking about model fit, it's not true that just a really, if I was given, if I gave you a model that fit the data exactly, I would expect you to be suspicious.

DR. WADDILL: Right.

DR. HILL: So there's a balance there that's not always easy to deal with ~~and certainly~~ [uncertainty -ed.] from your position.

DR. WADDILL: I agree. I agree with you completely.

DR. CLARK: Do we have any more comments from the panel or –

MR. HARDING: Yeah, sort of along those lines it's common to view analytical results as the truth, as the true value. But in fact, they are only an estimate of the true value, and what that value is depends on the question that's asked. And the model's being asked a slightly different question because we're dealing with a month-long stress period.

Somebody walks out with a sample bottle and takes a sample out of a well. And as I think Mr. Faye, Dr. Faye talked about the fact that things can change pretty fast under pumping regimes. We've seen cases where they'll change two orders of magnitude over a period of a couple of weeks of pumping.

And so I think it's really important as you think about that if you have a value that doesn't agree, so it affects your definition of accuracy, you really have to look at that in a much more, in a much richer way, a much deeper before you decide whether that's really saying the model isn't performing the way it should.

DR. WADDILL: Yeah, I agree, and I really just, you know, there are all kinds of issues associated with sampling and analysis, and there are inaccuracies associated with that, too. I just think that what I'm asking is that you consider the comparisons to the real-world samples that we have and to address among yourselves what's the best way to assess uncertainty. And I didn't mean to imply that I have an answer for that. That's a tough one, and I'm just asking you to consider it.

DR. CLARK: Do we have any more –

DR. GRAYMAN: Bob, just an add-on to what Ben says is that when you start going into distribution systems and look at water quality, you can have changes literally within minutes because of the dynamics. I could very much see this being the case in Holcomb Boulevard where you take the sample, and it reads something. And ten minutes later you took another sample, and it may be absolutely, totally different. So you have to be very careful in distribution systems.

DR. CLARK: Do we have any more? Richard.

DR. CLAPP: Just one more time. Dr. Bove said this morning I think the National Academy of Sciences Report, which has been delayed, will say the same thing, which is that we're not actually looking for numerical values for each individual subject. We're looking for a ranking of those, and just to make that point again.

DR. HILL: I have a question. Oh, go ahead.

DR. ROSS: Along those lines and for clarification of folks like me without much epi background, there's a response to the Don's comments that reads if I could just humor me for a second. I'll bore you.

A successful epidemiological study places little emphasis on the actual-parentheses-absolute estimate of concentration, and rather emphasizes the relative level of exposure. Can you enlighten me? And this speaks to the objectives of the model. What the objectives are.

DR. CLAPP: Well, I don't know how to say it more clearly than that actually. It is, for each individual subject, and that's like I said, for example, a child with a birth defect or a control in that study or later on in a person who died of kidney cancer versus a person who was at the base but didn't die of that.

We're looking to see whether in a relative scale, the exposed people were more likely to have gotten the disease, and so it can be -- for example in Woburn, in my own work on Woburn, we were looking at categories highly exposed, moderately exposed and either not exposed at all or unexposed. And we saw it. We actually saw that result that the highly exposed were much more likely, in my first study ten times more likely, to have been diagnosed with childhood leukemia than the controls, so in that stratum of highly exposed.

So it's really not about that you have to have had a cumulative lifetime exposure of 500 parts per billion or 531 parts per billion versus 497 parts per billion. It's are you in the high exposed, the medium exposed or low exposed. And that's how most of these studies are done. And especially in a situation like this where the data are either going to be uncertain or sparse. That's the best we can do.

DR. WARTENBERG: Just to follow up on that, the methodology that's used for those, the analysis Dick's talking about, look at if one goes up is that associated with a greater likelihood of disease. So it doesn't really use the numbers. You can back out of some of the numbers to try and have a handle to talk about it. But, in fact, the analysis doesn't care if the numbers are from one to ten or from one to a thousand. It still looks for that association. And that's why the comment is don't worry about the numbers. That's not the point of the analysis.

DR. WADDILL: I guess as long as the model is accurate enough to get the trend right and the ranking right, that would be my understanding.

DR. WARTENBERG: Where it becomes trickier is when you start grouping the data, I mean, what Dick was saying about having different categories, then that also becomes sort of tricky in terms of either making clear what the association is, but if it's done some ways, it can also make it more obscure.

DR. CLAPP: And luckily we have an expert on how to do those cut points sitting right here.

DR. HILL: So if I consider a first order analysis to be take the existing data I have at these different wells, and just assume, from that get some average concentration for those wells over time, and then apply the pumping schedule, I would get exposure rates for different communities, and they could be fit into these different categories. That would just be a first order.

Okay, so the question becomes in what ways can we use a groundwater model to improve on that first order estimate. Is that a rational --

DR. CLAPP: That's what I think we're doing here, yes.

DR. HILL: Has that first order analysis ever been done?

DR. CLAPP: Not yet, but I mean for example for Tarawa Terrace, that is now available to do that. It needs to be --

DR. HILL: Right, for either the numerical modeling or this first order analysis, you have to figure out some pumping schedule, but that's a step that's in common to both of them.

DR. CLAPP: Yeah.

DR. HILL: So it's just, it seems to me like that's the framework I'm thinking of in terms of --

DR. CLARK: Frank, did you have a comment?

DR. BOVE: No.

DR. CLARK: Do we have any more comments or thoughts for Dr. Waddill while we have him here?

(no response)

DR. CLARK: Thank you very much. We appreciate your coming in, sir, very relevant, very important and good advice to the panel. Thank you.

MR. MASLIA: We can hook Scott up. We'll take a ten minute break?

DR. BAIR: I'm a lot more nervous about this than I was an hour ago.

MR. MASLIA: Take a minute break while we hook you up. So if we can start back at five o'clock.

(Whereupon, a break was taken between 4:50 p.m. and 5:00 p.m.)

DR. CLARK: I guess they've been live video streaming all through this break so time to get back on board and get going. Scott's going to talk about some of his studies at Woburn, which I think would be very informative and useful for our discussion.

(Whereupon, a presentation was made by Dr. Scott Bair from 5:00 p.m. to 6:00 p.m. The meeting concluded for the day at 6:00 p.m.)

CERTIFICATE OF COURT REPORTER

STATE OF GEORGIA

COUNTY OF FULTON

I, Steven Ray Green, Certified Merit Court Reporter, do hereby certify that I reported the above and foregoing on the day of April 29, 2009; and it is a true and accurate transcript of the testimony captioned herein.

I further certify that I am neither kin nor counsel to any of the parties herein, nor have any interest in the cause named herein.

WITNESS my hand and official seal this the 19th day of June, 2009.

Steven Ray Green, CCR

STEVEN RAY GREEN, CCR, CVR-CM, PNSC

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CERTIFIED COURT REPORTER STATE OF GEORGIA 1776 A-2102

EXHIBIT 10

THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

convenes the

EXPERT PANEL MEETING

Analysis and Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point, Holcomb Boulevard and Vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina

APRIL 30, 2009

The verbatim transcript of the Expert Panel Meeting held at the ATSDR, Chamblee Building 106, Conference Room A, Atlanta, Georgia, on Apr. 30, 2009.

ORIGINAL

STEVEN RAY GREEN AND ASSOCIATES
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C O N T E N T S

April 30, 2009

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EXPERT PANEL

Analysis and Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point and Holcomb Boulevard and Vicinity, U.S. Marine Corps Base, Camp Lejeune, North Carolina.

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WARTENBERG, DAN, UMDNJ
WILLIAMS, SCOTT, USMC

Glossary of Acronyms and Abbreviations

ASCE	American Society of Civil Engineers
AST	above ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
AWWA	American Water Works Association
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	community assistance panel
CD-ROM	compact disc, read-only-memory
CERCLA	Comprehensive Environmental Response, Compensation,
and Liability Act	
CI	cast iron
DCE	DCE:
	dichloroethylene
	1,1-
DCE:	1,1-dichloroethylene or 1,1-dichloroethene
	1,2-
DCE:	1,2-dichloroethylene or 1,2-dichloroethene
	1,2-
cDCE:	*cis*-1,2-dichloroethylene or *cis*-1,2-dichloroethene
	1,2-
tDCE:	*trans*-1,2-dichloroethylene or *trans*-1,2-dichloroethene
DHAC	Division of Health Assessment and Consultation, ATSDR
DOD	U.S. Department of Defense
DON	U.S. Department of Navy
EPANET or EPANET 2	a water-distribution system model developed by the EPA
ERG	Eastern Research Group, Inc.
gal	gallons
gpm	gallons per minute
HPIA	Hadnot Point Industrial Area
HUF	hydrologic unit flow
IRP	installation restoration program
LGR	local-grid refinement
MESL	Multimedia Environmental Simulations Laboratory, Georgia Institute of Technology
MGD	million gallons per day
µg/L	micrograms per liter
MODFLOW	a three-dimensional groundwater flow model developed by the U.S. Geological Survey
MODPATH	a particle-tracking model developed by the U.S. Geological Survey that computes three-dimensional pathlines and particle arrival times at pumping wells based on the advective flow output of MODFLOW
MT3DMS	a three-dimensional mass transport, multispecies model developed by C. Zheng and P. Wang on behalf of the

	U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi
NAVFAC	Naval Facilities Engineering Command
NCEH	National Center for Environmental Health, U.S. Centers for Disease Control and Prevention
NTD	neural tube defect
PCE	tetrachloroethylene, tetrachlorethene, PERC® or PERK®
PEST	a model-independent parameter estimation and uncertainty analysis tool developed by Watermark Numerical Computing
ppb	parts per billion
PVC	polyvinyl chloride
SGA	small for gestational age
Surfer®	a software program used for mapping contaminant
plumes in groundwater	
TCE	trichloroethylene, 1,1,2-trichloroethene, or 1,1,2-
trichloroethylene	
TechFlowMP	a three-dimensional multiphase multispecies contaminant fate and transport analysis software for subsurface systems developed at the Multimedia Environmental Simulations Laboratory (MESL) Research Center at Georgia Tech
TTHM	total trihalomethane
USEPA	U.S. Environmental Protection Agency
USMC	U.S. Marine Corps
USGS	U.S. Geological Survey
USPHS	U.S. Public Health Service
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
WTP	water treatment plant

P R O C E E D I N G S

(8:15 a.m.)

HOUSEKEEPING RULES

DR. CLARK: Morris has got a couple of things that he wanted to go over, sort of general issues. One thing that we had talked about is ~~if I don't know~~ [-ed.] whether Scott can finish his presentation perhaps during lunchtime if that would be possible.

How long would it take? About 15 minutes or so to --

DR. BAIR: Ten or 12.

DR. CLARK: Okay, we'll try to work that out because I think you were right at the point, sort of the punch line, and we sort of missed that, very interesting.

Morris, you have a couple things you want to say?

MR. MASLIA: First of all I wanted to thank Barbara for bringing in the biscuits and all that this morning. That was a welcome treat, and Rene, ~~and Rene,~~ [-ed.] and also our staff, Kathy Hemphill, Rachel Rogers and Liz for administrative help in getting things going.

Second of all, for those who are turning in or traveling on ERG's money, you can mail in your receipts to Liz when you get back or e-mail them or however you want to do that. Then thirdly, and perhaps this was a misunderstanding but hopefully we can clear it up to this morning. I wanted to make sure everyone understood that the notebooks and the materials that were sent to you were not intended to imply they were anywhere near completion.

I think that impression may have been observed because we gave a time schedule and it showed we were planning originally to be finished by December of 2009. So that was not the intent. I apologize if that message sort of came about to appear and to sort of demonstrate we talked a lot about Table C-7 through C-13 yesterday so I printed them out for you.

And if you go to any one of the tables, even the last table, you'll see that it takes seven, eight, nine, ten, 12, a dozen, couple dozen files just to compile the data for one table. So the files are massive to go through, and so this was sort of our compilation of data that we had completed.

And it was not intended to imply that we are ready to send this thing out for clearance or peer review or anything like that. It was really to get your feedback, and in fact, feedback in terms of the timeline and everything else. So hopefully, that clears that up, and I think that is about all.

We really want to try to stick to the schedule. We did pretty good yesterday. Today, because I know some people have some near five o'clock or six o'clock flights, so we do want to do the final round of input from the panel, which we're looking forward to the recommendations to the Agency that, I believe is scheduled to begin at 2:30.

So with that, that's all I have to say, and Mr. Chair, I will -- oh, and they have asked us, we are having audio problems if you're watching it on streaming, and they've asked that you clip the remote onto your belt and the lapel up here, not hang this in a shirt or in your pocket or anything like that. So with that, we're up, is Jason ready?

RE-INTRODUCTION OF PANEL AND SUMMARY OF DAY 1 ISSUES AND DISCUSSION

DR. CLARK: One thing I want to do just for the record is go around the room and have everybody give their name so we know who's in attendance officially. So I'll start with Randall.

DR. ROSS: Randall Ross, U.S. EPA.

DR. KONIKOW: Lenny Konikow, U.S. Geological Survey.

DR. GOVINDARAJU: Rao Govindaraju, Purdue University.

MR. HARDING: Ben Harding, AMEC Earth and Environmental.

DR. CLAPP: Dick Clapp, Boston University.

DR. POMMERENK: Peter Pommerenk.

DR. WARTENBERG: Dan Wartenberg, Robert Wood Johnson Medical School.

DR. BAIR: Scott Bair, Ohio State University.

DR. ASCHENGRAU: Ann Aschengrau, Boston University.

DR. DOUGHERTY: Dave Dougherty, Subterranean Research.

DR. HILL: Mary Hill, U.S. Geological

Survey.

DR. GRAYMAN: Walter Grayman, Consulting Engineer, Cincinnati.

DR. CLARK: And I'm Bob Clark.

We're going to start off this morning with a discussion of water distribution system modeling. Heard a lot about groundwater yesterday.

Jason, you're up.

WATER-DISTRIBUTION SYSTEM MODELING

MR. SAUTNER: Can everyone hear me? Is this on? Is that better?

Today I'm going to talk about the historical reconstruction of the water distribution systems, and just as an overview I'll go over some background. I think many of you have a good idea about the background from discussions yesterday, and then I'll go into more of the water distribution system modeling. It's going to be an all-pipes calibration. I'll go into the interconnection, which is going to be a big topic, of transfer of water between systems. And then I'll go into some historical reconstruction and talk about some preliminary scenario results.

Overall, the water treatment plant service areas, we have Hadnot Point, which everyone knows about. It's 74 miles of pipelines. Approximately 71 percent of it is PVC. There's four elevated tanks. The controlling tank is SFC-314, which is right down in here in this area. All of the elevated tanks are 300,000 gallons. Delivered water is approximately 2.3 million gallons per day in 2004.

And then we have the Holcomb Boulevard system up here. It's about 73 miles of pipelines, approximately 67 percent cast iron. There's three elevated tanks. The controlling tank is right up here. It's Paradise Point S2323. It's a 200,000 gallon tank. And the delivered water in Holcomb Boulevard was approximately one million gallons per day in 2004. And there's two interconnections which we talked about. The Wallace Creek, which I guess now we're going to call the Marston Pavilion to avoid confusion. And that's the bypass valve located right here. And then we also have booster pump 742, which is a 700 gallon per minute booster pump.

Some significant events that occurred between 1941 through 1987: In 1941, the Hadnot Point water treatment plant comes online, which is located right here. In 1952, the Tarawa Terrace treatment plant came online. I don't have the Tarawa Terrace water distribution system model on here, but it's located right up here. And in '72, the Holcomb Boulevard water treatment plant, located right here, came online in June of '72.

From November of '84 through February of '85 is when most of the several supply wells were shut down due to VOC contamination. And January 27th through February 4th of '85, there was about a nine-day period where the Marston Pavilion bypass valve was open continuously. In 1987, the Holcomb Boulevard water treatment plant was expanded to provide water to the Tarawa Terrace and Camp Johnson areas. And in 1987, the Tarawa Terrace water treatment plant was taken out of service.

As for the Hadnot Point water distribution model, it's an all-pipes model.

We used EPANET. I think many of you are aware with EPANET and its capabilities. It simulates spatially distributed contaminant concentrations throughout the network, and it can perform extended period simulations of hydraulic and water quality behavior within the network.

The Hadnot Point model consists of about 3,900 junctions, about 4,000 pipes. And what we did was we conducted a hydraulic and water quality field test May 24th through 27th of 2004. During this test we collected and recorded hydraulic data, such as pressure and flow. And we also injected a calcium chloride and sodium fluoride at the water treatment plant, which was our source location. And we measured this continuously throughout locations in the distribution system.

Here are some calibration results. The Hadnot Point, the model was initially run using a single demand pattern. And this was obtained from a water balance on the distribution system. Eventually what we did was we used the PEST model to estimate eight different well, we aggregated eight different demand patterns throughout using the Water Conservation Analysis Report from 1999 in which they estimated water usage in different zones, and we allocated eight different groups. And by using PEST we estimated different 24-hour demand patterns.

The blue dots on this graph show the SCADA data, which is what we recorded in the field. It's actual water level data at SFC-314, which is the controlling tank at Hadnot Point. The red line is simulated data from the water balance, and the green line, which is a little difficult to see here, is the PEST water level simulation data. And you can see that the fit got much better by using PEST.

Over here we have some concentration graphs.

DR. HILL: With PEST what was it you were estimating? What values were you changing to create that fit?

MR. SAUTNER: The 24-hour demand patterns, and it was actually a colleague of ours, Claudia Valenzuela that did the PEST modeling. So we have a full report on it and details of how she conducted it.

Here is fluoride concentration just at a random logger that I chose in the system. You can see the blue line is what our continuous monitor recorded, and the red line is what we're simulating. And the same down here with the chloride concentration. The blue line still is field data from what we recorded on the continuous monitor, and the red line is the simulation.

MR. HARDING: Jason, can I ask you a question?

MR. SAUTNER: Yes.

MR. HARDING: On that, was that a four- or five-day period that you, yeah. Did you, if I recall what you said, you said you had eight different classifications for water demand --

MR. SAUTNER: Correct.

MR. HARDING: -- diurnal patterns, right? Did you use the same pattern? Did you calibrate one pattern that was used on the 24th, 25th, 26th or did you calibrate a five-day pattern that -- you see what I'm saying?

MR. SAUTNER: Yeah, that's what Claudia did. I'm not exactly sure of how she did the calibrations for the PEST.

MR. HARDING: What I'm getting at is if you calibrate an exact pattern for these five days, that's the best fit for those five days, you're not going to be able to extrapolate that to other periods of time when you don't have calibration data. You're going to have to have a pattern that you can use going back in time, and typically you have one 24-hour pattern for each category of use.

MR. SAUTNER: Right, and I'll get into this a little later. We assume that generally throughout both the distribution systems that the demand patterns didn't really change much. There was, I mean, historically. While there were significant changes that I showed you in that list of significant changes throughout the systems, overall demand in the systems didn't change much.

MR. HARDING: Yeah, that's fine, but I guess what I'm getting at is, is that if you are going to take a single 24-hour pattern for each of eight categories of use, then that's the way the calibration results ought to be shown. In other words the same pattern should be used on the 24^{th}, 25^{th}, 26^{th}, so on and so forth.

MR. SAUTNER: Okay, you're saying a 24-hour average of this.

MR. HARDING: Well, I don't know. You said you didn't know how she did it. Because you could fit it both ways. You could fit it to look at the, what is it, the five days -- I haven't done the math -- yeah, five days altogether or you could fit it to a single 24-hour period and then replicate that period. And that's what you're going to have to do --

MR. SAUTNER: Right, for historical extended simulations.

MR. HARDING: Right, so you just need to -- I don't know how you did it, and it sounds like you don't know, but the way you should do it is to do your calibration exactly the way you're going to do your extrapolated simulations.

MR. MASLIA: (off microphone) But the way the PEST model was run, because we've got all the files and stuff like that is we ran it for the entire period of the test. We put in what we thought were the initial ^ [diurnal patterns -ed.], and we did that based on five

^ [days -ed.]. Then we ran a test based on continuous water levels throughout the entire test period to go in and adjust ^ [the diurnal -ed.] patterns and we got a five-day length of time ^.

MR. HARDING: Yeah, and the problem with this is it violates Mary's first law, which is it looks scary. And it's too good a fit, right? And the reason is, is that you've fitted every hour of the water demand to the, and so what you should do, because you're not going to be able to do that in 1969 and '70. So what you should do, at least this is my recommendation -- Walter can weigh in -- but you should fit a 24-hour pattern for each category of use just like you started out with. But you're going to get one that's fitted, and then replicate that over the five days and see how your calibration works. That's what I suggest.

MR. MASLIA: But you have your data that you're measuring will vary over, during the test.

MR. HARDING: Right, it's going to vary. I mean, people don't behave exactly the same way each day, and when you look at, when you compare your idealized pattern to the actual pattern, it's not going to be the same in life. But this five-day pattern isn't going to be the same five-day pattern you see on May 24th of 1972, for example.

DR. GRAYMAN: Yeah, I agree with you, though what I'd like to see is that graph and then do the next step which take what would be the best repeating 24-hour pattern and see how that works. And I guess the other question on it is what does, the resulting best-fit demand patterns, do they look reasonable or are they, in effect, just --

MR. SAUTNER: Do you mean the demand patterns in terms of diurnal demand patterns?

DR. GRAYMAN: Yeah.

MR. SAUTNER: Yeah, they're all reasonable.

DR. GRAYMAN: But in the end you do want to come up with a repeating 24-hour pattern, which you can then use for future or past modeling.

DR. HILL: So on these other years when you don't have so much data, what data do you have?

MR. SAUTNER: Well, I'll get into the historical reconstruction later in the discussion --

DR. HILL: Okay, as you go. And just one thought about, you might do instead of a daily pattern repeated, you might do a weekly pattern.

MR. SAUTNER: That's one thing I also thought of because for the Holcomb Boulevard, which I'll show you next, we have a longer period of time.

So the Holcomb Boulevard system has about 4,800 junctions, 4,900 pipes, and we did a field test in which we just shut off the fluoride feed at the water treatment plant, at the Holcomb Boulevard water treatment plant. We shut it off and watched it drop down to background levels to about 0.2 micrograms per liter, and then we turned it back on and watched it go back up.

This test was, we did about a 21-day test with continuous monitors out there. You can see the date here is about September 23rd, 2004 through -- oh, I only have four days showing here, but the test did go from

September 23rd 'til October 11th or 12th. On this graph I just represented four days of data. And similarly, the blue dots are the SCADA data, which is what the operation rooms recorded. The red line was simulated from the water balance, and the green line was simulated from PEST.

DR. HILL: I'm sorry. I may have missed it. But how do you get the water -- what --

MR. SAUTNER: Water balance?

DR. HILL: The water balance, where does that come from?

MR. SAUTNER: That's just, it's taking what's stored in the tanks, how much water's delivered to the system, what the demand is on the system and during, you know, adding, subtracting and determining how much water was used in the system basically.

Is that an easy way to describe it, Walter?

DR. GRAYMAN: (off microphone) And then use a single common pattern, ^ [diurnal -.ed] pattern for all ^[days -ed.].

MR. HARDING: Yeah, that's the difference, Mary. They have one pattern, and then they're going to break it down to different categories of use.

MR. SAUTNER: Right.

MR. MASLIA: Jason, I think it's important to point out, and Mary, initially, where the patterns were derived from is each military installation had a water use survey done. They used a, a program was developed to really see how they could conserve, it was a conservation study. And the conservation study basically provides a gross amount on the average daily usage, what showers are being used, what swimming pools are being used. And so to start this effort off we derived initial estimates from those values to get the model going.

MR. SAUTNER: Thank you, Morris.

I know again it looks like this file lacks Mary's first law; however, I guess I should have chosen a different graph. This one is located close to the source so you're going to get better results right near the source.

You can see the, so now we have the date here from September 23rd through October

11th around. And you can see the fluoride concentration's starting out around one microgram per liter dropping down to about 0.2 and then going back up to one.

Here's some, I guess this is a little misleading. It says PEST-derived demand factors is actually the allocations, the different categories that we used. The red is bachelor housing. There's a gray, which is the cooling system. The light blue is family housing. There's a heating plant, vehicle washing, office and work areas. And unfortunately, I don't think this is in the packet that you have of my slides. I added this one.

Now I'll get into some interconnections discussions.

MR. HARDING: Jason, so how did you then allocate spatially to the nodes, the base demand that you varied with your diurnal pattern? How did you allocate across the categories? Did you do a separate demand pattern for each node?

MR. SAUTNER: No, no, no. There's eight different patterns, so depending on what location, you know, each node was identified as, it would get a certain pattern.

MR. HARDING: Those were in actual use. I see what you're saying.

MR. SAUTNER: So now interconnections, which I guess is going to be a big discussion. As you know there are two interconnections, the Wallace Creek, which we're calling Marston Pavilion now, and the booster pump 742.

It was originally thought that Marston Pavilion bypass valve and the booster pump 742 were operated only on very rare occasions and solely for emergency situations. However, additional data discovery and discussions with both former and current water utility staff have led us to believe that historically water was transferred from Hadnot Point to Holcomb Boulevard more frequently than originally thought.

As previously mentioned, the Marston Pavilion bypass valve was not easily accessed so it was not typically open long enough to be considered a significant source of water transfer. Basically, the historical scenarios that I've constructed, I don't open the bypass valve; however, through suggestions we can open it and run different scenarios just to see how the water reacts going through there.

As Ben pointed out, I think he alluded to yesterday, if you were to turn on the 700 gallon booster pump, and you had that bypass valve open, water is simply just going to go right back down. And I saw that. I ran a scenario. Exactly what you said happened.

However, there was that about a nine-day period from January 27th through February 4th where that Marston Pavilion bypass valve was open for about nine consecutive straight days, and from the logbooks and discussions with the water utility staff, we determined that booster pump 742 was generally used during late spring and early summer months to account for irrigating the Scarlet Golf Course.

There was actually two golf courses loaded up, located in Holcomb Boulevard, and that created such a demand on the Holcomb Boulevard system that water needed to be sent from Hadnot Point to Holcomb Boulevard.

DR. GRAYMAN: Jason, can I ask a question?

During that long period, what was it, nine days?

MR. SAUTNER: Uh-huh.

DR. GRAYMAN: Was the booster pump running, too?

MR. SAUTNER: That's another thing, I'm not sure of. Logbooks, we were told that whenever the bypass valve was open, the booster pump was always running first. If the booster pump couldn't supply enough water, they would open the bypass valve. I don't understand, as what I just discussed your scenario of if you have the booster pump pumping and you open the valve, water's simply going to go back down.

MR. HARDING: Well, nobody could see the way the water's flowing. There's no instrumentation or anything to reveal this, so people misunderstood the value of opening the valve, and it actually was a counterproductive action. So it would cause the penetration of the water from the booster pump to happen much faster. Right, Walter?

DR. GRAYMAN: Well, I think we need to establish, I assume there are pumps at each of the treatment plants essentially that are pumping the water from the treatment plant up to the tanks, which is the gray line in those two. And I'm guessing that the gray line is probably fairly similar between the two or the normal water levels in the tanks are they the same in Hadnot Point as they are in Holcomb Boulevard?

MR. SAUTNER: I believe they're fairly the same.

DR. GRAYMAN: And so then they'll put the booster pump on just essentially it's dedicated to moving the water from the treatment plant in Hadnot Point into the Holcomb system. And so whether the direction the water's going to be going if they open the bypass is really going to depend on what the water levels are in the two tanks and what the demands are. So you may not necessarily get a circulating system.

MR. SAUTNER: Right, if you had lower levels in the Holcomb Boulevard, you would have higher levels, and higher levels in the Hadnot Point tanks, you would have water pressure --

MR. HARDING: For any sustained operation eventually you'll get to the point where the flow is coming back through the valve. I can't imagine any other --

DR. GRAYMAN: Except when they turned off the Holcomb Boulevard treatment plant which is what they did right there in this case.

MR. HARDING: If there was an enormous demand, that's right. But your model will tell you this. The model will answer this question pretty well.

MR. SAUTNER: And to answer your initial question, logbooks indicate that the bypass valve was open. They never mention anything about the booster pump during this nine-day period. Typically, logbooks were pretty consistent and had good information on what was open and what was closed. However, during this nine-day period it does not indicate whether the booster pump's on. I can run different scenarios for both open, just the bypass valve open, you know, see how it reacts.

MR. HARDING: It should be fairly clear because if your tanks are really, if your heads are going down, if your grade's really low, it would probably not be tolerated and so they were probably running the booster pump, and that seemed like that was their normal mode of operation.

And where's the second, I found one of the golf courses. Where are the two golf courses? One was in Hospital Point --

MR. ENSMINGER: Both of them are there.

MR. SAUTNER: Both located in there.

MR. HARDING: Oh, okay.

MR. ENSMINGER: One's on one side of the street, and the other one's on the other side.

MR. HARDING: Okay, I didn't count the holes.

MR. SAUTNER: So as far as the interconnections, from the Camp Lejeune logbooks. We have information from 1978 through 1986. There are a few data gaps. You can see here in '79 we have no information, in '81, '82 we have no information.

The booster pump 742 operations, it's a 700 gallon per minute rated capacity during the study timeframe. That was later replaced with a 300 gallon-per-minute pump, and it's currently out of service. It was operated mostly in late spring to early summer, April, May, June, July, and it was operated more frequently in the mid-'80s as you can see here than it was in the early '70s.

I'm sorry, this is the number of days that it was operated for each month. You can see in the early '70s it was operated seven days, one day, three days in 1980. And then towards the middle '80s you can see it operating a lot more.

MR. ENSMINGER: I have a question. What is the, we understand that there was a valve right there at Building 670, the Holcomb Boulevard plant, that could be opened right into the treated water in the water treatment plant that was inter-tied to the Hadnot Point system. And from the discussion I had with a former water treatment plant operator, he said they could transfer water from the Hadnot Point system without running the booster pump from the elevated tanks, just gravity flow.

MR. SAUTNER: I don't believe that there's a --

Joe, you might be able to help me answer this question.

-- I don't believe that there was an

interconnection directly to the Holcomb Boulevard treated tank.

MR. HARTSOE: There's check valves in the ^ [Holcomb Boulevard -ed.] pump room that would prevent it from going back to the treated water reservoir. The only connection I know that he's talking about would be the 12-inch line coming from the booster pump. There was a bypass --

MR. SAUTNER: But that doesn't run directly to the treatment plant. It runs to the intersection but not to the treatment plant. It runs into the distribution system and not directly to the treatment plant.

MR. ENSMINGER: Where was that valve that opened and closed that 12-inch line?

MR. HARTSOE: Well, you had cut-off valves between the booster pump and Holcomb Boulevard, but if you have the valve shut off in the booster pump itself, then the pump was off. So there was no way to go back. Somebody had to either go in there and open up a valve inside the building itself and cut the ^ [valve to -ed.] booster pump ^ [742 -ed.].

MR. ENSMINGER: Well, would it be possible for somebody to take a short cut and leave that valve open at the booster pump and just shut the valve up at the plant off at the intersection there?

MR. HARTSOE: We never messed with that valve. I don't know of anybody messing with a valve there. It would still have to go through the pump, some way it would have to gradually feed through the pump and --

UNIDENTIFIED SPEAKER: And the flow would be so low that it probably wouldn't really make a big difference ^, because that's the reason why you have a booster pump that's to transfer a large amount of water.

MR. HARTSOE: I don't know who would have cut the valve~~,~~ ^[on -ed.].

MR. SAUTNER: So the next graph is going to be occurrences of the bypass valve openings, the number of days. As far as the logbooks are concerned, there's no openings all the way until a first occurrence which was the nine-day continuous opening on January of '85. And then beyond that nine-day period it's opened only a handful of times. One day here, four, three and one day here.

This is kind of just an overall summary graph of the hourly operation of booster pump. It's a little difficult to see on this scale since it goes from '78 all the way through '87. It's zero hours to 24 hours, and this is just simply when it was turned on or when it was turned off. To zoom in and get a little bit better of a picture this graph right here to the right is May of '86, and you can see this is the one that was used most frequently. I think it was used about half the amount of days of the month. And we averaged, it was used from about nineteen hundred hours to twenty-four hundred hours.

So we came up with some different scenarios. As I said, it was operated most frequently in May of '86. The hours of operation according to the logbook are nineteen hundred to 24 hours, and it operated about half the days during the month, and that was in May of '86. Then we also came up with just a typical May of 1980 case. The average hours that it was operated was seventeen thirty through twenty-three forty-five, which is about 5:30 p.m. to 11:45 p.m. And it operated about three days during the month. And we confirmed with Camp Lejeune former and current water utility staff that they would typically shut the valve off at twenty-four hundred hours when the operator's shift was over.

MR. ENSMINGER: You mean the pump.

MR. SAUTNER: What did I say?

MR. ENSMINGER: Valve.

MR. SAUTNER: Valve, yeah, sorry. Booster pump 742. Sorry about that.

Just to refresh your memory on the water distribution systems now. On the Hadnot Point system, the treatment plant's right here, the controlling tank down here. And then we have the Holcomb Boulevard system with the water treatment plant right here, the controlling tank over here. Golf courses. We have Berkeley Manor, which will become important in terms of the historical reconstruction simulations. Berkeley Manor is right here with an elevated tank right here.

And another important thing is to know that the golf courses during this timeframe were irrigated with potable water which is what created the big demand on the water distribution system. And we also have our two interconnections, which is the Marston Pavilion bypass valve, and the booster pump 742. So again, remember these are all preliminary results, nothing's finalized.

We have our first scenario which is no interconnection. This was done as the May 2004 extended period simulation so there'll be no water transfer between Hadnot Point and Holcomb Boulevard. This is controlling tank S-2323, which is the Holcomb Boulevard controlling tank. And you can just see extended period simulation simply fluctuates all the way out 744 hours, which is 31 days.

Now, we did some interconnection scenarios. This is May of '86 where it's open every other day. The booster pump was pumping every other day, nineteen hundred to twenty-four hundred hours, and you can see it cycling every other day. And we also have our third scenario which is May of 1980 which is the green line. And you can see fluctuation three days in the middle of the month which is when we planned it to operate.

So now our concentrations in the controlling tank for Holcomb Boulevard, no interconnection, there's obviously no transfer of water from Hadnot Point to Holcomb Boulevard. But it was open every other day in May of 1986, there was still no transfer of water to the controlling tank. And then obviously if it was only three days, there was no transfer of water. So no concentration was making it to the controlling tank in Holcomb Boulevard from the Hadnot Point water distribution system.

Now however, if you look at Berkeley Manor tank with no interconnections you can see the water level fluctuating. With the interconnection open every other day in May of '86 you can see it fluctuate every other day. And when it was open three days in the middle of the month, similarly just three days of fluctuation right here.

When we look at the concentrations, and this is assuming just 100 micrograms per liter or 100, I guess it would be considered units, just to get a percentage-wise, to get a feel for how much water from Hadnot Point went into Holcomb Boulevard, with no interconnection no water transfer, zero concentration.

With the interconnection every other day you can see concentrations build up in the tank at Berkeley Manor. When it was open three days in the middle of the month, the green line, you can see the three steps in the very middle of the month, and then there's no more water transfer so the tank has concentration in it and then you just see it start to dilute out.

Interesting thing is, is that this is for May of 1980. If you were to do, go ahead and simulate June of 1980, you would have to put this concentration in as a starting point.

Overall this is just a figure to look at the distribution of the concentrations throughout the systems. With no interconnection all the water stays down in Holcomb Boulevard -- I'm sorry, in Hadnot Point. And there's zero water transferred into the Holcomb Boulevard system. With the interconnection -- again, these are all just averaged out. So instead of running, well, with running the extended period simulation, instead of looking at over time, every value was just averaged.

So with water connection in May of 1986 conditions, you can see no water in these areas. Again, the yellow dots are zero-to-five percent and the orange dots are five-to-20 percent. So you can see on average in the Berkeley Manor about, it actually comes to about 22 percent water, well, 22 percent was averaged in the tank. Overall the system it's about 20 percent around these nodes.

And then with the three days in the middle of the month when it was open in May of 1980, you see no water transferred in this area. You see a few areas in here where you're going to get between five and 20 percent of water from the Hadnot Point system.

So future considerations that we have for this are to try and develop some historical trends, explore using climatic data which is directly related to when the golf courses were irrigated along with the known booster pump 742 operating conditions from 1978 to 1986 to try to estimate historical booster pump operations from 1973 to 1977. Remember, we don't need operations from '68 to '72 because Holcomb Boulevard received all of its water from Hadnot Point. So it was really only a five-year period that we're missing data right here on booster pump operations.

Some other considerations for historical reconstructions, we have actual data so instead of maybe doing an average condition for May of '86 and saying that the booster pump opened at nineteen hundred hours and closed at twenty-four hundred hours, we have the actual data on a daily basis and an hourly basis of when the booster pump was open and when it was closed. We could actually put this into the model and still run it as an extended period simulation.

We also want to run some scenarios where I include Marston Pavilion bypass valve opening into the historical reconstruction. As I was discussing with Ben, I've run some preliminary simulations. It appears that there's little influence in the Holcomb Boulevard area when the bypass valve is open.

And that's mainly because there's, I

guess it would be more influence in the Hadnot Point area. Water kind of goes from Holcomb Boulevard to Hadnot Point rather than going from Hadnot Point to Holcomb Boulevard. This can be changed also as we discussed with varying tank levels to create different pressure variants.

And also want to run the scenario where the nine-day event from January 27th through February 4th of 1985 with the bypass valve open continuously. And with that I'll leave it open to questions.

PANEL DISCUSSION: WATER-DISTRIBUTION SYSTEM MODELING

DR. DOUGHERTY: Remind me about 1972 and why there's no consideration in the second half of 1972.

MR. SAUTNER: In 1972 that is when -- correct me if I'm wrong -- isn't that when Holcomb Boulevard, in June of '72, Morris?

MR. MASLIA: June of '72 is our best estimate of when the Holcomb Boulevard water treatment plant came online.

DR. DOUGHERTY: So the assumption is that --

MR. SAUTNER: Prior to '72 it was receiving all of its water from Hadnot Point.

DR. DOUGHERTY: I understand, but there was no interconnection you had to worry about between the start up, which probably would be ~~pre-transferred~~ [pre-transfer -ed.] to the Department of Defense, and --

MR. SAUTNER: And so you're speaking the actual June of 1972, July of '72. Yeah, I suppose I could change that figure to be '72 through '77 and use, there would be no transfer, well, it would be all Hadnot Point water for April, May of '72. June/July we might want to also find historical --

DR. DOUGHERTY: Right because it does generate an additional exposure potential.

MR. SAUTNER: Correct.

DR. POMMERENK: Jason, for these very short-term interconnections in your illustrations here, you used 100 micrograms per liter as the mass and as coming across the interconnection. What are you planning on using for the historical reconstruction? Are you going to use the monthly mean that you get from your groundwater model or, because, you know, obviously these concentrations can change on a daily basis in the system.

MR. SAUTNER: You're talking about concentration input for the model?

DR. POMMERENK: Yes.

MR. SAUTNER: Well, we're not at that point yet, but one way to do it is to whatever number they get from the groundwater model, whatever number they give me, I put it in as a simple, we have a start, you know, they will give me a date, a time when the concentration was like that, and that will go into the model as is.

DR. POMMERENK: Okay, but I want to caution because we're going to have a monthly average concentration. In reality, of course, the concentrations can change on a daily basis. And if you look at Table C-13, it nicely illustrates how Building 20, which is the Hadnot Point plant is 900 micrograms per liter TCE, another day several days later 430 and then another day later non-detect which means within the distribution system there will be also considerable fluctuation.

Now, I guess from an epi standpoint, if you're using the mean that's fine for Hadnot Point. But for the short-term interconnection, you need to have some idea of how much is going, how much mass is across going across that interconnection during the six hours or whatever that pump was on in order to determine what the exposure will be downstream. Because you cannot simply assume it was mean concentration because it may have been zero or may have been a thousand ^ [micrograms per liter during -ed.] interconnection.

MR. SAUTNER: I don't think that there's any way we can tell that though. I mean.

DR. POMMERENK: That's my point.

MR. SAUTNER: Well, it's going to end up being an average. I understand that you're talking about a short period interconnection. We have what information we have. So I can run different scenarios and --

DR. POMMERENK: Yeah, I mean, I think it's going to be a stochastic problem though. Of course, you don't know but that's my question. How are you going to approach this in terms of uncertainty which is again what, I guess, the epi study's looking for since you don't know but you need to provide some kind of measure of how certain is your, of your exposure modeling results. How are you going to account for the fact that it could have been during the six hours of interconnection that the source could have had non-detect or 2,000, that's what I'm --

MR. SAUTNER: Yeah, I guess we'll cross that bridge when we get to it and discuss more later. That's probably a discussion for the panel to help determine. Maybe we could run some Monte Carlo simulations or --

DR. GRAYMAN: You're right in terms of there's both stochasticity due to the source term at the treatment plant plus a great deal in terms of when the booster pumps were on. And I think you do have to consider both of them. But it's, I mean, the amount of information you have in terms of exactly what the source concentrations are going to be at any given time, how they're varying around the mean and also when the actual booster pump was turned on and off, especially in this three year period where you have no information. You're really going to have to do it in a probabilistic manner.

DR. CLARK: We had a question from the audience back here I think.

MR. HARTSOE: Let me clarify something. I may have to get back with you on some of it. I was thinking about what Jerry said about a valve. I was thinking about what Jerry was saying about a valve at 670 cut on. And during that timeframe when the reservoir was contaminated with the gas leak, 670 was shut down, but water was still supplied through that 12-inch line.

Jerry is talking about to 670. I mean, it was being delivered water to 670, but 670 was not pushing any water out because the reservoir was cut off. The water would not go back to the reservoir because of the check valves on the high-lift pumps, and I'm wondering if what they were talking about when they say a valve, during that time when we put the, when we were putting the reservoir back online and having to fill it up and took all sorts of tests after that to make sure the water was good enough to drink before we sent it out.

We did have times when they probably

had to backwash a filter. And there is a valve on the outside of the reservoir that you had to, you could cut on, and that would be coming from Building 20. So that may be what valve -- I'm not sure and I'll have to get back with you. I could see where they would open that valve just to backwash the filters.

UNIDENTIFIED: And that's what I recall as well.

MR. HARTSOE: I mean, I can get back with you --

MR. SAUTNER: We'll get together in the future and discuss the --

MR. HARTSOE: And, Jerry, that may be, I don't know of any other valve they could cut on but that one. So I'll be glad to get back with Jason on that.

MR. ENSMINGER: And this other question about the contaminant levels when the booster pump was running and whether what the contaminant, the idea that you didn't really know what the levels were of the contamination. Well, we only have one test that shows what those levels were, and that was the split samples taken by the state which

I gave all of you in your packet of documents there. The analytical results showed the levels in the Holcomb Boulevard system.

DR. CLARK: Dave, you had a comment.

MR. ENSMINGER: And that was one of them that showed 1,148 parts per billion of TCE at the Berkeley Manor housing area's elementary school.

DR. CLARK: Dave, you had a comment?

DR. DOUGHERTY: It was just a question on, and I'll reference Table C-13 kind of as an example. Do we know the sampling protocol for this 1985 data? These, just to get it right.

MR. FAYE: What was that question again? I'm sorry.

DR. DOUGHERTY: Do we have a sample protocol for the 1985 data from taps and those sorts of things? In other words are these --

MR. FAYE: Protocol as to what?

DR. DOUGHERTY: The sampling protocols, how the samples are actually taken.

MR. FAYE: No, but I suspect from earlier information that in terms of the sampling, which is not really that definitive, in late 1984 samples were collected in glass bottles, iced and shipped to the laboratory.

DR. DOUGHERTY: How were they transmitted into the bottle?

MR. FAYE: I think it was just you open up the tap. You fill up the bottle.

DR. CLARK: You're thinking of the volatilization issue I presume and the loss of contaminant because of that sampling.

MR. FAYE: Oh, yeah.

DR. DOUGHERTY: I'm thinking of that and then in terms of for using these as part of the calibration targets that these may be considered somewhat less than an actual --

MR. FAYE: Sure, and also I think the issue that, the main issue is determining at the beginning of this process, when Hadnot Point was actually turned on to supply all of Holcomb Boulevard, we don't really know what the concentrations of the various, TCE for example here, were at Hadnot Point at that time.

But we know, number one -- well, first of all, we know all the wells that were pumping at this time. We know all but one of the contaminated wells was turned off at this time. And we do have concentrations in the contaminated well at this time at the beginning, which would be 651. So actually, you could just do a simple mass balance. And we know the pumping rates.

So we could just do a simple mass balance and estimate what that source concentration was at the beginning of this intervention. So I don't really think that's an insurmountable problem.

DR. CLARK: But I think you're correct. As I recall at that time sampling was an issue particularly for inexperienced utilities who were just beginning to learn how to take volatile samples of THMs and the VOCs as well. It's a good point.

MR. HARDING: What's absolutely critical about understanding the sample is the time of day and the, really what's important, it's 100 feet from one of the tanks. I can't remember the number, I think. Looking at it on Google maps. Whether that tank's filling or emptying has a profound impact on how you interpret the sample.

If you remember Scott's little diagram

of how the plumes move, well, it happens the same way in a water distribution system. I mean, water flows downhill or down gradient, however you want to think about it, but it happens much faster. Your divide shifts can happen in a matter of minutes, you know, the switch from flow direction can change in a matter of moments.

And so the exact moment you took this, the snapshot of conditions at that moment matters a lot. And we can't ever get that exactly right, so you have to keep that in mind when you're trying to calibrate a water -- you have way more measurements out in the system than I have ever had. I've got the luxury of maybe two or three samples out in the system most of the time. You've got this wonderful fluoride calibration stuff.

I mean, you should be able to do a pretty good job of getting a model that's reasonable. You shouldn't try to fit it perfectly because -- I'm going to talk about this a little bit later -- you're over-fitting your water demands right now, and we have to back off from that.

But what I wanted to do was address Peter's comments about the variability, and in part it's this how incredibly dynamic a water distribution system is, and how you could have a sample at 8:00 a.m. and a sample at 2:00 p.m., and they could be completely different depending on which source happened to be supplying that node.

But just thinking out loud conceptually what you need to do is you need to have a, you're going to have a groundwater model that gives you wellhead concentrations. This is a term I use. This is that average, vertically average, concentration on a monthly basis. And then you have to have a model of your well dispatch -- I've talked about this several times -- that will bring the water together into your unpressurized tank that then is at the water treatment plant. And this may or may not require a hydraulic model because of the differences in head at the different wells and the pump curves. You have to decide that.

And then you're going to have the rest of your water distribution model which you've seen. And you're going to have to model this concentration all the way through. You're going to have one model that's integrated together and it'll have to be stochastic because you don't know how they operated the wells absolutely, and you're going to have to make a model.

But you can inform that model with standard operating procedures or human tendencies. And we've done the same sort of thing before, you just have to do your best, but you have to recognize the uncertainty and quantify it. So I don't know, Walter may want to add to that.

MR. MASLIA: Ben, can I just clarify something because what you've said is absolutely correct, but we're not going to be getting that complex. From the start we made a decision not to model the actual transfers of water within the distribution system or from the different wells in other words. If the wells mixed in a single tank we would get that single concentration. If not, we would take the concentration on the finished water side of the treatment plant. Now, in this particular, a case like in Table C-13, and I agree with you, I mean, throughout all the data we have, except for the data that we collected, we have no time data. This is, if you put that together with the fluoride data that we gathered, I think we've got a very rich set to calibrate and test to. In other words so you've only got one well pumping during this period, and that's 651.

UNIDENTIFIED: Only one contaminated well.

MR. MASLIA: Only one contaminated well pumping. To me it would seem to be, to use this if you want to either verify the calibration that we already have based on our current field data and then try to model this and see what it would take in terms of either well combinations or opening-closing valves to try to duplicate this.

MR. HARDING: Just as a general comment, you guys focus too much on calibration and not enough on the practical question of how you're going to go back and extrapolate out the periods when you don't have enough information. It's wonderful to get your model to fit and then you violate Mary's first law.

But you have to think about how you're going to get a realistic model, a reliable model that goes back in time to 1972 and 1976 when you're not going to have any information.

And that's why I'm saying, and which well is on. I mean, obviously -- I can't remember all the numbers, but 651 was the real bad boy here, right? If 651 isn't on, no problem, right? Well, let me step back and say something about that in a second. But if it's on, then you've got big problems.

Now, one of the things that Jason illustrated up here is the reason why you have to do really long-term, extended-period simulation because that trace went off the end of the month. And typically what we would do is we would run a year at a time, continuous simulations, and then we would initialize the next year with our tank concentrations and even our pipe volume, the mass that was in the pipes, because the pipes can store a substantial amount of water and contaminant.

And so you'll have a memory in those tanks. It is the memory of the system, and you really have to respect that. If the tank at the school there was discharging at the time you took that measurement, that means your tank had a milligram per liter in it. If it was filling it, and it was getting initialized with a milligram per liter. So I just want to make that point.

But you really have to think about how you're going to go back and not worry so much about getting a trace that looks really, really nice. But figuring out how you're going to get a realistic and reliable model and go back.

DR. HILL: In order to do that, and in order to get an analysis of uncertainty it would be really nice to use the dataset you do have and do cross-validation where you'd leave off the, use your different, but instead of leave one out, leave a whole period out. And then go ahead and calibrate however you want to to your one set, and then look to see how well you do when you come back to the set that's not included in your calibration.

And you're going to want to use, for those periods you don't have information, you're going to want to use the method that gives you the best power in that cross-validation test. And that cross-validation test will give you a measure of how well you do when you don't have data.

And that's your uncertainty analysis so you don't go back and do Monte Carlo, you actually have an evaluation of how well you do when you don't have data for the period of interest. So it'll probably be faster than what you're doing now in terms of an uncertainty analysis, and it will have a better statistical background.

DR. GRAYMAN: I just had a comment on what Ben said. First of all, I'd turn it around a little bit. What I'd say is you're probably in a much more fortunate situation in terms of having a better intrinsic model of the distribution system than is normally the case in any of these. So what it's done is it's reduced the uncertainty in that part of the model, so that's good.

But then carrying on that's a starting point. We still have all of this probabilistic analysis has to be done for the source concentration for the operations. In terms of what Mary said, I'm a little concerned, and I guess I don't fully understand what information you have, what water quality information you have in the distribution system. It just seems to be very anecdotal still.

And so anything where you did an analysis, where you tried to calibrate the model and match this, and I'm not talking about today's --

DR. HILL: I wasn't talking about the concentration data. I was talking about the pumping schedules. In terms of your concentration data, I mean, what was done at Tarawa Terrace is to just throw all this raw data at the groundwater model and say fit it, when, if you looked at the data, there was absolutely no, you weren't providing a function that was consistent with the data.

Now, what the inconsistency was there I don't know, but you need to think about the concentration data in the context of some of the things people have brought up. Because it's pretty clear, I mean, things change so much day-to-day, there's something going on with the collection activity or, and I don't know those processes enough, but this data needs to be evaluated with that in mind first and altered.

So if these are all biased low because of processes you know occurred, there has to be some adjustment to those. If you throw this into the regression, it just tries, I mean, the models just try to match it, so you have to, that was one aspect that was presented by Professor Aral yesterday is that you need to really look at your data and try to develop, figure out what trends, your underlying trends, are involved there, not just throw the raw data at the model.

MR. HARDING: Let's be very clear --

DR. GRAYMAN: When you say this data, let's be very clear which data we're talking about.

DR. HILL: That was the concentration data I was talking about.

DR. GRAYMAN: The concentration data in the distribution system or from the sources?

DR. HILL: Well, I mean, you can calibrate the groundwater model on both of those. I think individual well data has been dealt with more frequently, and in either period -- I can't remember -- are there periods of time when we have distribution, we have finished water concentrations, and we don't have individual well concentrations?

MR. FAYE: I can answer that. The data to the best of my knowledge that we collected at several intervals, May of '84 was one where we were all out there, these were when we were injecting various --

Go ahead, Walter.

DR. GRAYMAN: Two thousand and four.

MR. FAYE: I'm sorry, 2004, yeah. We were all injecting the fluoride and some other, calcium chloride, into the distribution system. That was strictly an effort to calibrate the distribution system models. And then similar things were done for Holcomb Boulevard and Tarawa Terrace.

Now, there was no interest in collecting any well data at that time. There was, to the best of our knowledge, there were no contaminated wells active at that time. So this was strictly an effort to collect data to calibrate the water distribution system models, EPANET 2.

Now, to the only data that we have where a contaminated well or wells were operating and where contaminant concentration data were actually collected within the distribution system. Those data are all presented with respect to the distribution system on Table C-13, which you have in front of you now. The --

Excuse me, Mary, go ahead.

DR. HILL: I think that the issue is that if you have concentration -- I was going to say, if you have concentration data into the individual wells, I would think it would be better to use that even if at the same time you have finished water concentrations. But then I was thinking, well, maybe that's not the case because of the, there are so many contentious problems with the samples. Maybe it's not a bad thing to have duplication.

MR. FAYE: Let me just finish my thought, and then we can address what you're trying to say I think.

The only time that we actually have data coincident in time where contaminant concentration data were collected within the distribution system and when we have knowledge of the contaminated well or a well or wells being pumped, was for this nine- or ten-day period in late January and early February of 1985.

And those data in terms of the distribution system are presented on Table C-13. And the contaminant data at the individual wells are also in tables, well, it'd be Table C-7, basically, just Table C-7. And in terms of the actual WTP, that would be on Table -- help me here, folks, if you looked at it. That would be on Table C-11.

And we also have daily records of which wells were being pumped during this time and which were not so we can actually, but there was only one contaminated well at the time and that was HP-651. So whatever was going on, the other wells that were pumping were actually diluting HP-651. I mean, whichever ones they were, they were not contaminated or were very minimally contaminated, you know, as far as detection limits were concerned.

So those are the only data that we have where well data and distribution data were collected relatively simultaneously.

DR. HILL: And you don't have the pumping schedule. They destroyed those records, right?

MR. FAYE: Well, we know which wells were pumped on a daily basis, and because of the extreme conditions that existed at that time, it wouldn't be unreasonable to assume that those wells were just pumping 24 hours a day. They had to get the water into the system to maintain, to supply demand. So if those wells, you know, I think that would be a reasonable assumption.

DR. HILL: If you really, I mean, given that two-week period of time where you have this, you have measured concentrations at the wells, delivered concentrations, pretty good knowledge of the flow system, so you could use that as a test period, a really good test period for your entire system of modeling.

MR. FAYE: Yeah, to demonstrate the validity of the accuracy, precision, all the other terms that were used, we could demonstrate it as a test for that particular period of time.

MR. SAUTNER: And, Bob, also just to note. We have pumping schedules not just for that ten-day period. We have, I believe it's for two months, right around there, isn't it? December, January and February.

MR. FAYE: Right. So the whole process, I want to make a point again, the whole process is highly simplified because of the extraordinary condition that existed, that the wells were going full bore, full out to meet demand. We know the pumping rates at the wells, and there was only one contaminated well at the time that was pumping.

And that turned out to be one that was a real mess in terms of contamination. So it is sort of a fortunate situation where all this information happened to be -- and it was totally accidental as far as I can tell -- but it just turned out that that was the case.

UNIDENTIFIED: What were those days?

MR. FAYE: Basically from about January 27 or so of 1985 to February 11th, 12th, 13th, 1985. Something along those lines.

DR. GRAYMAN: I think it would be extremely useful to take that period and it's almost -- I'll call it an exercise, but that's a little bit pejorative -- but that you go through the exercise of seeing that the model can realistically match what happened during that one-month period. But unfortunately, it's such an unusual period that I'm not sure you're going to be able to gain much in terms of using that to simulate the other periods.

So it's almost going to be, it's going to be necessary that you be able to reasonably match it, but I'm not sure that that's going to be that useful in extending it for the rest of the 15-year period or 12-year period.

DR. HILL: You could use it as a test period, as a check period. Don't use it as calibration and do daily time steps.

DR. CLARK: We have a question back here in the audience.

MR. PARTAIN: Just an observation, on the May 1982 Grainger Lab report, actually, not the report is going to have that, but there was a sample taken from a point within the Hadnot Point distribution system. I believe it was Hospital Point and came with a reading of 1,400 parts per billion within the system. Can that not be a snapshot of what was going on in that system so you can compare it to what you got in 1985?

So you've got two different points separated by three years. One with a 1,400 parts per billion reading at the hospital and then later on the January '85 testing within Holcomb Boulevard, and you've got the school at 1,100 parts per -- 1,148?

DR. HILL: You can. The thing about this other situation is you have a pretty good handle on every piece. You have the pumping, the -- and that's what makes it so unusual. So the one you're talking about I'm not sure that it's a similar set of circumstances or not. I mean, maybe there is. I don't know.

MR. PARTAIN: That was a ^ [water-quality – ed.] sample that they were doing and the lab technician took it upon himself to actually quantify the levels, and he came up with a 1,400 part per billion reading for ^[TCE – ed.].

MR. ENSMINGER: Yeah, and three years later you get 1,148 parts per billion of TCE in another sample, and it's about 300 parts per billion less than the '82 sample. Well, you had some other contributing wells that had been already taken offline, but you still had that one hot one online, 651.

MR. PARTAIN: And that same technician also noted that they had, they did that sample, went looking again, and it dropped off, and then several months later the technician has a conversation with the base supervisor chemist and says, hey, the peaks are back and they're high again, but it doesn't quantify ^.

DR. CLARK: We'll let Morris get a point in here.

MR. MASLIA: No, I've got a question actually for both the epi people and the water modelers.

Since the case or the set of data as has been pointed out for the January '85 date seems to be our most complete in terms of all parts of the supply and delivery system or distribution system that we've got information on, and we know one contaminated well, 651, was pumping being diluted by other wells, which we know were pumping going in there, could we not use that from the epi side, would you not consider that potentially a worst case scenario?

MR. HARDING: How could that be the worst? Oh, for Holcomb Boulevard.

MR. MASLIA: Did they pump all the contaminated wells at the same time?

MR. HARDING: I couldn't even --

MR. FAYE: No, you wouldn't consider that in terms of the groundwater pumping. You wouldn't even come close to considering that as a worst case scenario. Because you could have a situation easily where 651 prior to 1984, 651 -- or July '84, actually -- 651, 602, 608, 634 -- what others, could all be pumping at the same time, and they'd be dumping contaminants into the Hadnot Point WTP like there's no tomorrow, so that would be more of a worst case than just one contaminated well pumping.

DR. DOUGHERTY: The entire 1968 through '72 period which --

MR. FAYE: Yeah, from 19, yeah, and prior to, actually, 651 came online in I think 1970, but prior to that you certainly had a good number of contaminated wells that existed, pumping into Hadnot Point WTP and being distributed through the Holcomb Boulevard pipe system. So, no, I wouldn't --

MR. ENSMINGER: If you use just the January samples that would not be, another reason it wouldn't be your worst case is because all your benzene contaminated wells were offline by that point.

MR. FAYE: Oh, yeah, I mean, considering your individual constituents, yeah. You can go right down the line and be indicative of that. I'd say this 1982 sample that was brought up that's on Table C-11 at the hospital, 5/27/82, 1,400 micrograms per liter TCE, that -- I'm just kind of blowing smoke here -- but probably 651 was pumping then.

We don't really know, but that concentration is comparable to some of the January '85 concentrations. So there might have been a similar situation going on. But, yeah, in terms of worst case we really don't know, but I wouldn't say January of '85 was the worst case, just my thought.

MR. HARDING: You need to know to be able to make a statement like that, you need to know a lot, and you'd need to know where the water was coming from that was at -- I can't think of the name of the point, but the school.

MR. FAYE: Berkeley Manor.

MR. HARDING: You'd have to know, and it could be coming out of the tank. It could be a blend. And it's really hard to know. At Hospital Point it's going to be a little more stable I would think because it's sort of out on the --

MR. FAYE: Out at the end of the distribution system.

MR. HARDING: And I can't see well enough to see if there's a tank between it and the water treatment plant.

MR. SAUTNER: There is because here's Berkeley tank right here.

MR. HARDING: I'm color blind too so I can't see the pointer. So anyway, you can't make a blanket statement like that. This is why you build the model is to make this evaluation. And you have to -- I want to make a little editorial comment here -- you have to comfortable going out on a limb and making some subjective judgments about whether this is a reasonable model or not. You're going to have to do that because you just can't do everything based on data analysis, as Mary said. You're just going to have to test and come out with, it's a great tool I think, but you're just going to come out with something that's over-fitted.

DR. DOUGHERTY: Just a quick question on this early '85 data. So they have the measurements at the treatment plant, and we have measurements at wells, and we have pumping rates.

MR. FAYE: Right.

DR. DOUGHERTY: Have you just done the mixing calculation to see if the well concentration and the treatment plant concentration match?

MR. FAYE: No, as Morris hopefully clarified earlier this morning, I mean, this work that you all have in your notebooks here is very, very preliminary work, very early in the process of the project in terms of getting some definitive results. So we just haven't got to that point yet.

DR. CLARK: So there is a point, I think Ben's got a good point. You could use the one scenario to validate and calibrate the model and then add in other wells as you think they might have occurred during some of these maximum contaminant mixing scenarios. You can get a pretty good picture, I think, of what might be going on within the system.

MR. FAYE: Absolutely. And whether we want to use it as a sort of a test as Mary suggested or as part of a full-blown calibration, I mean, I think those points of view just need to be worked out in a dialogue amongst the staff and you folks and whatever. But, yeah, it is the only time, it is the only time where we actually can integrate the complete system, pumping wells and their respective models, the distribution system and their respective models and then look at the results.

DR. DOUGHERTY: I really encourage you to take the ten minutes and do the calculation to see if the mixing of the well data to the treatment plant in that period of time is self-consistent, and if not, it may give you some sense of some response error and hence a measurement error.

MR. FAYE: I agree, and it's neat because it is a fairly simple thing to do.

DR. CLARK: But one thing I haven't heard discussed is the potential for degradation. Has any of that been factored into the calculations at this point? We haven't really done those simulations either, I know, but it seems to me some of that could be important.

MR. FAYE: Absolutely. We know from Tarawa Terrace as far as the groundwater's concerned that probably degradation is a major issue. Within the distribution system, that I don't know.

DR. CLARK: Well, there's some pretty long residence time in some of those tanks. I haven't done the calculations, but if you're given vinyl chloride as an endpoint then you have a very serious issue.

MR. FAYE: Right, right.

MR. HARDING: I think the residence times are ^[important -ed.].

DR. CLARK: It could be degradation also. Well, like also, well, some of it may be degradation within the system, but I don't know. The times might be sufficient for degradation.

DR. KONIKOW: Well worth looking at it, but the residence time in the groundwater much, much, much longer than the residence time in the tank.

MR. HARDING: If this is a matter of triage I wouldn't spend very much time on worrying about degradation in the water treatment system. You've got lots of other good stuff you could spend time on here that's way more important than that. Don't focus on the details, focus on the big picture.

I want to ask some more questions about water use, because water use, you have continuity, and you have energy that balance in these models, and some of us think in terms of continuity, and some of us think in terms of energy, and the systems are different, sensitive in different ways. But in this particular case where you've got this big old golf course out there, and that's what's driving some of these interconnections. You know, understanding the pattern of water use is going to be important.

And I'm concerned that I haven't heard enough, I don't quite understand exactly what you've done during your calibration period, but more than that I don't understand your plan for going back and modeling this during the periods for which there are no data. And the way I've approached it, and I think Walter's done it the same way.

We first sort of load the nodes with a kind of a fraction of the water use on a daily basis. And then apply a unit-less pattern of diurnal water use. I'm sort of getting the sense that what you've done is you've fitted both the total daily water demand and the diurnal pattern, using PEST, and again, it makes a beautiful chart, but it isn't going to help you when you go back in time. I don't know if you have daily records of water production at the water treatment plant, do you?

MR. SAUTNER: Daily? Daily records?

MR. FAYE: Yeah, we do have daily records I think in terms of production. That was on one of my slides the other day, yesterday.

What is it, Jason, 2004 to 2008 and then there's '95 through --

MR. HARDING: No, I meant back in the time that matters.

MR. FAYE: No.

MR. HARDING: So you're going to have to come up with a pattern of use on a total system use and then you're going to have to disaggregate that to the nodes spatially. And then you have to disaggregate it with your diurnal pattern. And so those are some of the conceptual steps. I mean, you can throw up your hands and say we can't do it, but I've done it. Walter's done it. You have to do it.

DR. GRAYMAN: I'm not clear. I think you weren't sure either in terms of when PEST was done. Was it done just to give you these representative eight diurnal, say, normalized patterns? Or was it also to try to determine the quantity of water that was used, say, over that period?

MR. SAUTNER: No, I believe it was just done for the diurnal.

DR. GRAYMAN: Yeah, that was my

understanding.

MR. SAUTNER: The quality, we used the water conservation analysis study.

MR. HARDING: How does that get water to the individual nodes? How do you know how much water was used at or near the school in Berkeley Manor, for example, just as an example? How did you understand that from the water balance?

MR. SAUTNER: Well, from the water conservation study we had different categories of demand, whether they were bachelor housings, family housings, so we know Berkeley Manor is a family housing area. Most of the demand nodes in that area were assigned.

DR. GRAYMAN: Okay, so the equivalent of having a meter, an annual meter.

MR. HARDING: That's good. That's good.

DR. BAIR: That's great, and I misunderstood that because I thought you were fitting --

MR. SAUTNER: I'm sorry. I wasn't clear, I guess.

DR. BAIR: No, that's the way, that's conceptually the way it should be done. And then but you're going to have to come up with a set of patterns that are either constant or respond to certain rules. For example, Mary suggested doing it every day of the week. It's probably not going to help you much, but you definitely want to take into account weekend days, for example.

On your golf course you know they're not going to water the golf course at two o'clock in the afternoon, right? You know they're going to water it at night --

MR. MASLIA: Actually, that's not correct. Ben, seriously, they water it when the general calls up and says he wants to have a tee-time, and then they turn it on.

MR. SAUTNER: We were told anywhere from early morning to afternoon to late at night it could have been watered.

MR. ENSMINGER: Having lived there I have some resident knowledge of the water usage on that base. Wallace Creek separates those two areas right there. The Hadnot Point and Holcomb Boulevard system -- that's Wallace Creek. It separates, this is Hadnot Point. This is the Holcomb Boulevard system. At eighteen hundred every evening, the water demand down in here where all the troops are at would drop off dramatically.

MR. PARTAIN: The Officer's Club?

MR. ENSMINGER: No, no, the Officer's Club was up here. It was up in here, right in here. All these housing areas, Midway Park, Berkeley Manor, Paradise Point, those demands in the evenings would go up because the people were coming home.

Now the troops, after we got off work we had PT, and then we'd secure the troops. They'd go back to the barracks and they'd either, well, they'd get their showers, and then they would put their civvies on and go to chow hall or head out to town to the bars. So the water demand over here would drop off. Then in the morning about 0500, the water demand here would start picking up again and level out. You know you had morning PT, showers, chow hall, formation, back to work, and then you had that same cycle.

On the weekends, the weekends the water demand here was low. On Hadnot Point the water demand here would be high because everybody would be home.

DR. CLARK: What about light industrial use or lawn watering in residential areas?

MR. ENSMINGER: You didn't have many people watering their lawns in base housing unless you had a few people that were trying to get yard of the month or something. I never did. But industrial, most of your industrial, all of your industrial use water would have been at Hadnot Point.

DR. GRAYMAN: Right. I think one step you want to take is take a look at those patterns as you develop from a PEST modeling and really to check them for being reasonable based on what he was saying.

MR. MASLIA: We actually, if you go back when we were, when we tested like the Hadnot Point system and injected the calcium chloride, you actually saw that exact diurnal pattern. It jumped up at 5:00 or 6:00 a.m. in the morning and then leveled off and then Hadnot Point went down around four or six or whatever. That we saw when we did the test. And so I mean from that standpoint, the PEST just confirmed that. It was just trying to optimize the tank water level

UNIDENTIFIED: And the different patterns for the different types of units.

MR. MASLIA: Yes, yes, that's correct.

DR. HILL: One thing on the, just thinking about those patterns and looking at like one of the figures -- it's Figure 8 in the text -- but this is, it's May 24th through May 28th. That's a Monday through Friday. And if you look at the different days, there's not, Monday and Tuesday it looks like they're kind of similar in pattern. But then the other days look, Thursday and Friday look similar. But to my mind there's not a lot of diurnal similar patterns in this.

MR. HARDING: This is real life.

DR. HILL: Well, yeah, so I guess any patterns we think about could be compared against this data and that could be part of what goes into the model testing.

MR. HARDING: Let me make a comment here that you can't expect under normal sort of modeling extrapolation conditions to be able to predict what happened at 2:00 p.m. on Tuesday, June 12th. You can't do that so you have to average things after, you've got to run these models on an hourly or shorter time step because you don't get the dynamics of the system. But then you've got to average things up.

And your goal is to get good statistics that support the epidemiology study over these sort of windows of three months, right? So you probably have a rolling average of over three months because that's your resolution need.

For these case studies where you've got a critical case, like this case we're talking about here at Berkeley Manor and maybe the Hospital Point, yeah, that would be great diagnostics to go down and just really detail this down and lock everything down and see if it's all consistent, but I wouldn't put too much stock in it. You've got to set your error bars. You've got to be comfortable with the fact that you're going to have some error bars in this.

MR. SAUTNER: I just want to add one thing also for the calibration procedures. We had other hydraulic information and we put some water meters out to record flows. So we have that as another calibration measure. We had -- Walter was in with us when we conducted some fire flow tests. So we do have shorter period of times that we can go in and look at more specifically for our calibration.

MR. PARTAIN: When we were talking about the golf course, I did want to show you all this memo here, and this is, if you look at the date, July 1985. So this is post -- I'll put quotes around it -- post discovery of the contamination. And this is a memo from the Base Maintenance Officer to the Assistant Chief of Staff Facilities. If you look on here, let's see, they currently have two 250 GPM booster pumps to provide pressure for the pump and sprinklers on the north course. It's one course.

MR. ENSMINGER: The whole course.

MR. PARTAIN: One course, which when operating do draw a considerable amount of water. We really need to pursue this. And looking at the rounding slip, let's proceed with vigor -- I can't read from here.

MR. ENSMINGER: Info from PWO.

MR. PARTAIN: Public Works Officer. Can you read that for me, Jerry? I can't see that from this side.

MR. ENSMINGER: When do you think we'll have -- incorporated?

MR. PARTAIN: Information, and that's Mr. Price, his comments.

MR. ENSMINGER: He was the head ^.

MR. PARTAIN: And then on the back, "Yeah, thanks, Bill, this is good idea. We should push hard." So the golf course is an issue here. I mean, they're, yeah, this is priority. They realize they've got to drain the system. And keep in mind now we've got wells offline. There's water problems.

We have documentation that there's water issues at this point, and there's a concern here. So the golf course evidently is drawing a lot of water somewhere. And one course, we've got two, basically, two 250 gallon pumps -- I'm sorry, two 250 gallon per minute pumps pumping out and what kind of draw is that going to put on the system.

MR. ENSMINGER: And this plan was actually realized and initiated in 1987. They drilled separate wells alongside of some of the water hazards on the golf course. They were pulling the water from the water hazard and replenishing the water hazard with water from the wells.

DR. KONIKOW: Would the recharge rate onto the golf course be higher than everywhere else? Was that in the groundwater flow model?

MR. FAYE: No, except for a couple of isolated areas out there, Lenny, what we call the Brewster Boulevard aquifer system is essentially a sand pile with some disconnected clays and lenzoidal clays in that system, which we call the confining units, respective confining units, but it's basically a sand pile. So what you basically got is whatever there's left over after ET goes, is infiltrated probably. And the water table's ten, 15-to-20 feet depending on the contours, the land contours. So that's essentially conceptually what I think is going on there.

DR. BAIR: Aren't you surcharging it with the golf course irrigation water in addition to the rainfall?

MR. FAYE: Yeah, that was the question that he asked.

DR. BAIR: So is that area given more recharge than other areas in the model?

MR. FAYE: Sure, well, like I said, there is no model right now. The work that Jason talked about yesterday is very preliminary, and so that represents, what he was doing represents a long-term, average condition. For the transient model, yes, there would have to be some higher rates of recharge for that area.

DR. DOUGHERTY: (Off microphone; indiscernible).

MR. FAYE: Yeah, yeah, and as somebody mentioned yesterday, it actually might even be what they call a SWAG, which is a Scientific Wild Ass Guess.

DR. BAIR: I guess I have a bad idea that I'd like to pass along. As we talk about golf courses, I'm a golfer. I hate the trees, but I think the trees might provide you with a surrogate for some information you're looking at on a longer average than what we've been talking about on the water distribution system.

But some types of trees take up TCE,

and if you were to core some of the trees on the golf course in Berkeley Manor and other places, I suspect you can find a laboratory that could analyze the annual growth rings for the amounts of TCE. Now, it won't tell you a microgram per liter, but it will tell you a high, low, none. And you could use that timeframe as a surrogate for what's being distributed across the base by looking at different trees across the base. So that's my bad idea.

DR. GRAYMAN: I was just going to comment it's either brilliant or totally off the wall.

DR. KONIKOW: I'll go for off the wall.

DR. GRAYMAN: I think it's a good idea, Scott. At least look at it.

MR. ENSMINGER: I saw that capability. I saw exactly what he's talking about. They do test and they can help.

DR. GRAYMAN: So what are the trees like on the course.

DR. BAIR: Are there trees on the course?

MR. ENSMINGER: Oh, yeah.

UNIDENTIFIED: But they're not watering the trees. They're watering the --

MR. ENSMINGER: Yeah, but those roots go way down.

DR. BAIR: They're watering the fairways, too, aren't they? They have to be.

MR. FAYE: Well, that's probably what we need to do (off microphone).

DR. BAIR: Right, and then you could go to the yard of the month and get tree rings from that.

MR. ENSMINGER: Don't be cutting all the trees down, Scott.

DR. HILL: You don't have to cut the tree down. You just core it.

DR. BOVE: This is an interesting idea, but aren't we talking about from '72 to '85, we're talking about a few days a month during the summer months. That's what we're talking about. We're not talking -- and before '72, yes, Hadnot Point is serving this area. But after '72 we're talking about a few days in a few months during the summer so I don't see the point. Am I missing something?

DR. HILL: You're getting data for the period you don't have any information on.

MR. HARDING: Yeah, I think the button is on the golf course. I'm sorry, but I thought it was a good idea for Hadnot Point in general, and I forgot that the golf course was outside of Hadnot Point probably because it was such a small event it may not show up. But other, it's an interesting idea for Hadnot Point. The thing is is that sort of the anecdotal evidence indicates there was a lot of TCE a lot of times there probably in Hadnot Point itself.

DR. BAIR: Anywhere there's an irrigation system on the base. Are they keeping the Headquarters' petunias nice?

MR. PARTAIN: There are sources of TCE within Hadnot Point, too.

MR. ENSMINGER: I don't know that would find anything that was a confounding factor.

DR. BAIR: It was just an idea. I mean, as an academic it's my job to come up with something that uses my time and other people pay for it.

MR. ENSMINGER: But in the Hadnot Point system I don't think you'd find anything that had a constant irrigation in it.

DR. GOVINDARAJU: I just wanted to go back to this question of calibration. So the test that was conducted in 2004, was the purpose of that test to back calculate the demand pattern? Because that means there's an expectation that that demand pattern is going to be repetitive of what happened in '84.

MR. SAUTNER: I'm sorry. So this test right here?

DR. GOVINDARAJU: Yes.

MR. SAUTNER: This was a test we did -- let's do this test here. We actually injected fluoride and chloride into the systems. This was to help us calibrate the model, and we gathered different hydraulics on the system and pressures and water levels, flows.

DR. GOVINDARAJU: True, but when you are fitting, you are saying I will ~~assimilate~~ [simulate -ed.] by fitting let's say the demand patterns or demand factors from test. So it looks like the purpose of this test was to basically get the demand patterns out. Was that the goal of the test then?

MR. SAUTNER: Yeah, well, we did not have demand patterns except for a water balance, so we used the water conservation analysis to get a general demand allocation.

DR. DOUGHERTY: So did you fit only the water patterns or other parameters, too?

MR. SAUTNER: Well, we did other sensitivity analysis. We tried to change pipe frictions and stuff like that.

DR. DOUGHERTY: Tank mixing?

MR. SAUTNER: Tank mixing, yeah.

DR. GOVINDARAJU: So basically, my feeling is that system parameters ^[including -ed.] perhaps tank mixing and all, those have been ~~formatted~~ [fitted -ed.] because with that you can perhaps get an estimate of what the friction factors were back in '84. The demand pattern is going to be, even if you prepare it very correctly with this, the chances of being able to reproduce it for '84 are very difficult. Already I think we have heard about what you are going to get are monthly averages which you have to somehow fractionate or disaggregate into much smaller intervals.

MR. MASLIA: Can I make a couple of comments to maybe hopefully clarify what we have and what we did and why we did it? We came in there in 2003 and there was, from a model standpoint, a description of the distribution system. There was no information available as to daily demand patterns and things like that.

What we had, as I said previously, as most military bases have done, they've got a conservation study that was done. Not only for Lejeune, the Air Force has done it. The Army's done it at all their military bases. The purpose of that really was to study on an average basis the water use and see how they might reduce or conserve water.

And so it identified different water outlets, swimming pools, showers, latrines and so on and so forth. That was really our -- and then we knew the volumes of the tanks obviously. That was the only real, you know, that type of information that we needed. And when we summed up the water balance from the conservation study, we were off -- I mean, I say we, I mean taking the numbers from the study, off by about 30 percent from if you added up the storage in the tanks and the stuff the wells were pumping and all that sort of stuff. So there was a discrepancy in information there.

So one of the purposes in conducting the distribution system test was to see if, in fact, we could account for this discrepancy because we knew we would have to have a more robust -- I won't use the word accurate -- description of the distribution system.

We also made the assumption, and I believe it's still a correct assumption, is that the distribution system, with the exception of obviously separating off Holcomb Boulevard from Hadnot Point, but the activity patterns would have been the same whether the troops were there when we were doing the test or the troops were there in 1968 or whatever. And as Jerry correctly pointed out and we did in the test, they get up, run the shower at 6:00 a.m. or whatever and then it goes on in the Hadnot Point area.

In doing the test or gathering the data, we then were able to, as we had suspected, were able to, through using PEST, determine that the friction factors were insensitive. The system, the changes to that were basically insensitive. That left a demand pattern and water levels that were measured in the tanks through the SCADA available. And so we adjusted the demand patterns. In fact, we were able to match what actually was flowing through the system based on our measured data.

What was interesting also was at the end of the test, and I believe, was that, that may have been a Thursday or a Friday, as troops left for the weekend or whatever, because we got folks at the Hadnot Point to flow the system, I think it was, what, 2,100 gallons per minute, something like that. They came to us and asked if they'd cut that back because they were spilling water out of the controlling tank, French Creek tank was spilling water because they were pumping it at an average rate of what we had gone through the data and figured that the average flow was.

So he's correct. Over the weekend it drops. But our entire concept was that from average operational sense what we saw when we were doing the field test, which is what our goal was, that we could use that at any typical period historically to provide input to the epidemiological study. And hopefully, that clears where we got initial information from.

DR. CLARK: Was the pipe material ~~the same, had been~~ [-ed.] pretty much the same over the years or was there a switch from, say, cast iron to vinyl chloride at some point?

MR. MASLIA: Joe can probably give you a better idea, but at least now when they replace it they use PVC, don't you -- right, when they replace it presently, they're replacing it with PVC. But to give you an example, Tarawa Terrace was basically the same as it was, and it's got a mix of cast iron and PVC currently.

And even though C factor was not very sensitive, it was much more sensitive to PVC than it was to cast iron. And I've got those plots in Chapter I report under the water distribution part or the sensitivity of the water distribution system. It really was the purpose of the test or our concept going in is that there was, in terms of where the pipes went and all that, it would be no significant changes from the historical system.

And that's why we felt or why we justified that we could go out and get some field data. But it was basically what the primary driving factor was this big discrepancy of 30 percent between what the water conservation study said summing it up and what we knew presently was the volume that they were, you know, having.

MR. HARDING: The water conservation claim was summing it up from estimates of individual either categories of use or -- I'm not alarmed by a 30 percent difference then. Those are the same number. You've got to think in astronomical terms sometimes.

Yeah, I mean, if you had measurements coming out of the water treatment plant, those obviously would be your best piece of information which you don't have.

DR. KONIKOW: You're talking about historically, right?

MR. HARDING: Yeah, if you had the flow meter and you had the daily records, those, I've had cases like that, then that's great. We've had situations where all we had were monthly data. You don't even have that, but you're going to make an assumption about your stress periods, right?

And the assumptions you make should be the best you can make. Then they should be consistent with the water distribution model, and then you're going to have to disaggregate that down to a daily pattern. There's a variety of ways to do that. You know, you have to understand and be comfortable with this, it's going to be wrong. But as Locke said it will be useful. And that's the comfort you have to have. You have to be willing to be wrong but provide a useful piece of information.

MR. FAYE: We do have monthly data back to, into the 1950s and also into the '70s and '80s and '90s. So we do have a lot of monthly data to deal with.

DR. GRAYMAN: Can I broaden this a little bit? We can bring it back, but looking at the schedule where we're scheduled to talk about distribution system really for the rest of the morning, I think at some point the group should be looking at a little more broadly and that we really have by my count at least five different areas we're trying to simulate what we're going to be giving to the epidemiologists.

We have to be looking at wellhead concentrations, which we talked a lot about yesterday in terms of the groundwater flow models. We have to look at the well operation scenarios. How were the various wells combined at any given time. The interconnection scenarios, how was the booster pump operated and the Wallace Creek valve. The water use demand scenarios, which we have ideas from the present study, but these are still a lot of unknown. And then there's a system operation scenario and that's primarily how did they operate the system not from the wells but once from the treatment, when would the treatment plant pumps come on, how were the tanks operated.

And I think it would be useful as a group to try to discuss how are we going to bring all these together. I've heard the idea of using Monte Carlo simulation or some kind of partition hypercube, but we're talking about a large number of scenarios in all these different dimensions. And I hope we can at least start addressing that at some point.

DR. KONIKOW: Well, I don't think the epidemiologists want all of that information. They want -- correct me if I'm wrong -- they don't want to know the details of the groundwater flow model or the details of the groundwater transport model or even the wellhead concentrations. They want to know the outcome. What went through the distribution system.

DR. GRAYMAN: No, exactly what gets delivered to the customer.

DR. KONIKOW: Exactly.

DR. GRAYMAN: But all of those things bear upon making that vital decision.

DR. KONIKOW: Exactly, yeah.

DR. ASCHENGRAU: Just to add to that, I mean, to me there were lots of issues that came up yesterday that are similar of this sort, right, on the groundwater modeling. So it has to go even further than that, and it's just to me we would consider all those sensitivity analyses. And so we would want to know sort of the bounds of the estimates, the monthly estimates, that we are trying to get.

DR. KONIKOW: Let me add that there were quite a few, I think, important issues causing uncertainty and error in what predictions could be made that we didn't get to discuss yesterday. I mean, it's really much more complicated and uncertain than we even, we just began to scratch the surface.

DR. GRAYMAN: Right, and what's complicated here, when we were dealing with Tarawa Terrace, we were at the point where we really weren't that interested in the distribution system because it wasn't one of the factors or wasn't a primary factor or even a major factor in contributing how much was delivered to the customers. Here we're now having to, everything that was said about Tarawa Terrace and complicating it by the fact that Hadnot Point and Holcomb Boulevard appear to be significantly more complex situations. We then have to overlay that with the water being delivered to the customers primarily in this interconnection phase.

DR. HILL: This is actually just going back to something that Bob mentioned earlier, and it's coming back to the groundwater model study. I apologize for that. But the idea of this is just a pile of sand, I would like to back off from that a little bit.

From the Castle Hayne downward it's been there for 20 million years, and it's a deposit that has some structure to it and some information that we can take advantage of. And the idea of representing, thinking of it as just a pile of sand, I'd kind of like to back off, thanks.

DR. KONIKOW: Maybe it was mentioned, it probably was and I just forgot, but what is the present situation at Camp Lejeune? Where is the present water supply coming from? And on a related issue, were the wells that were shut off and abandoned, how were those plugged? How were those sealed? Did we, was the annulus ~~crowded~~ [grouted -ed.]? So really two separate questions: one, what's going on there today for the water supply? And second, what was done with the abandoned wells?

MR. FAYE: There are some slides showing the well locations, the historical wells and the modern wells. I'm not sure if Jason has any handy there or we can flip something up. But the well, the modern wells, the modern, active wells, Lenny, have been distributed along Brewster Boulevard and then through the, sort of the eastern extension of Brewster Boulevard and down North Carolina Highway 24. So they're well north of -- we'll see here hopefully in a minute. You can look on the posters as well. Just a second. And down Sneeds Ferry Road, and these are all well away from points of known contamination and indeed the sampling indicates that there's no additional contamination happening. Here we go.

MR. ENSMINGER: Unless it's munitions.

MR. FAYE: There you go. Lenny, these are the modern wells right through here in this area and then down here, down Sneeds Ferry Road down in this area. These are the modern wells.

DR. KONIKOW: Aren't those down gradient? If you look at the head distribution, isn't that down gradient from the contamination?

MR. FAYE: Sure, but you're looking at a relatively small radius of influence here for most of these modern wells out here. There's not any influence in terms of contamination unless there's an unknown source out there.

DR. KONIKOW: Well, what's the slope direction?

MR. FAYE: Pardon me?

MR. HARDING: Yeah, I'd like to see a head map, I guess for the side gradient.

MR. ENSMINGER: It flows toward the New River.

MR. FAYE: What's your question in terms of the regional flow patterns? They would be toward the streams, Wallace Creek and then toward the New River.

DR. KONIKOW: Well, it certainly isn't shallow, but as you go deeper is there -- in the upper Castle Hayne, is the flow direction the same as in the shallow system?

MR. FAYE: Pretty much, yeah, left undisturbed by pumping wells, yeah, it would be very, very similar, very similar, just like Tarawa Terrace actually. That goes back to my comment that Mary objected to that it's kind of a big sand pile out there. You see very little head difference.

Actually, there's some -- and this is discussed in one of the Tarawa, I think Chapter C, Tarawa Terrace report. There's an excellent set of observation wells out here from the lower Castle Hayne aquifer all the way up to the Brewster Boulevard aquifer. This is observation well clusters by the North Carolina folks, the State folks.

I think there's maybe like a three-foot head difference between -- and this is undisturbed -- three-foot head difference or four-foot head difference between the lower Castle Hayne aquifer and Tarawa Terrace aquifer.

DR. BAIR: That's huge. That's enormous.

DR. HILL: That's up or down?

MR. FAYE: Well, of course, it's upward because it's right next to Wallace Creek. You have an upward flow pattern. So we have about a four-foot head difference here.

DR. BAIR: Yeah, but that's an enormous head difference. For a pile of sand you shouldn't have any head difference.

MR. FAYE: I beg to differ. If you're by a regional drain, I don't care whether you've got a pile of sand or not. If you've got 300 feet of sediments or so, you're going to have a vertical upward --

DR. BAIR: You won't have a vertical drain without a head difference.

MR. FAYE: Pardon me?

DR. BAIR: If won't flow vertically unless there is a head difference.

MR. FAYE: Well, if you have a highland area here where you have recharge, and then you have discharge down to your main drains, which is the New River, Wallace Creek or whatever, you're going to have a diffuse upward leakage in the vicinity of the drains, and that's going to be vertical.

DR. DOUGHERTY: It means that the best technical data's a turning point.

MR. FAYE: Yeah, I mean, all you have to do is look at what ~~Hubbard~~ [Hubbert -ed.] did back in the middle '40s. You can look at what ~~Tote~~ [Toth -ed.] said in '55. And you've got, that's typical regional flow patterns.

DR. HILL: You've got three head maps in the material that I have. One is in Report Chapter B. It's on page B-30 and it's estimated pre-development, and so this is contour measured. But the points aren't on here so I can't say what's controlling the contours, but these are these contours.

Okay, then you have one in the material we were sent in the notebooks. It's Figure 1, page 8 under Tab 6 after the, in the second section of that. And that's also contoured measured. And then you also have the contoured simulated values later in that section if I can find it. And that's Figure 3.

In every one of these maps, the contours next to the streams imply a completely different hydraulic connection between the groundwater system and the stream. And that's true for the Northeast Creek and the Wallace Creek. So I mean, you're talking now about that the three-foot head difference and what that means in terms of interconnection with the stream.

And really, without the groundwater flow model, I don't know. I don't know if what you're saying is correct or not. But I can say that your potentiometric surfaces in these three figures imply, each of them implies, I mean, there are some similarities, but there's some drastic differences.

And I don't know if you have these in front of you. We haven't seen them in any of the slides, but the one from B-30, the Tarawa Terrace report, but that figure goes down into part of Holcomb Point.

MR. FAYE: If you look in Chapter C of the Tarawa Terrace reports, there's a discussion in there of the simulated potentiometric surfaces, and you can't quite see the upland areas of Tarawa Terrace here, but they would be here. Where you have recharge in the upland areas in layer one.

DR. HILL: I'm not talking about that. These are really dramatic differences. I mean, it didn't come up yesterday and I don't have slides, but in Chapter B the Northeast Creek shows that it's highly gaining like this. The contours look like this indicating water coming into the stream.

MR. FAYE: Right.

DR. HILL: But the contours on Figure 1 that we were given show the contour is going directly across the stream like this as if the water was really just going --

MR. FAYE: No, that's a boundary for -- well, it may be true, but what I'm saying --

DR. CLARK: Is this something we might want to take up after the break?

DR. HILL: Yeah, that's fine.

MR. WILLIAMS: The wells, there's a State standard for ^ [abandoning -ed.] wells [; -ed] fill them with generally with bentonite and so that there won't be an interconnection between the possible transportation of contaminants between layers. So we did abandon those wells according to the State standards.

DR. DOUGHERTY: That's really not very definitive because it doesn't say that you, because there are various stages of abandonment. One of them is simply pulling the pump and leaving it in reserve. Another one is filling the existing casing with bentonite cement, and another one is yanking the casing and actually making sure you've grouted the entire annulus because we had, I think we have well water records that say that the annulus is open. So if you just filled up the casing, which I don't know North Carolina State standards so please tell me. Did y'all yank the casing or --

MR. ASHTON: No, we did not yank the casing. And typically these are gravel-pack type wells. And, no, we did not yank the casings. Typically, how these wells are constructed is about a 50-foot grout to prevent surface influence. Then, of course, they go down between 150 to, in some cases, we have some wells that are 250, some that are even deeper --

DR. DOUGHERTY: (Off microphone)

MR. ASHTON: Pardon me?

DR. DOUGHERTY: How were they installed here?

MR. WILLIAMS: Oh, those were all rotary.

MR. ASHTON: Yes.

DR. CLARK: Why don't we take this up after the break and give you a chance to get together and talk about it?

MR. WILLIAMS: Yeah, and the other question that was unanswered is what's the state of the water system now. And we can take that up whenever you want.

DR. CLARK: Why don't we address all this after the break?

(Whereupon, a break was taken between 10:20 a.m. and 10:33 a.m.)

DR. CLARK: We're going to change the format just a little bit and change the order a little bit. I think that maybe we're not giving ATSDR the kind of advice that they need to continue on with their work.

So what I've asked Morris to do and Frank to talk a little bit about what they think they would do for the future and what kind of advice and input they would like to have from the panel. We've got you guys here, an expert panel, tremendous input, tremendous help, but I'm not sure they're getting the kind of advice that ATSDR really needs to continue on with their work.

So, Morris, why don't you go ahead?

PANEL DISCUSSION: WATER-DISTRIBUTION SYSTEM MODELING (RECOMMENDATIONS FROM THE PANEL)

MR. MASLIA: What we would like to focus really on is, and at the end of the day when you make your recommendations, besides the details is the big picture. Because what we have to be able to do is go back, or if any of our management is here, and also go back to the Navy and say, yes, we're going to finish in this timeframe or, no, here are the steps we need to take to accomplish to provide the epidemiologists with an estimate of exposure.

And to be able to do that I think we need to step back or go back to the bigger picture recognizing that the details are important; however, what I've noticed is we were, I thought, getting down to so much detail that we lost sight of the big picture in terms of the distribution of water historically at Hadnot Point and Holcomb Boulevard.

So I just put up, just real quickly here, from 1941 when the system came online, Hadnot Point supplied everything until Holcomb Boulevard came online approximately in June of '72. During that period you have one system, and you have all the wells contaminated, non-contaminated going into a water treatment plant so we can go back to what we did at Tarawa Terrace and use a simple mixing model. So that takes the distribution system water dynamics and water quality dynamics of a distribution system out of the picture completely, and we just have to concentrate on, yes, important factors, but the well cycling and from a groundwater standpoint.

From 6/72 when Holcomb Boulevard came online to '87, from August through March there's no indication that there are any interconnection, the booster pump or the Marston Pavilion valve was turned on. So again, we still have simple mixing because the wells are feeding into storage tanks, combining into storage tanks. So again, that takes the detailed water quality dynamics of a distribution system out of the picture.

So that leaves us basically this time period in here for April, May, June and July with an interconnection issue a couple of days during the month. So the question or the idea would be can we use, can we come up with a typical day, a typical day that we could say during a typical day -- with bounds on it.

I mean, I'm not throwing out the uncertainty, but with bounds on it that we could then say during a typical day to the epidemiologists, this is what the exposure would be at different locations in the distribution system given what data we have, given that we have a two-week period where we've got test data or sample data or whatever when the line broke, given that we also have field data that we collected in terms of calibration or seeing that the system operated realistically from a diurnal pattern. And that's --

I guess, Frank, is that stating I guess the big picture?

And that's what I'd like to throw out to the panel here to see if we could focus the discussion really on that so we can get, hopefully, some direction as to how we should proceed on that.

Frank.

DR. BOVE: The other big picture is can we get monthly averages? Does that make sense given the complexity of the situation? Can we get quarterly, should we move to a quarterly situation where we get just quarterly data averages? So that's another question that the epidemiologists, I would like to know.

DR. KONIKOW: Doesn't that hinge also on how well we do in predicting what the wellhead concentrations were?

MR. MASLIA: Yes, absolutely, absolutely.

MR. HARDING: You can't model at those longer time steps in the water distribution system. You have to do it on an hourly basis or a sub-hourly basis. The model will choose the time period that it needs. But what you can do then -- I'm thinking out loud here, but Walter and I had a discussion in the hall here.

What we've done in the past, because as the water distribution people are always the tail of the dog, and the groundwater people deliver their stuff to us at the last second, and then we have to make our calculations. And so we adopted as a matter of convenience, but it happens to be good in other ways though, using the method of super-position to provide a fast way to make the calculations of nodal concentrations to the concentrations of the source in use.

And we have -- my brain isn't completely functioning here, so correct me if I'm wrong. But we have two sources of water at Holcomb Boulevard during the interconnections. We have the Holcomb Boulevard water treatment plan, and we have one, possibly two, interconnections. I think the second one is when the booster pump is running is going to prove to be a drain, but you could do the modeling during those actual interconnection periods.

The hydraulic modeling will calculate, just like Jason did up there, and use a hundred part per billion or use the source of water function in EPANET and calculate the percentage of water from each source and each node, average that over a rolling three-month period, which is your resolution that you needed, and will help avoid overconfidence in what you're predicting because you're going to be wrong on any particular day. You know that.

But over an average of a period of three months, and that's usually what I felt I had some confidence in, you should be getting close. And then keep those coefficients there, and then you can do whatever you want. You can load them however you want with what comes out of the Hadnot Point mixing model.

MR. MASLIA: I'm in absolute agreement with you. In fact, we took a similar approach, not contaminant-specific, but in Toms River. In other words put a hundred units in and did it that way as well. And that's I think what I was trying to hopefully get to here is to try to simplify that in that --

MR. HARDING: And in the Hadnot Point system the memory in the tanks is going to be important if the wells, if the contamination's going on and off. If it's more smooth ^ but if you've got contamination going on and off, then the memory of the wells becomes significant.

But you can use the same approach. You can use the, what we call transfer coefficient super-position approach to run it once, and then use it to force it with a Monte Carlo or whatever you come out of a resampling from your groundwater results, just thinking out loud. Walter had some thoughts as well.

DR. GRAYMAN: You were talking about temporal averaging period. Spatially, under most circumstances we'll be able to say, well, we can treat Hadnot Point as a single unit just as we did Tarawa Terrace. Holcomb Boulevard, hopefully, we may be able to just do it by ~~assume~~ [assuming -ed.] Berkeley Manor is homogeneous. And that can be tested in the water distribution system model to see if that's the case.

DR. WARTENBERG: I have a question about this temporal averaging. One of the things that would be helpful for an epidemiologic analysis is to know the variability of your predictions. And I don't know where in the process you're doing the averaging and whether or not it's possible to give us more fine scale data that epidemiologists would average using rolling averages or some other approach or finally give us some sense of that.

DR. GRAYMAN: Finer scale temporally or --

DR. WARTENBERG: Temporally.

DR. GRAYMAN: -- probabilistically?

MR. HARDING: You can do it, but you have to then use it in a longer timeframe because you're going to be wrong. You're not going to have it exactly the right time. But if you want to calculate frequency information, I think you could do it.

DR. WARTENBERG: Well, all I'm saying is if you asked me what's the right temporal increment? Should it be one month, three months? I don't know the answer. But if you gave me the data, say, daily data, then I can average it different ways and look at it.

MR. HARDING: It scares me if you're going to use it and on a daily basis.

DR. WARTENBERG: No, I wouldn't use it on a daily basis, but I could look at how it changes and aggregate it weekly, monthly. Otherwise I don't see that variability. That's what I'm saying.

DR. KONIKOW: Look at the first page of Table C-7 that they handed out this morning and look at the wellhead concentration in the first well, 602, over a two-week period. It hit a high of 1,600. The next sample is 540 and the next was 300.

DR. WARTENBERG: Those are still going to be the data, right? Those are the data, and you're going to have to --

DR. KONIKOW: You want to know what the variability is on a less than a mean monthly, well, there's the information we have. Whatever we reconstruct in the model to feed into the water treatment plant isn't going to be any better than this. And this is your sample, and you know, you say, well, there's three samples in two weeks. What's the odds of actually hitting a peak? Well, pretty small. Somewhere close to this time it was probably much higher than 1,600. There you have an example of the range in a contaminated well, and if you go to the really bad well, 651, you see similar things over basically a two and a half week period it went from 3,200 to 18,000. Well, there's your sample of a local area --

DR. HILL: And I really agree with that, but the model's going to give you a very smooth representation of what that system was doing. The actual variability is just what Lenny said. You've got it there, and that's the best information you're going to get.

MR. HARDING: It won't be smooth in the water distribution model. It will be step functions. It'll be on and off. It won't be smooth. But when you average it, you -- but it will be wrong on Tuesday, or Wednesday.

DR. DOUGHERTY: Right, but if we do a multiplicity of scenarios and then provide those averages across the scenarios on a sub-daily basis, which way do you want to, it just becomes risky.

DR. KONIKOW: Well, there's no way in terms of the wellhead concentration according to the plan modeling scenarios, there is no way that you could possibly reproduce the observed variance in what gets fed to the water treatment plant.

MR. HARDING: I can't even speak to what gets fed to the water treatment plant. That's your business not mine, but I'm saying that what happens in the water distribution systems is going to be way more dynamic. That's the point I'm making. And let me just ask this question about objectives here.

All the work that I've done in the past, we've been looking at chronic effects, and we haven't been looking at acute impacts. And so what we looked at was what we called either whole body dose or intake of a particular contaminant, typically TCE, vinyl chloride or chloride sometimes. And so you would be looking at the accumulation by on an annual basis.

And the reason that you looked at it on a shorter basis was because people moved in and out and things like that. Now, in this case we've got to look at it on a shorter basis because somebody, because we're worried about these trimesters. But is it really necessary to know that, or even useful to know, that that occurred in the first month or the third month? See what I'm saying?

Because I'm very, I think you're going too far if you break this down more than a quarterly basis, but you could do a rolling three month summarization. And I'll leave it to the statisticians to figure out just how much structure you could put into that summarization. Typically, we've used the mean.

DR. GRAYMAN: Let me ask you a couple [of -ed.] questions and interpret how you'd use the information. Would it be different if you were to get the information, let's say, on a monthly basis or on a three-month basis that the average concentration in the water was 300 micrograms per liter. If you had that information, but if we were to tell you that during that same period, the concentration varied between zero and 1,500, would you use that information? But on average it was 300. Would that impact your study?

DR. WARTENBERG: I guess I don't know enough about what people think the mechanism might be in terms of how the causation works, but there's certainly been studies where people looked at maximum exposure levels or percent of time above some level. In other words how many days were they exposed above, and I don't think there's good theory behind it.

What I was trying to get a sense of if you're telling me the data are, I don't care if they're not reliable for that day, but are they really representative of the variability, then that's useful. If they're not, then obviously it's not useful.

But for things which people can actually measure over time, sometimes people have taken these daily numbers and then looked at different ways of summarizing the exposure not assuming that the average is what makes sense.

MR. HARDING: I think that's okay. There's some technical or mechanical issues that have to be resolved. I mean, this is not going to fall right out of EPANET as it comes off the shelf and you pull the shrink wrap off it. So there's some mechanical difficulties, but that's why we pay Morris the big bucks and Jason the big bucks, right? I'd be happy to describe the way we've modified it, but, yes, you can do that.

And you can basically -- leave to the statisticians to figure out just which of these things would be valid. But I would think that days above a threshold would be valid and a mean. The problem is that if you don't do this right, you're going to have to go back and re-run the model to get it again with a different threshold.

So I would suggest figuring out a way that you can run it on these short timeframes and store your transfer coefficients on a short period and then be able to run it through a subsequent processing step to --

these are technical details, but I think it can be done.

DR. WARTENBERG: Yeah, but I don't know if Frank's thought about this at all. Just listening to you talk about the different timeframes just occurred to me.

DR. BOVE: When it comes to, say, neural tube defects, we're talking about a time window here of vulnerability of a few days during the fourth week of gestation. We can't, of course, know when those four days occurred based on what the birth date of the child or even if we have LMP, last menstrual period, where a clinician decides on gestational age. I'm not sure we could pinpoint those four days anyway, or five days. But that's how tiny the window is for neural tube defects.

For clefts we're talking more of a week or two, a two-week period for each of the clefts, cleft lip and cleft palate. So we're talking small timeframes of window of vulnerability, but there's also uncertainty as to when those two weeks occurred given what we know about the child's birth and the mother's

LMP. So those are issues.

MR. HARDING: Well, I think the best you can hope for would be this percentage of time above certain thresholds, and I think that would be a valid statistic to calculate. I'm looking for support here from somebody that knows more about this, but I think you can get that, and then from that you could probably make some inferences about what the odds would be that this particular causative factor was a factor in that particular.

DR. BOVE: Where are these thresholds coming from?

MR. HARDING: Well, let's say that you'd say that during this particular three-month period the concentration was above 300 parts per billion for sixty percent of the time or something like that. And if your threshold for impacts a hundred, I mean, we could do a hundred, too. Maybe it's 100 percent of the time. And so you've got a clear answer there. It's going to be diceyer [dicier -ed.] if your threshold is, say, 200 and the percent of time above 200 is 30 percent. I don't know.

I can't answer that question for you,

but I think you need to step back. I wanted to go back to Walter's point here. You need to just climb up to about 20,000 feet for a minute and look at this, and you guys need to look and ask for your endpoint what you need, and then talk about how you're going to try to get the best estimates of those things you can from the models.

DR. GOVINDARAJU: I'm seeing two kinds of variability right now. First is if you have a model run which has all these behavior fluctuations and ^ [temporal -ed.] fluctuations, if you want to average them or do the moving window of let's say one week or ten days or three months, then you'll get fluctuations within one single model run.

But if you want to incorporate the variability you're getting from wellhead concentrations and so on, then you're talking about doing many of these model runs to try and capture that variability as well. So there is almost like an internal, intra-model variability, and somehow we have to combine all this information to answer questions like what is the likelihood that you will exceed a certain value over a continuous ten-day period.

Or what would be -- and so some of those we can, I think those could be done, and we could perhaps attach some probability of what is the likelihood, what is the probability of this kind of event happening.

MR. HARDING: In fact, what you're dealing with in the water distribution system is variability. And what Rao's talking about is uncertainty, I think. And I would suggest bringing Owen Hoffman who's a guy we've worked with before on the, to help frame this team. He's a really excellent person on risk out in Oak Ridge. But, yeah, that's the issue.

You've got variability in the water distribution system, which is more profound than in the groundwater system, but just happens faster a little bit. There's still variability in the water distribution system, and then there's a profound imperfection in our state of knowledge about this, which is the uncertainty we face. And that's going to be represented by different iterations of a Monte Carlo, for example.

DR. HILL: So we have this range of things that epidemiologists might want. We have just give me bulk, high, low, medium exposure or no, medium and high exposure. And then we're getting into these ideas of, well, if I had more detail, this is how I would use it so that I could use it.

And we've talked about different strategies for creating more accurate concentrations at the wellheads and whether or not those are worth it and maybe they're not worth it if you're just trying to get rankings. But maybe they're well worth it if you're trying to dig any deeper.

So it seems to me like there's a goal of this groundwater model that's a bit of a moving target as of these last couple of days. And I'd be interested in, and I don't know what you think about this, but it seems to me like the design and effort in the groundwater model depends very much on these priorities.

DR. GOVINDARAJU: The answer is yes, but just to bring the discussion back, I think we're talking about just the water distribution system right now. Is that

correct?

MR. HARDING: I don't want to limit it to that.

DR. HILL: It seems like the, it may be that the water distribution system impact dominates. I don't know, but I wouldn't think entirely.

DR. GRAYMAN: I think it's time to broaden this discussion back.

MR. HARDING: But certainly it only dominates for, it may not even dominate, but it's ^ [important -ed.] in this relatively small piece of a relatively small piece probably of Holcomb Boulevard. Unless the wells are going on and off and there's big step functions in the forcings [? -ed.] from the contaminants, which I think is probably unlikely, then the tank memory in Hadnot Point will become important. But if it's not, it's not important.

DR. CLAPP: I'd like to just respond to Mary's laying out of the range of opinion that's been made by us epidemiologists. I sort of staked out the three-category thing yesterday. But it's definitely true that the more, especially for Frank's birth outcome studies, the more detail the better.

I guess what I'm worried about is that we're getting to a point where we publish an effect estimate that has so much uncertainty bound or bundled up in it that the confidence bounds go off the page, and you're left with just a big fuzz ball. So if we can narrow the bounds of uncertainty to the point where it's useful on a monthly basis, fabulous, and not just a guessing game.

MR. HARDING: Don't expect -- I keep saying this. Think in log space. Think in terms of astronomical framework. I mean, when I've done this before, the medical causation people think that way. I mean, if the exponent doesn't change, we don't have a significant difference. I mean, you've got to be to that point. I mean, you're talking -- we never did get to the calibration standards, but you're talking about a half an order of magnitude plus or minus, so you've got an order of magnitude range just in your calibration standards. So how can you expect to be conceptually better than that in --

DR. HILL: And that was heads.

MR. HARDING: Yeah. But I just think if you can't use it for an epi study in the log space, maybe you can't answer the epidemiological question. But there's a lot of other questions certainly that can be answered or be thought about.

DR. WARTENBERG: I don't know if the ^ will fix that or not but I mean, some epidemiology has really ^ [had -ed.] horrible exposure data and worked. There are countless occupational studies where if you worked in a given profession versus not, there are really clear associations with disease.

And then it goes off in the other extreme where people have very fine-scale, accurate estimates of exposures and can show associations. So in something like this where I think it's less, there's less data to say what the association is, it's a little hard to say what we really need to show an association if one exists.

MR. HARDING: But if I've learned anything here, the one thing you want to avoid is misclassification, right? So if we can get that right, then we've made a step forward.

DR. WARTENBERG: Right, misclassification will just blur the whole thing.

DR. HILL: So let me go back to -- it seemed to me yesterday there were three ways to deal with the wellhead, developing wellhead estimates of concentration. One was just to take the measured concentrations that we already have. Say, okay, I'm going to project back in space or in time that this really contaminated well had some kind of average value back, almost a step function or exponential or something.

And just say, okay, based on measurements here, I'm just going to project it back. No physics, no nothing, just a direct, and then feed it through the mixing system of the well distribution system and get exposed node, high-level node, whatever in three categories.

That would be like level one. Level two or level three, whatever, the other two options that were discussed were doing some linearization of the system and doing what Professor Aral said. And then the third one is to go through the whole groundwater model.

And so if this is level one, it seems to me that then you want to think really closely about, okay, if I can start with this level, what do I want to get out of those next two levels, and very specifically. Because I think if you have very specific objectives on what you want to attain from those given the data you have and given what you have a hope to, then you can make some progress.

But I'm a little concerned that the charge being given for the groundwater model isn't focused and defined enough, and it's just like, well, just represent the system accurately. Well, given this data what does that mean? So I'd be interested in a discussion that kind of address those three things and what to get out of it.

DR. ASCHENGRAU: So I think with going further would be to get a more accurate ranking of those study subjects, that that's what all of that effort would do would be to boost at that accuracy and get a more accurate ranking that would be possible with the first method. So and it just seems as though there's a huge amount of effort that needs to take place in order to do that.

DR. BOVE: I think Mustafa's approach does not take a whole lot of effort and may still give us some of what we got for Tarawa Terrace, if I'm not mistaken. So I think that's the approach we've been thinking about all along. That that approach might give us a good answer, a good answer for the epi study.

And then if we need to move beyond that, we could use that part, step two, to help us with step three if we wanted to go to step three. But we could try step two to try to get the monthly averages like Tarawa Terrace. And then if that was sufficient, we could stop. Does that make any sense?

MR. HARDING: How do you know it's sufficient?

DR. BOVE: We make a judgment. I mean, --

MR. HARDING: That's fair, but the concern I have -- and I'm not a groundwater --

DR. BOVE: Not by -- we make a judgment without looking at the outcome, blinded by the outcome, of course.

MR. HARDING: Coming out of the world of litigation I know there's a huge weight put on trying to acceptance and I think that it's a novel idea, and it seems to conform to Clark's law about a sufficiently developed technology. It really is cool what it does though I have a problem thinking that people are going to accept this very much when they can't get in and dig around and look at the physical underpinnings and say that these make sense.

Do the constraining layers, you know, we've gone into all these details, and that's a real pain for the modelers. And some people focus on little details that are their specialty, but on the other hand that's the way you're going to develop confidence with this is that does it look reasonable. And unfortunately, you can't do that with a matrix that's got 16 elements in it or 25 elements.

DR. GRAYMAN: Yeah, building on that, again from the legal standpoint or at least my observation of it, is a lot of reliance is on has this model been used before. So if you go in and you say I've used MODFLOW. MODFLOW's been used for 25 years all over the world. It develops a certain confidence. If you use something else that's new and innovative, then you, the burden of proof is on you that that is valid. It's a tough thing to prove.

DR. KONIKOW: Well, in this case if you get to the point of trying to develop a history of wellhead concentrations using this full-blown modeling approach, deterministic approach, it's really going to be difficult to defend it in a litigation requirement. I mean, there are just so many weaknesses in assumptions and uncertainties in it that it really will be very difficult. I mean, you get very open to attack.

MR. HARDING: It is, but it's been done many times.

DR. GRAYMAN: Is it more so than other situations? Is it more --

DR. KONIKOW: In this case more so than other situations.

MR. HARDING: I've seen some really messy situations with not nearly as much data.

DR. DOUGHERTY: But is it more than the linear control approach?

DR. KONIKOW: Well, no, I think they both hinge on what do we know. And what we know is very limited. And so whichever, it's a question of how do you want to extrapolate back. For the wellhead what we really need to know are two things. One is the pumping history of each well. That's important to know if the modeling will not give us a clue about that. We have to tell the model what that is, not the other way around. So that's one thing that's needed.

The other thing is the concentration in the well or in the well discharge, the history of that. Now that we could try to get that starting from a very deterministic approach. And I'm not saying it's not worth doing, but I'm saying we better have something to compare it against such as Mary's level one and just see how they compare. I think we could do a little bit better and still keep it very conceptually simple but key into the history that we have even though as limited as it is, those are the knowns.

And then there were all kinds of questions about what causes this variability. Look at the contaminated wells. It shows a peak. You know, you've got five data points, it goes up and then down. Well, is that variance, is that just representative of a saw-tooth pattern or was this the real peak in the whole full-blown history.

But what I would say, and you will have to reconstruct something about the mass loading history to do the transport model, so you will have some estimate of that information. Well, take that information, use your flow model in MODPATH analyses from each well to each source and reconstruct the distribution of travel times.

Use that then to lock in the starting points in growth history of a concentration curve, and then just bring it, just use a thick pencil and bring it up, if you want to work on a log scale exponentially or on an arithmetic scale, try them both, then just bring it up, use your MODPATH to get you a starting point, an initial curve, and then bring it up to your known history. And then feed that into your mixing. Do that for each well.

You still need as good a groundwater flow model as possible, but you use MODPATH instead of -- but then you'll still have other complications. Do you want to retard the movement field or retardation factor to catch, but at least you have a starting point, and it'll be much simpler and more defensible and easier to explain conceptually than the full-blown transport model. Do the transport model also, but I think have this simple, I'll call it level 1.5, as a way to get at the numbers you really need and --

DR. CLARK: What about linear control?

DR. KONIKOW: I don't understand that well enough to know that it's any different from the drawing with a thick pencil.

DR. CLARK: Dr. Aral.

DR. ARAL: I think Mary wanted to say something before I --

DR. HILL: Oh, no, all I had just wanted our discussion to progress further before Dr. Aral talked, but if this is the appropriate time for that, that's fine.

DR. CLARK: That's an issue, I gather, is how appropriate the use of linear control theory would be.

DR. KONIKOW: If the linear control theory is as good as it looked, then fine. Do it for the wells where there's enough data to do that, then great, but I don't understand about the ^.

DR. BAIR: To me the shortcoming of it is not in where it can be applied, it's where it can't be applied. And do you go forward with something that is an incomplete picture of the whole thing from 20,000 feet, which would be the linear control model at three or four places, where you have sufficient data to go forward with it.

Can you ignore -- I don't know -- 70 percent of the area or 60 percent of the other production wells? And how do you enter that missing 60, 50, 40 percent into the water distribution model? And if you're missing 40 percent, how do you analyze that in an epidemiological way when you're missing 40 percent of the possible source terms because you didn't address all the wells in the flow system?

DR. KONIKOW: Yeah, one of the things that the transport model could do for you that the data don't is that at least within the framework of the conceptual understanding of things, it may show you some surprises. It may show you a pulse of contamination going by one water supply well where you have no records of contamination because it came and went before the period of observation. So things like this could be gleaned from this. You just don't know whether to believe it or not. You don't know what to do except to say, well, there's a possibility.

MR. FAYE: Let me just say that Lenny has pretty well articulated what we have discussed in our planning conversations amongst the staff. And in terms of the deterministic model about the approach, the methods and how to do it. And somewhere I hope there's a verbatim transcript of that because it lays out very well, as I said, what we have looked forward to doing.

The issues with the linear model, the difficulty there is what Dr. Bair talked about is that you need concentration data at the supply wells, and there's very little concentration data for all of the abandoned supply wells through time, and there is none.

And unless you have something going on at that well that represents in the linear model, there's no way to construct anything from that in terms of a monthly concentration, quarterly concentration, whatever.

DR. HILL: Okay, now I'm confused. Because it seems to me that you have been advocating the use of that approach, and now it seemed to me that that was a very clear explanation of why it was really pretty limited and so now I'm confused.

MR. FAYE: Why are you confused? Because it was totally presented yesterday as a screening tool. I mean, well, it was, as I heard --

DR. BAIR: Twenty minutes ago it wasn't.

MR. FAYE: -- as I heard it was to be used as a screening tool, as an adjunct to developing our deterministic model.

DR. HILL: I have definitely been getting mixed signals about how it would be used exactly.

So, and Frank, some of your comments, particularly made me think you were thinking of it in a more, in a broader perspective. So maybe you can --

MR. MASLIA: Let me clarify because we've got some objectives here that need to be mutually compatible. And that is that we need to give the epidemiologists results that they have some confidence in. And at the same time we do not have an infinite amount of time or resources. So what we need to try to do -- and I'm not necessarily talking about the December date that we had thrown out. I'm just saying in realistic, you know, we can't go on for another five years like that.

With that said we were looking to develop a screening-level method that could initially give us some rough cut or estimate to give us some handle on what the concentrations would be back in time, and at the same time, as Lenny and Bob said, perhaps help us avoid from going to the full, dispersive fate and transport approach and using a much smaller sized advective transport model.

DR. GOVINDARAJU: Well, I think one of the things that we could consider is from what Professor Aral explained yesterday, his method is allowing us at least to have an idea of what happened in the past for the wells that we have observation. For wells that we have observations recently, it can also reconstruct some of the stuff in the past.

So we could use that information and then have that also constrain the full-blown groundwater model. Because the groundwater model as it is has too many unknowns, too many things that we aren't able to pin. So having some other guidance to perhaps pin it at these locations and for wells which have no data, you're right, we have no data, let the groundwater model, full-blown model, do its best.

It'll already have a lot to do just trying to capture that. So if it is outcome guided in some other way with some other information, I think we should use it.

DR. DOUGHERTY: Okay, I'm an engineer so I'm trained to be conservative and have big safety factors on things. So with that as a preface, I'd like to move on. I'm in agreement with Lenny in many respects here. I like the idea, the linear control, the black-box model, whatever you want to call it, I think it's intriguing, and I think it should be explored in parallel.

I think hanging your hat on it is inappropriate because you're going get too many hits once the first document goes out the door. I do think it's very intriguing, and I think it should be explored in parallel in those locations where they are appropriate.

But I think we need to move past it and get on with the other significant things to deal with, which are the sources of uncertainty that drive it, pumping schedules, source locations and release times and mass loadings and all the other things that we've talked about.

DR. HILL: One thing that I'd be interested in talking about is what groundwater transport model to use. Because there's -- and I brought this up in my comments as well -- there are widely used transport models that I believe simulate the processes that are being simulated, that are of concern for this model and instead of a relatively, new untested model that's being used. In this highly political situation, I really wonder about that decision.

MR. MASLIA: We used MODFLOW and MT3DMS.

DR. HILL: Yes, but for the reactive transport.

MR. MASLIA: For the degradation, one of the reasons we went there is we thought we might need to get into the unsaturated zone.

DR. DOUGHERTY: So the plan here moving forward is to stick with MT3DMS --

MR. MASLIA: Or MODFLOW/MODPATH.

DR. DOUGHERTY: Or MODFLOW/MODPATH.

MR. MASLIA: Yes, that is correct.

DR. DOUGHERTY: So we don't foresee the unsaturated issue showing up here? I mean, this because I have a hard time --

MR. FAYE: Actually, it could because there's issues with vapor from PCE, BTEX into the buildings, particularly at the HPIA. We didn't really even anticipate a problem of that nature with Tarawa Terrace. It did show up with respect to one of the schools there, and we had, it was a good thing that we had the unsaturated zone model. So all I can say is we just don't know, but it would be handy to have because there are issues out there where it would be useful.

DR. DOUGHERTY: So do you see that in this particular study or other studies that are in planning --

MR. FAYE: Well, as it happened in Tarawa Terrace, it turned out to be a secondary thing, a post-modeling thing, but it did happen, and we did have the model there to attempt to deal with it. And so who knows? If the very same, as Mary said, this could be a highly litigious situation, and it could come up just right out of the blue as it did at Tarawa Terrace.

DR. KONIKOW: Well, in terms of informing the calculated wellhead concentrations, I'm not sure I see the connection.

MR. FAYE: No, there is none. It would just be an ability to simulate the unsaturated condition.

DR. KONIKOW: So in terms of the objective maybe that's going a bit astray then.

MR. FAYE: In terms of the objective as it's stated now, yeah. I would agree with that. But like I said, at Tarawa Terrace it was the same issue. I mean, it was a kind of a research thing to do. It worked out nicely, and we did the whole degradation scheme with it.

It happened to have an unsaturated zone component. And from the point of view though of doing the degradation, the complete degradation pathways, Lenny, that was a model that we used. It just happened to have an unsaturated zone component that came in handy later on.

DR. KONIKOW: Yesterday when we were talking about the models we, I mean, we're kind of at a disadvantage here projecting where the transient flow model and MODPATH and the MT3DMS will get us, we really never talked about them, but you were having some experience with Tarawa Terrace. And looking at some of the documents in the three-ring binder, there are still many -- maybe we need a day or two, you know, eight months from now to talk about this.

But I'm really particularly concerned about projections of degradating calculations of degradation rates or decay rates in there. Because I saw preliminary estimates using observed concentrations assuming that there's no advection, no dispersion, no nothing else going on and ignoring the fact that there were remediation efforts going on, just using the best fit to get a decay rate. And then saying --

MR. FAYE: It wasn't even a best fit. It was just two points at a time.

DR. KONIKOW: And then saying that that's the rate you should use in the transport model, and this is circular reasoning that I think will be difficult to defend. So I mean, there are many issues on the transport modeling, and that's just one example that really will leave the whole thing open to severe criticism. I don't see any easier way around it.

DR. DOUGHERTY: Those particular pages I, those should be red-lined right now. Throw them out. I'll be direct. They're terrible.

MR. FAYE: Which ones are you talking about?

DR. DOUGHERTY: The biodegradation reaction section in -- I forget which tab it was under -- there are two pages ^, and they're not biodegradation or reaction fittings.

DR. ARAL: Morris, they have to log on.

MR. FAYE: All I can say is with respect to that, Lenny, you're right. There's all kinds of limitations. We have on the one hand, we have a lot more opportunity because of data to compute degradation rates in this study from field data. But they're still limited by the same caveats that you describe regardless.

And then the other choice is literature data. All I can say is you know we'll do the computation so we'll take the field data out. We'll take the literature data and look at it and make our best judgment and defend it as well as we can. We know that. We're aware of the limitations of using those field data, for sure.

DR. HILL: Just coming back to the transport model, having the capability to deal with the unsaturated zone is fine, but usually to deal with the unsaturated zone you need a fairly fine grid. So you might consider using a very fine grid, a much finer grid usually than you need for the saturated zone. So you might consider using the more sort of tested and accepted model for some of your simulations and bring in the model with the unsaturated zone for those simulations that have that requirement.

MR. FAYE: Yeah, I think that the point's well taken. The application of that model would only be with respect to what Rene was talking about yesterday was the child models, you know, where the --

DR. HILL: Right, I understand.

MR. FAYE: And that would be a very high grid resolution.

DR. HILL: Let me just finish. I just wanted to mention that the name of that model is RT3D, which you know I'm sure.

DR. CLARK: Right.

DR. ARAL: I'm not going to defend any model or any procedure. I'm just going to summarize probably what has been said in this group this morning.

As a technician in this field in developing models and as a technician in this field in applying models, we all know that the model sophistication can be put forward in terms of its ability to model this and that and other things in the field that we observe in any which way we want.

In other words technically we are capable of developing a mathematical representation of a physical system and then computationally discretizing it and solving it. We are technically capable of doing that. And I'm summarizing that in this slide here. This is one sophistication level that we can look at. We can go beyond this. We can go backwards from this. So model sophistication from a technical point of view can go forward from that in any direction that we would like to go.

However, in an application the model to be used should be a function of availability of data in the field. We cannot go to a more sophisticated model than that if we don't have available data for the parameters that we introduce at that sophistication level because as we go forward in sophistication, we are adding additional parameters. If we don't know the parameters then the uncertainty that we introduce into the outcome is going to be greater than the capability of the model to represent the physical system.

So this is what has been discussed in this group all morning. I mean, basically, we have limited data. We have to accept that. Can we go to a daily pattern in a water distribution system? Yes, I have worked in that. Yeah, I can put a daily pattern in. But do we have that data? No. So the discussion has to concentrate and focus on what we have and what the model can do in that arena.

The other aspect of all this in my opinion, what is the outcome that we are after? Yes, the data is limitation. The model can be of any sophistication level, but what do we want as an outcome? That is the other consideration which is also discussed in this group that we need to address. The outcome is what the epi people want. Do they want monthly data output of concentrations? Do they want daily output or quarterly output? So that needs to be a driver. All of this I think has been discussed, and all I'm saying is let's summarize that, and let's look at it from that perspective.

The other concept that has been discussed here is in litigation we should use established models. Well, if you put me to a litigation desk, I can always criticize MODFLOW. I can always criticize MT3D because they are not sophisticated enough for certain applications. And we have discussed why they are not because vapor exposure. They don't address that.

So if there's a model which does an additional analysis over what other models can do, if it is available, why not use it? If it is available in terms of duplicating what MODFLOW does, why not use it? Just because MODFLOW has an earlier history doesn't make it better.

So I just want to leave it at that. I think the summary here is we have to look at the data. We have to look at the output required. The models are just tools. We can choose A, B or C if it helps us getting from A to Z, then that's okay. That's all I have to say.

DR. ASCHENGRAU: Dr. Aral, have you validated your methods against the other methods or against data --

DR. ARAL: The new method that I have talked to you today or yesterday? No, that's a totally new method. The only validation that you have seen is on the Tarawa Terrace application. That's a totally new application.

DR. ASCHENGRAU: But this third thing, the matrix, it may be --

DR. ARAL: Oh, yes, this solution that we have, I think it's the name was not mentioned but ^[TechFlowMP -ed.] ~~FLOW MP~~ is a new 3D model -- not new, started in the '90s we are working on it -- does solve these equations similar to the way MODFLOW and MT3D solves. On top of what they do in MT3D, it looks at the unsaturated zone and the vapor transport.

DR. DOUGHERTY: I think there's some confusion about which model's being discussed in terms of questions and answers. So I think Ann was asking about the linear control where it has been validated against other methods in any particular way. A majority of your comments, I believe, are on the multi-phase, multi-media.

DR. ARAL: My comments were referring to groundwater flow, contaminant transport analysis aspects. Those models can get to be as complicated as we want. But in application we are limited, as we are hearing all day yesterday and today, we are limited by the data. So the complicated nature of the model doesn't make it better in terms of an outcome if the data is not available to use that complicated nature of the model. We have to accept that.

DR. ASCHENGRAU: But it's just people who have been expressing their discomfort with some, with what I perceive as some new method that other people haven't used yet. And so I'm just trying to figure out is if we can be more comfortable with it because that new method has somehow been compared to the existing methods. And so they shouldn't be as comfortable about it. That's all I'm --

DR. ARAL: That's a very good point. We are not proposing this black-box model to be used which was developed three months ago. We accept that. We developed this three months ago. And we are not proposing to use this without extensively validating it in other areas, in other databases, so that it establishes a footing in the field. We are not proposing that. We have to test this model over and over again to have confidence on its outcome.

DR. GRAYMAN: Getting back to your comment when you referred to when you were in court testifying. I think we'd all agree as scientists we want to use the best, most appropriate method, and that sometimes is not totally in line with what you see if you're in a court case, and it just isn't. I mean, court cases aren't necessarily about the best science. They're about whatever they're about.

But it would almost be like if you were doing climate modeling and you'd developed some new climate model that had some additional processes. And you felt that this was definitely much better than what the established methods were that were tested by the IPCC and had gotten the Nobel Prize for it.

And you're in court and you're trying

to say, well, my model is better because -- and they ask you, well, has this been validated. Has it been used other places. And you say, no. You're going to be probably a lot better off in convincing the court by using one of the established models. And then so we are in a situation of science versus a legal situation, and I don't know where this whole thing is going to go to.

DR. ARAL: Well, I fully appreciate that, but --

DR. BAIR: There's a huge change in the law for expert testimony in the mid-'90s between the Frye Rule and then the Merrill-Dow Pharmaceutical lawsuit where the judge now sits as the gatekeeper of what is acceptable science. And it is up to the scientist prior to the trial and the expert witnesses or the engineers to convince the judge, who's the gatekeeper, that what they're doing is not junk science that just appeared, but it has foundations and validations in the steps that people have been talking about.

So I just, I don't know where this is headed one way or the other for lawsuits. It seems like everybody's walking around the hat without ever putting it on. But I think that effort that you've talked about has to be way up front before you put any of the effort into looking at a Camp Lejeune.

DR. ARAL: Oh, I agree with that.

DR. CLARK: Morris, you wanted to make a comment.

MR. MASLIA: Yeah, I wanted to make the point again after we completed, essentially completed the Tarawa Terrace -- and you need to, I guess, put your administrative organizational hat on --

DR. CLARK: Doesn't fit.

MR. MASLIA: -- I know, that's a problem for us. We saw the effort that it took -- and there's still a question about it, I mean, looking at all sides and all questions, the effort that it took to get the answers that we got to give to the epidemiologists.

And we were looking for an approach to speed us up to get some initial results. And we wanted an alternative because you know the amount of effort and multiply it by ten for Hadnot Point. That's at least by ten if not by a hundred. And if we do that, December 2009 is not even in the question. Probably December 2012 is not in the question given the discussion here.

So we have to, I think, look at some alternative ways. One way, as they said, let's cut out for the time being the dispersive transport and all that and look at a flow path approach to get some indication. Another approach is where we have the information and see if we can reconstruct the concentrations from that. It does not in my opinion invalidate the use of either one. It actually may add some additional insight for us to maybe enhance the more sophisticated modeling.

And that's what I asked Georgia Tech to do because I only had one tool in my toolbox, and we knew it was too heavy at this point to pick up and try to fix the second part of the problem. So that's really our objective is to see what results, does that give us some additional insight while not expending as much effort and resources.

DR. CLARK: To get back to Ann's point, are you thinking in terms of using Tarawa Terrace as a validation tool? Because you've done traditional groundwater modeling in Tarawa Terrace. Could you use that example as a validation tool for the linear control theory model?

MR. MASLIA: Well, Dr. Aral's used that already. In other words he's tested the method out on Tarawa Terrace, but again, that is assuming that the simulation mean values or whatever are, in fact, quote, surrogates for real data. Now what needs to be done, and we can go to other sites, do a literature search or go to other sites, let's test it out on some other site data, not necessarily Camp Lejeune, and see if we get similar results or results that build further confidence in it. The fact is that this approach does not take a lot of effort to run on subsequent datasets.

DR. CLARK: Do you have some datasets that you can [use to -ed.] perform those validation tests?

MR. MASLIA: I can't. I don't have them in hand or know of them at this point.

DR. ARAL: Just a few comments on what I have heard just now. Obviously, the judge is the gatekeeper and established models have to be used in court cases because they are established. That's the only reason. But that shouldn't hinder the science.

In other words science has to go forward in bringing new ideas, new models, new concepts into the field. And in the next 50, 60 years maybe they will be the accepted models to be used in the court cases. Can you imagine a world which is stuck to MODFLOW? And a hundred years from now that will be extremely limited because the science is advancing. We have to bring that new science into MODFLOW.

DR. WARTENBERG: But it seems to me that they're two different issues here. There's no question that science needs to go forward, but that doesn't necessarily address why we're here and what we're looking at. And it seems that's that's --

DR. ARAL: I know. I'm looking from a, to this problem from two perspectives. I will continue with this method. I will publish technical papers, and then it will be applied or not at Hadnot Point is a different story.

DR. CLARK: I'm going to suggest that we go ahead with our lunch break. I do have a question.

Scott was in the process of giving a presentation, and we cut him off due to ~~technological~~ [technical -ed.] error problems. Do you want to try to do it during the lunch period, [or -ed.] at the end of the lunch period?

DR. BAIR: I'd rather do it later than now. I just think the demeanor in the room will refresh itself over lunch.

MR. MASLIA: Bob, if he wants to, just before the end of the lunch break, because I am concerned --

DR. CLARK: Yeah, after you have the lunch break.

MR. MASLIA: -- because we have to meet our 2:30 to start summarizing because some people have planes.

DR. CLARK: Does 12:15 work?

MR. MASLIA: That's fine.

DR. BAIR: So I can be here at 12:15? Yeah, and I think what you're going to see are some of the comments that Ben made about what the step functions are going to look like when you get to the end of this.

(Whereupon, a lunch break was taken between 11:40 a.m. and 12:30 p.m.)

DATA DISCOVERY - ADDITIONAL INFORMATION AND DATA

DR. CLARK: We're reconvening. We're going to modify the agenda again just a little bit. From about 12:30 to 1:30 Morris and I guess Frank are going to talk about data discovery issues and new [, -ed.] additional informational data.

MR. MASLIA: And I'm basically just opening it up and let the panel also obviously join in and all that. But as you see the data that we have gone through, and there's a lot of it to consider. And we mentioned yesterday this data that are in the notebook represents the IRP Program on the base. And there is about another 100-plus documents that represent the above and underground storage tank data.

And what our proposal is or our approach to do with that is to actually separate this report that you have or the collection of, the draft report that you have, and have two sets of reports, one strictly with the IRP data, and then pull out any UST data from that report. And then have a separate report with the UST data. That's the, I think, straightforward approach to dealing with that.

As far as from a modeling or use of data in whatever form of modeling we want, whether it's calibration, verification or whatever, our thoughts at this time are probably to try to use that second set of data as almost a verification stage. In other words sort of treat it as if we don't know about it right now. Use what we have.

And then if we get to the point of where we have some confidence in model simulation in terms of concentrations or whatever, see how it compares to this other set of data. I say that because to add, put this into, quote, a calibration set or whatever, still does not get us over this hurdle of uncertainty, variability or anything else.

So I think it's maybe limiting the use of some data that could maybe even help improve our confidence in the model. That's just my thoughts right now. And I think that also helps us in terms of resources expended, people, time, money and stuff like that.

And it'll help us learn with the model what the models may be doing or may not be doing with an existing dataset that we've gone through pretty thoroughly at this point. And save that other dataset in terms of modeling that may, as I said, help improve our confidence which may be more of an advantage for us and then lumping it all together.

And I'll just throw it out and see what the panel thinks about that approach or any other approach you may have. But that's our thoughts right now as to how to handle that.

So anything else, Frank?

DR. POMMERENK: Morris, let me get started on a couple comments. And I also appeal to those panel members who were here in 2005. You know, there were several recommendations made in 2005, and if I recall it correctly, and I tried to focus the discussion back on this, was the whole uncertainty analysis and you addressed with Tarawa Terrace some of those issues where you acknowledge the model results and so on.

We saw this was at least piece-wise brought up by panel members, you know, the overly optimistic narrow band in the Tarawa Terrace concentrations that we need to address also uncertainty in other things which will be for Hadnot Point no doubt be greater. We saw it with the mass computations. So I just would like to recall from the 2005 panel meeting that one of those key recommendations was, if I recall correctly, the focus should not be on so much on the little details in the groundwater model and hydraulic model versus trying to quantify uncertainty because in all the little errors that we may make in a non-representative model or whatever, may be swamped out by uncertainties upstream. For example, in this case the mass was disposed in the first place. So I think I should throw out this just to refocus the discussion. I hope that the other --

MR. MASLIA: I think that your point is very well taken to incorporate what the previous panel said. And that was I think impacted two things. One, why a lot of effort and emphasis both the Marine Corps and Navy in going out and hiring a company to go through their records. And we spent an additional amount of time going through data and information. And then the second thing is, and this brings us back to this morning's discussion, is why -- I'll say I -- I asked Georgia Tech to try to come up with a simpler method because that was one of the recommendations out of the panel in 2005 is to look maybe at the bigger picture, but a simpler representation because of all these factors. So your point is very well taken, very well taken.

DR. POMMERENK: Yeah, just as an aside on that. You know that linear control theorem, we may not care about what the individual coefficients of that matrix or the matrices represents because we may have sources of uncertainty elsewhere that would ~~swap~~ [swamp – ed.] out any little issues that we may have with the groundwater flow model or the hydraulic model or when interconnection was there or not.

And that's why the panel and again in my recollection, recommended the increased efforts in data discovery where they have actually hired a company to go through all the records on base. That just is a reminder. And I believe that is all documented recommendations of the expert panel.

MR. MASLIA: Yes, it's in the yellow-color folder report there that's available both -- yeah, that one. It's in Section 6 of the report. That summarizes it, and then if you want the detailed actual final recommendations you can pull out the verbatim transcript that's included on the CD there. But the report just summarizes that in generalizations. But that is correct.

And I know we focused, I mean, as an Agency we did. We hired more people and obviously tried to go through more, and I think that's how some of this discussion on the interconnection came about as well. Because if you recall at that meeting or the generalization was made that, well, if there's no very limited interconnection, well, simple mixing will do the trick. And that worked correctly for Tarawa Terrace.

That was, we looked, and we could not find any instances of, I used a rule of thumb of a two-week period just at Tarawa Terrace, and that was correct. But in looking further and actually understanding what was written in the logbooks, which takes some doing, you know, how they make notations and what it really means. And in discussing with the present and former operators, we came across the short intervals but pretty much consistent, but that they would turn it on in dry late spring or early summer months.

So again, I think what we do in your recommendations here are adding to the recommendations of the 2005 panel. But we do have a much more complex issue, and that's hopefully y'all can put some recommendations down that we can take to both our management and the Navy and tell them what our plan is for concluding the study. I think that's really what Frank's looking at is an exit strategy that's satisfying.

DR. BOVE: Maybe not as quickly as some.

MR. MASLIA: Well, not as quickly as some.

I didn't mean to imply that we're walking out the door today and that's our exit strategy. But, no, and that's why I think it's motivating me to say with the additional data that we have, let's not be quick to just use it or throw it in for model calibration right away. Let's see what we can understand about it first, and then maybe help us improve or reduce maybe some of what we perceive to be as uncertainty or build confidence in whatever model or modeling approach we take for Hadnot Point.

DR. HILL: And just one comment on that. In terms of a simpler modeling approach, it can be a simpler physical-based model. That's an option instead of, so there's a lot of ways to ^.

DR. GOVINDARAJU: I just wanted to, you know before lunch we were talking about what if it were to do a court case and so on. And when you're given this charge and when I started looking at the document, I was not preparing myself by trying to advise people by what one should do in case of litigation. And maybe if that is the case our objective functions should be somewhat different. I thought we were going to be doing this to see how we can reduce uncertainty and stuff like that. So I just want us to be able to explain that if we should be thinking in terms of what would fly in a court of law or see what we can do --

MR. MASLIA: Well, the answer is anyone can sue or sue anyone at any time of the day, but for anything, so no, we're not gearing our study for that. What we're gearing our study for is for to be able to provide the epidemiologists and the epidemiologists to be able to assess epi results.

DR. BOVE: Maybe I should say this. There is not much in the literature about the health effects of these chemicals from drinking water exposures. But there's even less about birth outcomes in these. So the main reason we embarked on these studies was to add to the scientific literature. I mean, that was the primary goal here. People want to know what the effects are of these chemicals. Well, we have occupational data, but we have very little drinking water data. We have a birth defects, one study in New Jersey looked at birth defects that so far has been published. We have a few studies looking at cancers and these chemicals. And so that's what we have that are published, a few studies out there, and some of them may not even agree with each other or they do to some extent with very little good exposure information as well. So that's what the literature is out there. We want to add, make a major contribution if we could to that literature. That's the primary goal here. It's not litigation. It has nothing to do with litigation.

DR. CLARK: Dick, you have a comment.

DR. CLAPP: I was just pointing at Dr. Aschengrau, who's done some of the studies.

DR. DOUGHERTY: I have two things. One is I took the litigation court of law as a metaphor for other courts of opinion that bear on reliability and judgments of reliability.

Second was a question. In the data that we're talking about, do we know the contents of these tanks?

MR. MASLIA: You mean the contents of the database?

DR. DOUGHERTY: No, what materials were in these, what chemicals are we talking about?

DR. CLARK: In the new information.

MR. MASLIA: Oh, in the new information.

DR. DOUGHERTY: Yes.

MR. MASLIA: Bob, I haven't looked at it. I just catalogued the information, but Bob can generally describe what's there.

MR. FAYE: Some of the tanks were just pure gasoline, diesel fuel, heating fuel, waste oils, that's pretty much the gamut of the contents.

DR. BAIR: What else could you wish for?

DR. WADDILL: Would you like me to clarify that?

MR. MASLIA: Yes, please.

DR. WADDILL: In regards to the new documentation, this is all leaking underground storage tank program studies, records of decision. Clean up information related to the leaking underground storage tank program per NCD nuregs*. So it's all POL contamination. Any solvent contamination falls under the IR Program per ~~CIRCLA~~ [CERCLA -ed.].

DR. DOUGHERTY: What about the waste oil?

DR. WADDILL: Waste oil if it's solely benzene or BTEX or POL falls under the [UST program -ed.]. If it has solvent co-contamination it usually goes into the IR Program.

DR. DOUGHERTY: Thank you.

DR. ROSS: I have a comment that that information may be useful because of all of the compounds, the BTEX compounds are going to serve as good fruit for the bugs for one thing to break down the solvents over time.

DR. POMMERENK: Okay, since nobody else is saying anything, I just want to make one comment so it's in the record. Because we've been talking all day today and yesterday about the groundwater flow model and then the water distribution system model, and the one thing that I would like -- that's why I want it in the record -- there's a big five ~~entity~~ [MGD -ed.] treatment plant in between, between the groundwater collection system and the distribution system.

It consists -- and correct me if I'm wrong -- of a ^ [ground storage -ed.] tank. I don't remember what the size is, but it's probably a million gallon or larger. The

Hadnot Point plant has a pump station that pumps water from that water collection tank into what are called catalytic softening units or ~~spiracteristic (ph)~~ [spiractor -ed.] cones to which ^ ~~line~~ [lime -ed.] is injected to facilitate softening and it overflows into a central pipe.

It goes from there through ~~a currently still through~~ [-ed.] a rectangular basin that used to be a re-carbonation base, and I'll get back to that. And from there into gravity filters and you know after chlorination and fluorination into a finished water clear well.

Obviously, in this facility there's several quiescent or not so quiescent surfaces from which ^ [volatile -ed.] organic compounds can escape. And that kind of depends on the physical properties of these compounds, PCE more so than TCE and so on. We made an estimate a few years ago, a rough estimate, that probably PCE and TCE, we didn't look at BTEX, removal would be incidental, minor, probably. The tanks are covered so there's no way effluents could stir up things.

However, what was not looked at that

was, because of lack of information is the re-carbonation basin. The re-carbonation basin serves to, it's typically a small, flow-though basin to which you inject carbon dioxide that is generated from a propane generator or from gas bottles. And carbon dioxide is an ~~asset~~ [acid -ed.] in water and ~~increases~~ [decreases -ed.] the pH which has been pretty high prior to, because of lime addition.

So that's how this whole softening process works. You bring the pH up you're still going to have calcium carbonate. Bring the pH back down within the allowable limits. So as far as I know, and as far as I can recall, I've never seen this basin in operation. It was just water flowing through.

However, it was put in for a purpose originally some time in the '40s, and nobody can tell me exactly if it ever has been operated and how long it has been operated. Because if it has been operated, it could have ~~been~~ [caused -ed.] substantial removal of PCE and TCE. It would have been in the 90 percent removal.

And it kind of depends on the gas flow

rates. It kind of depends on the turbulence that got generated. So there's a variety of factors that would have presented. But it could have affected removal of these compounds in the plant. And again, we just looked at PCE and TCE as from volatilization from the basins that are there, not ~~re-carbonization~~ [re-carbonation -ed.] because we didn't have any additional information.

But it might be worth looking into BTEX volatilization from the basins, you know, whether that as a source is uncertainty again. And I'm not trying to get exact numbers or anything, but it's another source of uncertainty for the exposure calculations for what could potentially be the removal of these compounds from the plant, A. And B, finding out whether this has ever been online, this re-carbonization basin.

MR. MASLIA: Hopefully, we're sending five, six people up to Lejeune this month, sometime this month, because in the BAH when they indexed the records that were there, we looked at the Tarawa Terrace stuff knowing that we would be back to look at Hadnot Point. And so there may be some information on that in those records. I don't know in other words. So we have not gone through the ~~BAX~~ [BAH -ed.] information index and then told, you know, requested that those documents be pulled, if in fact, there are documents in that index that would be useful.

DR. POMMERENK: You may want to look first in any purchasing records of propane or whatever they used. You may want to start talking to Bernash* [sic -ed.] when you get down next time with him. I can't imagine it has never been used because it's still comparable, softening plants operated by the Navy or Marine Corps. Kings Bay, Georgia, they still use re-carbonation basin. Guantanamo Bay has recarb basins, you know, it's not uncommon. So if you look for these kind of records. I always find these kind of things.

DR. DOUGHERTY: So, Peter, when you were there and there was not ^, were they not dropping the ~~TH~~ [pH -ed.] or was there some other procedure that they were doing?

DR. POMMERENK: As far as in dealing with that plant, they've always softened just below -- well, this is the secondary MCL anyway. The ~~TH~~ [pH -ed.] leaving the plant should be below nine, and they're always, eight-eight, eight-nine, fluctuating. Of course, you know, you have a certain ~~goal treatment~~ [treatment goal -ed.], the soft pH, its hardness, and if they get within their 60-to-80 milligrams per liter ^ carbonated range with that pH, that's -- in fact, Holcomb Boulevard is operating in the exact same manner and so is New River across the river when it was still operational as a lime softening plant. So it's not uncommon with that type of water that you would soften at a somewhat lower pH and not adjust it finally. So that's not uncommon to do that.

DR. DOUGHERTY: I just wanted to know if there was a different process that they had temporarily used or if it was just as he's described, and they just bumped it up just enough and left it there.

MR. MASLIA: The pH throughout the system was fairly high. It was higher than I've seen in other distribution systems. Because when

Jason and I were there, we were doing the field test, we first thought the instruments were out of calibration because it was always well over eight, 8.5, 8.8, I mean.

And that's why we thought there was something, you know, we had to go back and recalibrate the instruments or whatever to make sure. But then we checked with them inside, so it's a pretty high pH.

DR. POMMERENK: With a gain in precipitation.

DR. ROSS: Downstream?

DR. POMMERENK: I can't say. I mean, you know they have had problems. I have pictures, in fact, one of my memos that I sent to you a while ago ~~it picks up~~ [depicts -ed.] the ~~spiroactors*~~ [spiractors -ed.], so they get pretty badly encrusted downstream. So all the softening is not done in the ~~spiroactor~~ [spiractor -ed.]. Softening's going to go on throughout. That's been one of the hassles that they've always, ^ has been complaining about. Now, I cannot say for sure what, how much precipitation's going on in the distribution system, but, yeah, it will happen. And now to bring up a point here. How does that affect ~~POCs~~[VOCs -ed.].

DR. CLARK: Is it possible that they had cast iron pipe in the system at one time?

DR. POMMERENK: Yeah, you should be able to see. We inventoried that system.

MR. MASLIA: No, the system is cast iron, and then when they would replace them, now presently when they replace them, they presently replace them with PVC. They've got a few lines of ductile iron and very little AC pipe at all. So it's mostly cast iron and PVC now. And one would think it was historically then cast iron.

DR. POMMERENK: Two years ago we had excavated some pipe, four-inch pipe, in New River which is across the river on the other side where they also until 2007 operated a lime softening plant in a similar manner. And they got water from wells in what is called the △ [Verona Loop -ed.] area which is, you know, you can see it west of New River, you know the left, top corner. Left top, left, left, left, left, left. All the way on the left is --

DR. DOUGHERTY: The ~~N~~[M -ed.]-C-A-S, Morris.

MR. MASLIA: Oh, here, okay.

DR. POMMERENK: Right down there, ^ wells from a hardness standpoint a similar composition as the wells at Hadnot Point. And again coming back to those pipes that we excavated, I don't know exactly where they came from in the system, but they didn't show any large amount of scale. There was ~~tuberculation~~ [precipitation -ed.] and you could clearly see on there ~~tuberculation~~ [precipitation -ed.], various layers of all the different iron oxides and ^ mixtures of that. But there was not a distinct calcium carbonate layer.

DR. DOUGHERTY: Do we know the frequency of well rehabilitation just as another indicator of this?

MR. FAYE: We have some records of actually a lot of records in the early '50s and perhaps up to '65, '66, '67. Then there's a gap, and then beginning in '78 up through '85, '86, '87 we have records of gross rehabilitation. On the one hand the records may indicate things like notes in the margins, well down May, bearings replaced in pump. Or well down in October, air line replaced. Things like that. So you have to make a judgment. Was it down for three days or three weeks? So that's kind of the extent of that kind of information.

DR. DOUGHERTY: So there's no direct information that the well was acidized or ^ [cleaned -ed.] up or something?

MR. FAYE: In some of the records that are quite detailed, I've never seen those kinds of activities take place or have no indication that those activities took place.

DR. KONIKOW: I wonder if some of the local well drillers would have that information more readily available than the Marine Corps base, maybe foot work there might.

MR. FAYE: Well, that's a good question, Lenny, and it's a possibility based on my experiences with drillers, some of them do keep really good records. On the other hand a lot of folks that work for government, and particularly the military, I think they took their training from squirrels. They take care of everything. They hide everything, and so I got a strong hunch if those records were available, we'd know it.

DR. CLARK: Anybody else have any more comments at this point?

(no response)

DR. CLARK: Well, one thing that occurred to me, [and -ed.] I think Frank maybe alluded to it at one point, is the possible extension of the study to include something other than birth issues. Some of the levels that were being distributed in the finished water almost ~~looks~~ [look -ed.] like occupational exposure levels and could [have -ed.] inhalation and dermal effects.

And I think you've mentioned that you're giving some consideration to extending the study to include that, but I didn't know whether you wanted to talk about it now or not.

DR. BOVE: Just briefly, we have two studies that we're going to embark on this summer. One is a mortality study of adults obviously which will take into account hundreds of thousands of Marines at the base plus a comparison group at Camp Pendleton population. And with that, monthly data, of course, isn't as relevant in that kind of a study as it is with a birth outcome study, the small for gestational age study or the case-control study we were talking about all day.

The other study is a health survey which is going to ask people about their, any cancers they may have had and other diseases that we think are related to solvent exposure that we see in the occupational literature as well as any information from the drinking water literature, which I already said was very sparse. And then we'll confirm those diseases as well as we'll confirm the deaths and find out the cause of death.

So that's roughly, without going into too much detail, what we plan to use this data for as well as the current case-control study and the re-analysis of the small for gestational age study. So any questions about those two studies I can answer them, but just so you know that what we produce here in the water modeling will be used for additional studies.

DR. CLAPP: I don't think he's talking about dermal or inhalation exposure as part of the extension. He's talking about different study types.

DR. BOVE: Right, what we assume -- well, in the health survey as well as the case-control study, we do ask about people's consumption habits, how long they shower, for example. So that we start getting at some of those routes that way. But really, we assume that everyone's pretty much getting the same kind of exposure. They're showering roughly about the same amount. They're getting the same kind of dermal exposure, and they're ingesting roughly about the same amount of water.

MS. RUCKART: Frank, we don't ask about that on the health survey.

DR. BOVE: We don't ask about their consumption at all?

MS. RUCKART: Just the case-control.

DR. BOVE: Okay, I'm getting confused between studies. That's right. For the case-control study we ask that question. Actually, as I said yesterday, the usefulness of that information is not that good.

There are also civilian employees who were exposed and there we're going to take into account their occupational exposures as well as -- and also the military have occupational exposures, too, and also where they drank water at their occupational sites, workplaces. So these are things that we're going to take into account in the future studies.

So does anyone have any questions about that? I don't want to get into that because we have so much to discuss about the modeling and wanting to get advice. We had an epi panel actually a year ago discuss these two studies and the issues there.

DR. CLARK: Any reaction to ~~your~~ [the -ed.] comments or thoughts on that?

(no response)

DR. CLARK: I know when we were ~~doing,~~ [-ed.] setting a radon standard ~~in~~ [for -ed.] drinking water, we looked at some of those kinds of issues. So there is some literature in terms of --I think it's the University of Pittsburgh that actually has a physical shower where you can go and measure the transfer of water of the radon from the water into the air. And I would assume that [at -ed.] some of those levels [, -ed.] that eventually the household would be basically saturated with~~,~~ [-ed.] volatilized ~~with~~ solvents [BELJIN -ed.], which would apply not only to the Marines, but also their dependents and children.

DR. BOVE: Right, and then there's also some concern, for example, cooks at the, in the Hadnot Point area getting heavily exposed.

DR. CLARK: Yes.

DR. HILL: Laundry workers?

DR. BOVE: Laundry workers, yeah. So we'll be looking at them in the future studies.

DR. CLARK: I ~~gathered~~ [gather -ed.] from what Mr. Ensminger was saying, that he has had contacts from people who'd been on the base and adults who've had follow-up health issues that kind of were linked to that sort of exposure.

DR. BOVE: That's why we have to do these studies.

DR. CLARK: This is the quietest I've ever seen this particular group.

PANEL DISCUSSION: INCORPORATING AND USING ADDITIONAL INFORMATION AND DATA

DR. HILL: I don't know if we want to get into this now, but Lenny and I were talking at lunch about looking at the model fit, and methods to do that and some of the results.

Lenny, am I interpreting our discussion correctly and did you want to start with that? So it was model fit and the use of the sort of preconceived criteria for measuring whether or not the future model fit was going to be good enough. And I'm not quite sure, this is a discussion that's sort of better done with a bunch of maps on a table and pointing at this and this and saying why is this ^.

So I'm not exactly sure how much of this can be done in this kind of format, but a couple of general things I'll start with was there's -- and I'll start with the head data just as a beginning -- and essentially what head data gives you is sort of the pipes of the groundwater system, kind of what are the directions of flow. It's sort of similar to topography on a land surface, but it's fully 3D, and you can't see it. And it's hard to figure out.

And so the heads and the geology are

essentially what we have to constrain that and also where concentrations go. And so in this model there were two kinds of head data. The data in pumping wells essentially taken with air lines, which are known to be extremely problematic.

And so one of my concerns was even that they were put on the same graph with the other kinds of head data. It seemed like it should be analyzed separately. And one of the things that allows you to do better, too, is to look for patterns within the, so the residuals are the observed minus simulated. And ideally, they will be random spatially in the system, and any distinct non-randomness suggests bias in the model.

And when you had observations like those air line observations that have so many known problems, it's really unclear whether, what they represent and how much you can depend on them. And it could be that some of them should not be considered at all and others have good information.

But we have to look at where they are in the system and what trends they might have.

Does it make sense? If the pumping from the well is greater, do they actually -- you know, do they make sense? And a thorough analysis of that was perhaps outside the realm of some of these reports, but really, without that analysis, my feeling was there was just a lot of data kind of thrown in, and it didn't fit very well, and there were some patterns in that set of data.

In particular, if I looked at the graph, there's a band that goes through a certain, I think it's observed versus simulated, and I think the simulated range is 13 to 15 or something like that. So you have a band that goes through. So there's issues related to that. Maybe I'll stop there. You were looking like you wanted to say something.

MR. FAYE: No, actually, I agreed with almost everything you say. And also, I don't take exception at all to your comment that we threw everything in there but the kitchen sink. You're exactly right. And it just came down to a choice of on the one hand we felt that we would be severely criticized if we didn't try to deal with the data, and on the other hand we felt we would be severely criticized if we did deal with the data. So we came down on the side of inclusiveness and did our best. In fact, I appreciate your comments very much about the air line measurements because, frankly, there are some people that just don't believe you and me that those measurements are totally perfect, but be that as it may.

DR. BAIR: Who are those people?

MR. FAYE: Well, I can mention a few that I'd rather ~~now~~ [not -ed.] ~~of~~ [have -ed.] met, but I won't. But anyway, your thoughts, I've read your notes about the residuals and the variability of the accuracy of the data. Very well taken, and we definitely have already decided to do some major analysis of the data before we try to use it in this next model, and so I accept that.

The only point I would take exception to is the, I think it's your notions about the graph and the boundary lines on there. I thought I was doing a good thing when I copied that directly out of the USGS report, but so be that as it may, it is what it is and I appreciate your comments very much.

DR. HILL: In other studies I've been involved in if you don't have every data point somewhere, someone will come and say did you pay attention? Did you do this? Did you do that? But my thought is that it could be, that some of those points, I think this is consistent with what you're saying. Some of those points can appear in graphs that are used to determine a trend, and then the trend is used in the model calibration so it appears in the report just not as a verbatim --

MR. FAYE: Yeah, in the report obviously we tried to have our cake and eat it too. We did not deliberately, explicitly attempt to weight the data, weight the head data. The real accurate data was fine, but what do you weight the other data as? Is it a 1:2, 1:1, we just didn't know.

So we didn't deliberately, explicitly attempt to weight the data from a formal analysis point of view. But then on the other hand we did spend a lot of time explaining why one set of data was better than the other. We tried to have our cake and eat it too, and, yeah, I'll take that. I'll take a hit for that.

DR. HILL: That's all right. I don't mean to hit.

Let's see. Another aspect of that is the idea of sort of pre-processing the data, thinking about it spatially and stuff and getting trends. It could be that there are situations where, for example, that vertical thing we were talking about where there's a three-foot decline at head. It might be better to use that difference it had and have some observations that are changes with depth, changes at head with depth.

And specifically, and basically take your data and -- on the one hand that's three feet. On the other hand you are saying you think your variability is plus or minus three feet. Okay, so then that begs the question do you have faith in that three-foot change.

Is the situation such that because of where the well is or blah-blah-blah-blah-blah, that you really think it is pretty close to a three-foot decline which means when you take that difference, you're getting a small, you're getting rid of errors that might be constant in some manner and actually the difference, you have more faith in the difference than the actual values.

MR. FAYE: No, actually, those are very accurate measurements. So, yeah, I can answer both because that's a bona fide well cluster for the State of California. So it's good data. I mean State of North Carolina. My dreams have overtaken reality there for a second. But we really didn't have data like that to that detail, Mary, at Tarawa Terrace.

But we've got gobs of data in the Hadnot Point-Holcomb Boulevard area where we have well clusters, vertical gradients and both at substantial depths even. So we can really identify those issues in some pretty good detail using actual field data. And it would be typically like you would suspect.

In the Berkeley Manor area they're sort of in the center of Holcomb Boulevard, which is a highland area, your vertical gradients are downward. You're close to the Wallace Creek and other major drainages. You've got your heads coming up. HPIA is a similar area. It's in a highland area. You know, your vertical gradients are downward, et cetera, et cetera. So it all fits a pretty good conceptual ~~Hubbard-~~ [Hubbert- -ed.] type model of the flow system, so it works pretty well.

DR. HILL: Yeah, it's the graphs ^.

DR. BAIR: I was just going to say I think that that's a really worthwhile calibration target under a transient flow because you're going to have certain pumping conditions that either exacerbate or mitigate that vertical gradient. And if you incorporate that as a calibration target, that in turn, helps you pin down the hydraulic conductivity to the confining layers which so far one foot per day because it's the confining nature that's going to give you that large gradient, only a small grade.

MR. FAYE: Absolutely, and also from a limited number of aquifer tests, and again you have the scale issues that you have to deal with in terms of point data versus extrapolating it out to a large model cell and all that. But we do have some fairly decent data, ~~Noyman~~ [Neumann- -ed.] Witherspoon* and where we've been able to apply some nice aquifer test analyses and determine ~~leak-ins~~ [leakance -ed.] of confining unit. So for whatever it's worth on a scale issue or a scale-dependent value, we do have some of those data.

DR. KONIKOW: Well, this also gets to, I mean this first modeling phase, which developed a steady state, full model representative of pre-development conditions. And that's part of our concern, I think, on the data that you use in the calibrations is that much of the data is so influenced by transient conditions that it just probably shouldn't have been in there.

MR. FAYE: That's really not true. And that wasn't true at Tarawa Terrace either although I think one of you gentlemen might have, someone might --

DR. KONIKOW: I thought you were saying that some of these, some of the data used from all those measurements were influenced by --

MR. FAYE: They are. They are. But those data were not used, to the best of my knowledge, in determining the pre-development surface. And also at Tarawa Terrace I think there were like 50 or 60 measurements that I listed in the report that I said, okay, these were estimates of pre-development heads. And someone did mention that they were possibly influenced by pumping, and that is correct. Six of those 60 were perhaps influenced by pumping, but I --

DR. KONIKOW: I'm talking about the 5,000 or so observations that were --

MR. FAYE: A number of those, Lenny, if you've got ten years of data, and you can see how it varies over time and the data are near a pumping well, and you can see -- or a supply well, and you can see some or infer that they are being, that the heads are being influenced even though the screens in the supply well are rather deep, and you're looking at shallow, et cetera, et cetera.

But you have ten years of data to look at. So you can either select a data point that seems to be the highest point or the one that isn't influenced if you really, really, really want to use that point as a control point or you can disregard it.

But obviously 5,000 measurements, hundreds of sites distributed throughout the study area, you have an opportunity to filter your data pretty readily. And at most of the sites there was no, virtually no influence except seasonal influences. And if you got 20, 30, 40 measurements over ten years, you take an average, et cetera.

So that's pretty much the way those control points were developed. There was a pretty serious effort to filter out influences from anything other than seasonal variations.

DR. KONIKOW: Okay, I didn't gather that there was, but okay.

DR. DOUGHERTY: In the ~~permutation~~ [presentation -ed.] it said that there were some obvious ones to pull.

MR. FAYE: Pardon me? Oh, Rene said yesterday that he needed to look at some of the data in addition. If he said it, I believe it, but it wasn't a pervasive issue with respect to the representation of the potentiometric surface that he's showing. I'm pretty sure of that, that he showed.

DR. KONIKOW: Now, when you go from the steady state model ultimately you'll be going to a transient model. I think you have to be open to the idea that your boundaries and boundary conditions and discretization, particularly the vertical discretization, that may be adequate for a steady state model, might prove inadequate for a transient model. And you may have to go back and revisit.

MR. FAYE: Absolutely. Those are, that's good advice, and I believe that we've got our arms around that issue pretty well.

DR. KONIKOW: On a more philosophical level perhaps, I'm not sure I saw the value of setting, you know, pre-determining calibration targets in terms of accuracy and fitting. I'm not sure I saw any outcome.

In other words it's just something to measure against and one of the values of doing that is you're assessing the accuracy of the observations. But beyond that saying that your goal is to come within plus or minus three feet or 12 feet, I don't see the value of that if you don't meet the target and then don't do anything about it.

MR. FAYE: Well, that's not true because it's a target that you meet as well as you can. So what you see as far as Tarawa Terrace is concerned is our best effort to meet the target. So you don't know what the worst --

DR. KONIKOW: You're always making your best effort to do the best that you could.

MR. FAYE: That's right. But before I get to the issue though of calibration standards, good or bad, though, you didn't see what our worst effort was. So we progressively got better and better and better. So you saw our best effort in terms of the calibration standard.

And, frankly, I agree with you a lot, and I agree with what Mary's comments were and her notes as well. From a practical point of view I think having some explicit standards up front at the initiation of calibration are kind of a good idea. It gives you sort of a target to shoot for based on your best judgment about the quality of data, et cetera, et cetera, et cetera, but at the end if you, whether you really represent it as such or don't, I don't really see it as a major issue.

DR. KONIKOW: Well, I mean, I'm just getting at what does it mean.

MR. FAYE: It was more of a tactical tool to provide some guidance perhaps I could say during the calibration process rather than something that we, and I think Mary made the point that you might focus too much on appeasing the standard rather than on the conceptualizations and all the other things that relate to a good calibration process. But I don't think --

DR. KONIKOW: I mean, my concern is it's not a standard. There's no standard approach for doing that and picking a number ahead of time really is rather on the arbitrary and subjective side and doesn't lead to any action afterwards when, I think, in the steady state there were, if I recall, 55 percent of the wells or the observations fell outside the pre-determined calibration limits. And so that's not a very good, you didn't meet the target.

MR. FAYE: Well, I would also say that that effort is, as Morris said this morning, that that effort is somewhat to substantially incomplete right now. I mean, it was just a point in time that the staff said, okay, this is as best as we're going to do up to this time to get a notebook ready to send out to the peer review panel.

Your point's well taken. I'm not really arguing with you at all. I'm just saying that in terms of what I did, what I personally did and what I personally used it for was, like I said, sort of a tactical tool to make me feel warm and fuzzy if I got close to it during calibration.

DR. BAIR: I guess what I'm hearing is the panel people saying that philosophically that they don't really care for that type of criterion. And we would recommend that you kind of drop it. I'd much rather not meet a really stringent requirement than barely meet a very loose one myself. And I think a more accepted calibration target might be the mean absolute error over the total relief in the water table surface. So if you're at 100 feet of relief and your mean absolute error is ten, you've got about a ten foot error over that distance. If you're in a mountainous terrain, you have 1,000 feet of relief, a 100 foot error is ten percent. You're in a very flat terrain --

MR. FAYE: Well, we have -- if you look at our good data, you know, the what we call the monitor well data, I think our mean absolute error for almost 300 of those data points was less than two feet. And we have a total topographic, i.e., water table drop of about 30 feet. On the other hand if you look at the air line data --

DR. BAIR: Yeah, dump the air line data. They're ruining you.

MR. FAYE: Your notion of being ruined might be my notion of saving my ass, so that's kind of a relative thing. But it is what it is, and I accept the philosophical, it's really not a philosophical difference of opinion. As I said, I agree. And how we apply that, and how we use it will hopefully be more pleasing to y'all the next time around.

DR. HILL: I think, just one thing I want to say is when you publish a standard, when you, I don't mind you having that in the back of your head and feeling warm and fuzzy when you make it, but when you put it out front in the beginning, you set an expectation up. And I think it's that disappointment of expectation that you're having trouble with.

MR. FAYE: I agree, no problem.

DR. CLARK: We have a comment. Randall has a comment.

DR. ROSS: Just a question. Out of the 5,000 or so historical measurements you had, it seems like you said a minute ago you took the average, but I seem to recall you tried to take the highest elevation. And in a situation where you have precipitation ranging from less than 40 inches to 80 inches between years, would the high measurements kind of bias?

MR. FAYE: Yeah, there's no question about that. And if you're referring to the Tarawa Terrace, we only had less than a hundred compared to the 5,000 or so there. So we really didn't have an opportunity to select through a lot of data for Tarawa Terrace. I can't even recall now. I think there was something like 60 measurements that we actually ended up using to estimate a predevelopment surface. Some of those were earliest in time, and some of those where we might have had two or three multiple measurements at the most other than the air line data. Again, let's not deal with that.

DR. ROSS: I'm with Scott. Bag the air line data.

MR. FAYE: Yeah, bag the air line data. But the good data, and those were all what I would call high quality data that we used there for that potentiometric surface. Where there were two or three measurements that we actually did have at the same point, I might have used again the highest there, not necessarily the earliest in time but the highest. It was a --

DR. ROSS: And something that we see at sites all over the place is the lack of good survey data for the wells. It's, for god's sake given the cost of surveying the monitoring points is nothing compared to the other efforts that are going on at the site.

MR. FAYE: Again, most of those data that are in that table for that use, those points were surveyed in. And I don't know whether it's actually explicitly noted in the report or not, but it's true with all the tables in Chapter C, if you happen to see head data reported to the tenth of a foot, those were all surveyed-in points. If you happen to see data published to the nearest foot, those were estimated from topographic maps or something like that. I don't know that it's explicitly said in that report, but that was the protocol that was used.

MR. HARDING: Dr. Faye, let me ask a question on that because I thought I saw in there -- I'm poaching on the groundwater folks -- a plus or minus two and a half foot standard for those ground surfaces that were taken from the topographic maps. Why can't that be refined at low cost nowadays? I'm just curious. Is that worth the effort to go refine that since you've got this N-square error of two feet? It seems like it's a pretty big chunk of it.

MR. FAYE: I think it might be mixing some apples and oranges there.

MR. HARDING: It could easily be.

MR. FAYE: To answer your first question, no, I don't think it would be worth the cost of refining those data at all. Second of all, most of those 5,000 measurements that we talked about for Holcomb Boulevard/Hadnot Point, 5,000 plus measurements, I would say, well, certainly the vast majority of those relate to wells that are surveyed in.

And your two and a half foot issue there is kind of a, I don't know whether it's ever been formally recognized, but in 30 years of work sort of a standard rule of thumb that I've always used to estimate that altitude using topo maps was plus or minus one-half the contour interval. And the standard contour on these maps that we were using was five feet, i.e., the two and a half plus or minus rounded off to make it simple to three feet. And that's where the three-foot standard came from.

DR. DOUGHERTY: Just to follow on, first, I'm working on a project with some reasonable data of questionable quality for reference elevations, and we used a similar topographic approach. So I'll just give you some validation on that. But, and you can do it, because it's not that expensive, but sometimes it is. The thing I was going to talk about was where these calibration curves, and again this single plot that we're looking at, the Q-Q plot or the one-on-one plot. If I didn't have the units' ~~little blanks~~ [unit slope - ed.] to guide my eye, I would not get a one-on-one slope for this. I would say this is on an inclined line that has a break point and the slope of each leg, neither one has a slope of one. So this is a fine type of plot, but if you did the residuals versus the head, I think you'd find that the errors are not homoscedastic, and it would lead you to, the residuals are not constant with the observed heads.

MR. FAYE: I'm not sure there's a sexual preference to the points but --

DR. DOUGHERTY: It's more political because you've got red points and blue points. I did notice that. Where are the purple points? If you looked at these residuals as a function of observed head, I think you'd find that there is a structural issue that might inform you how to go forward from here.

MR. FAYE: No argument. I think Mary

articulated those issues I think really, really well in her notes and we acquiesced on behalf of the project. I'll just say that we acquiesced to those sentiments and heartily agree, and we'll follow through on that. No problem.

DR. HILL: So we have yet the concentration data to discuss? And are we ready to go on?

DR. CLARK: I'm going to suggest we take a break. A couple of housekeeping things. Who has flights that are going to be tight?

(multiple responses)

DR. CLARK: Anybody else?

(no response)

DR. CLARK: Liz, can we make sure that they get some better transportation?

(Whereupon, a break was taken between 1:40 p.m. and 1:55 p.m.)

DR. CLARK: First, Mary would like to start a discussion on the concentration calibrations. And then after that, we'll do that for about ten minutes, and then we're going to go around the panel, and I'm going to ask for every panelist to give his opinion and summarize for the record. And I think Walter and Ben are tight on time. Who else, somebody else was going to go with you in your cab. Dan, okay, so three, so when we start out I'm going to go with Walter, Dan and Ben.

MR. HARDING: I don't think we're that tight.

MR. FAYE: That's really famous last words.

DR. CLARK: Well, let's start the discussion that Mary wanted to have.

MR. HARDING: Then we have a three o'clock cab.

DR. HILL: This will be real quick because Lenny's laid all the foundation or the foundation I was interested in. And that is to take the concentration data and first calibrate, use it to derive effective transport paths and use those to calibrate first to get yourself in the right direction and then obviously, and then really manage your water table non-linearity to your advantage.

Don't let it, because that can add 50 percent to a project. It's amazing. And then when you do bring the concentrations in you can weight them so that you can consider your heads at the same time and your stream flow, we talked about the stream flow gains. I'll open it up if anybody has questions or comments about that.

DR. KONIKOW: You kind of mentioned earlier that you have quite a lot of variability over short periods of time in the observed concentration. And that's really going to be a big obstacle to calibrating the model.

MR. FAYE: It was and it is.

DR. KONIKOW: Look at Figure F-16 in your Tarawa Terrace report. You have this simulated curve that's coming up, a nice smooth curve, and then there's one point in, I guess, 1985, where you have five frequently, samples collected over a short period of time --

MR. FAYE: I know.

DR. KONIKOW: -- and they have a range much greater than the long period of the --

MR. FAYE: I know. I know, Lenny. Let me make a comment on that, and in part of my comment I'll reference, for example, the Table C-7, if you want to check that out.

DR. KONIKOW: Yeah, I've got it right here.

MR. FAYE: There's a lot of reasons for variability of the concentration data. I'm not going to go over all that again. We know sampling, et cetera, et cetera. And the point that I'm about to make I also make in Chapter F, perhaps not well, but I attempt to make it anyway.

My belief is that the major variability that you're looking at in terms of TT-26, I think in about a 28-day period, there's a two and a half order of magnitude difference in the water quality that was as a result of sampling at this well. The highest measurement and the earliest measurement, I think which was about 1,580 micrograms per liter, that's the greatest measurement, and that's the earliest measurement.

That was sampled actually when that well was probably still operating routinely before they formally shut it down or was very, very, very close to the time that they actually shut it down. And the subsequent samples there that were compressed within about a three- or four-week period of time were, my guess is -- this is my supposition --

were probably sampled with perhaps the well turned on to evacuate maybe two or three casing volumes or something like that.

And as a consequence, the result was the fact that there was not a lot of contaminants solute in the well at that time at a concentration that would have been there if the well had been operating for 12, 13, 16 hours, whatever, and more that mass of, from the center of mass of a plume had been attracted toward the well at the time.

And we see that. I give an example with respect to TT-23 in Chapter E, I believe, and Chapter F where indeed TT-23 was operated for two hours and sampled and then operation continued for another 22 hours so it was operated for a total of 24, and the contaminant concentrations doubled in that period of time.

So my point is, after this long and drawn out craziness, is that there's an issue of how these supply wells were sampled in terms of the length of time that they were run prior to sampling. And I think that accounts for a large amount of the variability that we're seeing.

And you can look at 602 is another example on page C-7 that the analysis there on November 30th, 1984, that well was still operating routinely at that time. And it was very shortly after that shut down, and then subsequently sampled quite frequently at week intervals or several day intervals after that. But it was not operating routinely at that time.

Well, the latest data, water quality data, that we have for the supply wells, I think as far as data that I have, is for the year 2000, and there was a massive undertaking on the base as well as over at the air station to sample supply wells at that time. And the protocol observed for sampling at that time was to let all of the supply wells run for 24 hours and then sample them. So I think finally the issue, the sampling protocols, were catching up to the real world finally by the year 2000.

DR. KONIKOW: So this gets at really a basic issue of when you get to the calibrating the ~~solu~~ [solute -ed.] transport model, what are you calibrating it against?

MR. FAYE: We made a point in Chapter F, I believe, that we, again, perhaps we tried to have our cake and eat it too, and maybe got a ~~stomach ache~~ [stomachache -ed.] over it, but we made a point that we say that we believe these data are more realistic in so many words than other data. And again, it was this earliest in time data.

DR. KONIKOW: Shouldn't you say that before you calibrate the model though?

MR. FAYE: Pardon me?

DR. KONIKOW: Shouldn't that, I mean, in keeping with your setting of pre-calibration targets, shouldn't your decision about which data are more reliable for a calibration bracelet[bracket -ed.], that assessment should be made before you decide to see which fit match better.

MR. FAYE: We did. Those statements are made in Chapter E which is a summary of all the water quality data, and that was clearly before we attempted to do any model calibration or anything like that.

DR. HILL: But yes but, you didn't then use that information and perspective to inform how you actually conducted your calibration. And let me just provide an example of that -- and there's a bunch of things that come in here.

One is that you have this very long in time kind of base model. And that's your goal is to get this as accurate as possible. But you end up having detailed concentration information at different times along that path. Now, you're using a methodology because you have to sort of degrade your model and because it's a long time period, you're using a solution method for your transport that has a lot of numerical dispersion, but it's fast.

Okay, so that's fine for your sort of long-frame model, and when you get to that point in time where you're trying to match information at that well, it's probably a higher concentration I would say that's going to be consistent with that methodology. But you could also take your model as calibrated and for a fairly short simulation use a methodology, a method that has very low numerical dispersion.

You're going to have to figure out

your initial condition, your initial concentration conditions. And then compare that simulation, basically, what your short-term, temporal data is telling you is that once that well stops pumping, that it's the pumping of the well that's making the plume come over there. That if you stop pumping the plume's going to recede. And you could test to see if that occurs given the flow field you have.

DR. BAIR: On a short-term basis.

DR. HILL: On a short-term basis. So there might be some combination of kind of this long-term calibration and then some short-term simulations that test certain hypotheses.

MR. FAYE: Yeah, we did that at Lenny's suggestion for another reason, basically, to look, not to test the retreat of the mass, contaminant mass in the plume, but we did that to test the possibility of numerical dispersion. We came right down to one-day stress periods, so that's easy to do. And that's a good idea. We can give that a try.

DR. HILL: And you can use one of the solution methods then that's --

MR. FAYE: Oh, not only that. We can actually use some of the field data that we have to test that out.

DR. CLARK: As worthwhile as this discussion is, I'm afraid we're going to have to cut it here, but first off let me thank, in case I don't get a chance to do this and they have to leave in the middle of this discussion, I'd certainly like to thank everybody for their input, attention, perseverance and patience for putting up with us. It's been very interesting, and I hope it's been very useful for ATSDR. I think it has.

CHAIR SOLICITS RESPONSE TO CHARGE FROM EACH PANEL MEMBER

Why don't we just start with Walter. We'll go around the table with Walter. I guess Walter, Dan and Ben might have to leave before we're finished. So, Walt, we'll start with you.

MR. MASLIA: If you would, obviously all comments are welcomed and desired, but if you could try also to specifically address the questions --

DR. CLARK: That were in the charge?

MR. MASLIA: -- that would help us out. And anything else above that, that's also fine. It would help us out if you focus.

DR. GRAYMAN: I'll start by seconding Bob and just say it's been quite a privilege in working with this distinguished group. And I think this has been an excellent and hopefully very useful to ATSDR. Thank you, Morris; thank you, Liz, for organization, and the rest of the group.

I'm going to concentrate on the area of water distribution system analysis in my comments. First of all, the previous work that ATSDR has done in developing a detailed water distribution system model has put them in a good position to move forward in analyzing the Hadnot Point and Holcomb Boulevard during the interconnection periods.

Second, the water distribution system analysis is going to be needed for analyzing the impacts on Holcomb Boulevard, primarily the Berkeley Manor area during the interconnection periods with Hadnot Point. For other times in the areas the mixing model approach used in Tarawa Terrace should suffice.

I think that the analysis of the Holcomb Boulevard system during interconnection can be separated into two types of analysis, first of all the groundwater wellhead, water treatment plant type of analysis that was done in Tarawa Terrace and second the distribution system analysis, and I think it's important that they can be separated. And it can take place by using the distribution system model to calculate the percentage of water from Hadnot Point reaching points in Holcomb Boulevard. In other words for each node in Holcomb Boulevard you calculate the percentage of the water reaching it at any time that comes from Hadnot Point. Subsequently, the concentrations reaching the customers can be estimated by overlying that percentage of water from Hadnot Point with the calculated concentrations leaving the Hadnot Point water treatment plant.

For assuming the concentrations leaving the Hadnot water treatment plant can be estimated probabilistically on a monthly basis, then with a manageable amount of effort in the distribution system area, I think that a monthly probabilistic estimate of concentrations reaching the Holcomb Boulevard, Berkeley Manor customers can be made. And my question for the epidemiologists is, is this an acceptable form of results for them to analyze.

And finally, the detailed data that was available for that 1984-'85 period when Holcomb Boulevard water treatment plant was offline should be studied and used at least as a partial validation exercise. However, it really is not that useful as calibration because of the operation during that period was so different. That's all. Thank you.

DR. CLARK: Thank you.

Mary.

DR. HILL: Let's see. One thing I did want to mention that I hadn't mentioned previously was that, Morris, you had spoken about a timeframe of 2012 for the modeling at one point. And I think really that you can, I actually do think the November deadline is tight, but that something like next May is plausible. So that's the kind of extension that I might consider if recommending.

So that's one issue. The other issues I've really, we've just been talking about them, and I'm going to focus on the groundwater model, but the issues of being more strategic and more hypothesis testing kind of focused in some of the testing that's done with the model and that comes into working with the observations in a more kind of strategic way, having observations that represent more solidly specific kinds of dynamics in the system including vertical flow, maybe even flows in different directions you could have or have differences in different parts of the model.

You might break it down geographically. It'll depend on draw-downs over time. That's another option. But having graphs of residuals that make a little bit more physical sense so it can be interpreted better. Observations of any kind of stream flow gain and loss that you can get your hands on is just a really great cross-check.

In connection with that as well, you might define, you might keep track of the flows going in and out of the ~~conson (ph)~~ [constant -ed.] head boundaries along the rivers. Not that you have a very good handle on what the values should be, but you might be able to say that value's ridiculous.

And in terms of the concentrations, I think we've spoken quite a bit about that. Since we just did it I won't repeat. In terms of the parameters for the model, obviously we've talked a lot about over-fitting and trying to avoid that because usually an over-fitted model doesn't have great predictive capability. And you can demonstrate that to yourself with your model, using suppressed validation exercises and stuff.

And being a geologist in my undergrad and engineering in my grad, in grad work I tend to really want to constrain models with geology a lot, so I tend in that direction. And I think this system has potential for perhaps doing that more than has been done. And that's all I have. Thanks.

DR. CLARK: Thank you.

Dave.

DR. DOUGHERTY: Here again, it's been a very interesting couple of days, and I know I've put a little bit of water from the fire hose on the end. I suspect I'm not alone. I guess my reactions are kind of mixed because in some ways I feel we're coming in quite early in this process, and in some ways we're coming in a little bit late in the process. I'm not sure exactly where the balance is.

But to try to answer the basic questions, there seems to be a reasonable possibility of delivering data useful to epidemiologists with some periods of time where that[data -ed.] may be less reliable than others. And this interconnect time I think is one that's going to be a little testy.

We've talked about the data analysis somewhat, some things to do with taking the January '95 period data and doing a very simple mixing model to make sure we have some sense of measurement errors, either, not sure of the treatment plant or to the production well, but it will give us some sense of one measure that we can use that constrains or informs concentration measurement errors because I don't feel we have a very good handle on that.

In terms of calibration we talked about looking at different ways of representing the residuals so that we can extract some information rather than just saying we've made it, -- and I haven't seen Mary's notes, so I don't know the details of what she's given, but I'm sure she's given them all, all the various plots.

On the concentration calibrations looking forward, we didn't get into a discussion of the treatment of non-detects in, lower bounds of non-detects in the calibration process. But they are, as I read it for Tarawa Terrace, they're set at one microgram per liter no matter what the detection and/or reporting limit may be. That seems to me inappropriate.

Think about it, another way to do it if you're limited by taking logarithms, take the log of one plus the concentration so that your variable can be logged without blowing up on you. Do something, use the data better where it's limited.

Simpler by [Simplified -ed.] physically-based models are the way to go. I like the idea of pursuing a second path that's totally data driven, but it can't be used in preference to before the physically-based modeling systems. I don't think it's worthwhile spending a lot of time on fancy transport systems. Try to keep them relatively simple. The approach that Lenny talked about earlier really simplifying, grossly simplifying the transport processes and getting some representation of early arrival times makes a lot of sense to me.

With respect to arrival times, I would note that in the documents at Tarawa Terrace that both densities seemed out of line. There may be a nomenclature issue. Both densities were around 2.8 or 2.9 because I calculated them. It seemed a little like one too high. So it may be a nomenclature issue. It just needs to be clarified and get it right so we're not retarding excessively. Thank you.

DR. CLARK: Ann.

DR. ASCHENGRAU: Well, I just want to say from an epidemiologist perspective, and it might seem strange given the discussion of the last two days, but that this is really state-of-the-art, even beyond the state-of-the-art epidemiologic study of drinking water pollution. And what's been done here just goes way beyond what's typically done in most epidemiologic studies that have been able to find effects and associations. So I have in spite of all the problems we've heard about, I have every confidence that the study has a very good shot at finding an association if it's there.

My problem comes more from the size of the case control study, that that's a limitation. But I'm heartened to hear also that the great efforts that have been undertaken will be used to reanalyze the prior analysis of small for gestational age in the two planned studies. So that's really excellent.

That being said I also want to reiterate the point that I made yesterday that the Department of Navy should make every effort to identify and give to ATSDR all of the relevant data that they need to do the best job possible and that they need to do this immediately. I think it's a real shame that they now have to go back and reanalyze the study data from before because they didn't have all of the necessary information.

I do think that the goal should be to try to get monthly data for the current study, so monthly exposure data that should be the goal that people are aiming for. And that, you know, if you don't reach it, that's okay. Epidemiologists have never been stopped by having imperfections in their data. It doesn't stop us.

And the other impression I've had is just that there are sort of lots of possible sensitivity analyses that can be done with the groundwater modeling, the distribution water modeling. It just seems like a huge, huge job, but that somehow some plan has to be made for developing what needs to be done, and it needs to be done strategically. And that the goal should really be to keep the epidemiologic study in mind and not spend a lot of time on things that really won't make such a difference in the exposure assessment for the study.

In terms of just some particulars, they're not so much to do with the exposure modeling, but for the case control study of cancer, I do think that the exposure assessment should go beyond the first year of life and that it should go up to the time of the diagnosis of the cases and some comparable date of the controls. That that may end up being a large source of error if that's not done. So you may have to go back and get supplemental data from the study subjects or somehow get that data from records.

And the other thing, well, is the school. That really high value at the school is problematic. And so I think that you should monitor or assess the exposure, not just at the residences but at the schools. And so that would only be really relevant for the cancer study I think at this point. And that that source of exposure should be taken into account.

And then my last point has to do with the behavioral data so it's the water consumption habits of the study participants.

Frank has said a couple of times he doesn't think the data are very good. So I think that the goal would be to try to pick up the extremes so the people that take like long hot showers basically, and drink a lot of tap water and to try to distinguish them from the other study subjects if that's possible.

DR. CLARK: Ann, thank you very much.

Scott.

DR. BAIR: Yes, I guess I'd like to also thank people for inviting me. This has been a very worthwhile and educational process for me. I think the discussions over the last two days have probably convinced those who already recognize it at the table and elsewhere and those of you in the audience that all models are wrong. There are some models that are useful.

So the goal here is to incorporate enough uncertainty and analyze enough sensitivity aspects that we come up with a useful model that can be used by the epidemiologists. So I don't want all the discussion of the nitty gritty that went into the making of the sausage to discourage people that this can't be done. Because I, like Ann, share a positive idea that this can be accomplished. Having read the Tarawa Terrace and the other reports that we were sent before we got here, I was a little skeptical about the amount of data that was available.

And through the discussions with Bob and others there are a fair amount of data that are present that can be used to help constrain the models that I don't think have been mined to their greatest extent yet. For example, the grain size analyses, I think more can be squeezed out of that just looking at the percentage clay or looking at something as simple as a uniformity coefficient or ratio between D-60 and D-10.

I think being the geologist that Mary mentioned, all three of my degrees, anything that is deposited in water because of particle size differences and settling through water, is going to be anisotropic inherently. So I think there's an anisotropy within each year model layers that you may need to consider. These are stacked channel deposits so they are deposited in water. So I'd encourage you to try to glean as much as you can.

The grain size data, there are actually geophysical logs that we didn't get to mention, SP logs and resistivity logs that are giving you information that can be interpreted to show that these are not continuous layers, and they're in some of the older wells, but I think that, too, needs to be incorporated into the model either as an uncertainty analysis, a what would happen if this data point is correct and there's a hole in the confining layer here or not. Getting at the pumping test data, the slug test data that Bob talked about and incorporating that in the model I think is essential to get the velocity fields pinned down a little bit.

Having said that, that y'all have a lot of data to squeeze yet, I do think that there are some simple pieces of data that you can add within your timeframe to help you lower the uncertainty in your model by adding a couple monitoring wells and locations there where water levels are sparse and then just using that to help guide your model even though you're going backwards in time, the water level in the sparse areas probably has not changed that much because it's not in the middle of your well fields, and I'm thinking specifically on the northeast border of the model area.

Perhaps getting some tritium/helium data would be useful to help get another full velocity measurement like Mary talked about getting stream discharge data to help corroborate -- calibrate, corroborate -- what's going on. I think MODPATH is an essential target of your future work, and it wasn't in the Tarawa Terrace report, but I think it should be an essential part.

And then the last thing I have, and we really didn't get too great a discussion on it, is the source term issues. For me one of the biggest problematic areas you have is how you're going to treat all these different source terms. Are they going to be pulse sources or are they going to be continuous sources? If they're continuous sources, is there known DNAPL at depth that can continue to shed off dissolved phase TCE or PCE? What are the initiation dates of those and how are you going to bracket those in some sort of uncertainty analysis?

That's about -- oh, yeah, one last thing. Dump the air line measurements.

DR. CLARK: Scott, thank you.

Dan.

DR. WARTENBERG: I'm also going to thank everyone. I found it fascinating to hear about all the inter-season groundwater modeling and the complexity and the difficulty in obtaining accurate estimates. But as Ann said, as epidemiologists we're used to complicated problems and data that's not as good as we want and are still able to move forward.

But that having been said, I think we've seen maybe the best data that can be provided for this study because the better the data, the more accurate would be the epidemiological results, the more sensitive the study will be. And also, fine scale data are important in helping us resolve some of the epidemiologic issues in terms of how the exposed were related to outcomes.

I think that just speaks to the notion

of if it's at all possible to get the monthly data to get an opportunity to try and see at what stage in the pregnancy there is this effect would be very important, although I recognize that's going to be harder. And there's always the opportunity to aggregate it back up to whatever timeframes if needed to do the analyses.

I think one of the other things that would be useful to do which hasn't been talked about as much is also to do some sensitivity analysis from the epidemiologic studies in terms of if they're different estimates based on different assumptions. Those also can be explored epidemiologically to see if there are associations in different ways.

One of the challenges here is, I guess there are a few challenges, there are a moderate number of studies looking at TCE and PERC and vinyl chloride in terms of cancer, but there's much less in terms of reproductive outcome. And being able to get a better handle on that's pretty important. So I think that trying to complete that picture, even the cancer data right now is still very controversial. But I think, again, it just speaks to how important this study is in doing as good a job as is possible.

I guess a couple other things to say are that I support Ann's statement about really asking the Navy to provide whatever data are being requested and available to help inform the study that that would be an important component to try to understand what's going on and trying to understand the epidemiology of these compounds that we know definitely affect people's health and to try and better understand that.

I guess those are my main comments. I just think again, just to reiterate, the better data we can get the better the epidemiologic data will be and the more retrievable and reliable. I think that's an important thing to try and strive for. Thank you.

DR. CLARK: Thank you.

Peter.

DR. POMMERENK: Well, I'll say thank you again for having me a second time on this panel. I find a certain new perspective that

I hadn't heard about groundwater modeling before, and I also heard some things that we spoke about last time. And instead of repeating again, I just want to keep it short and want to reiterate that it appears critical to this study that uncertainty is included from the get-go.

From every aspect, starting upstream from the mass that was deposited, when it was deposited to have some measure of uncertainty in all these estimates and how they propagate through our model and whether it's the simplified physical model or linear control theory model or highly complex transport model, the uncertainty that is upstream will propagate ~~for~~ [through -ed.] the model and will possibly skew it.

In the end we need to be, a logical study needs to be able to distinguish certain levels of exposure, whether it's not exposed versus exposed or whether it's a little exposed, medium exposure, high exposure and just providing a number will not help that cause. So it needs to be accompanied by some level of certainty in those numbers.

So with that in mind from my perspective certain things that will have to be addressed in Hadnot Point is the pumping schedules, having a well operate 24/7 over a month at a reduced ~~apportion~~ [proportional -ed.] flow rate may not be appropriate, and you may want to look into at least a cursory analysis of how using 12-hour stress periods may affect the outcome.

For the Holcomb Boulevard wells you may want to use 12-hour stress periods because that's the typical amount of time they operate versus Hadnot Point, those wells seem to operate ~~in~~ ^ [continuously -ed.] for a week or two or even a month. Anyway, it would be worthwhile looking at how this type of model or approach will affect the outcome and uncertainty in the study.

And then secondly what I mentioned earlier, we need to look at some of the issues of volatilization up at the treatment plant. You know, just a cursory analysis and say it's significant or not. But it should be on record somewhere because that question may come up at one point.

And I think moving downstream from there, again, it's a lot about uncertainty. We need to wonder how much detailed modeling we have to do in the distribution system. Will that increase certainty in our, in the end or is it not worthwhile by the time we get to what [we want -ed.]^. Anyway, that's all I have.

DR. CLARK: Peter, thank you.

Dick.

DR. CLAPP: Thank you all for teaching us a lot. I think some of you mentioned yesterday there are boundary layers between the engineers here. Well, there are tribal differences I think between ^ [various -ed.] epidemiology tribes. It's fascinating to listen and learn from you all.

To me, I would like to reiterate the points that Ann and Dan made from the point of view of an epidemiologist. When you get the final number that you'll use to assign a dose or an exposure to a particular subject in a study, that's the result of a lot of phenomenal work, and it will have error bars around it.

But there is still going to be a central tendency for that number. I know it's a sort of probability density function that goes along with that number. Our goal is to see that that's as peaked as possible, not as flat and as compatible with anything as sometimes happens. So that's the goal here, and I think everyone has established that that's what the modeling effort is going to lead to. So anyway, I think that's in good hands. As Ann said it's state-of-the-art work, and I commend the ATSDR folks for doing it.

I'd like to mention I think there is a particular problem which is this Hadnot Point to Holcomb Boulevard interconnects during four months for a period of years from 1972 to 1987 where the problem is or a lot of the problem is in the distribution system at least. And so that seems to me to be a tractable problem, that it's not as big as or hopeless as some of our discussion today or yesterday might have made it seem, especially today, I guess.

So I'm optimistic. I think this is going to work. I think that the process that we've engaged in is going to have a fruitful outcome. I think it will be useful to veterans, the people who lived and worked at Camp Lejeune, and that we shouldn't lose sight that that's what this is all about. And I think some aspects of this we learned, for example, there may be a simpler solution than we realized, one of which can be done this weekend. We may have data next Monday I think from him, Dr. Aral. Without being too silly, I'd like to say I think this is a useful exercise that's going to lead to an important finding and glad to be a part of it.

DR. CLARK: Thank you.

Ben.

MR. HARDING: Thanks, Bob. I want to thank ATSDR for allowing me to have this opportunity. I really learned a lot in the first pass, and I've learned a lot from this one. I thank all the panelists, too, for allowing me to poach on your territory and talk about things I don't really know that much about.

And I want to say how remarkable Morris is. I don't know what, does he drink

Tension Tamer Tea or something like that? Your ability to stay calm in the face of all this is really impressive.

MR. MASLIA: Thank you.

MR. HARDING: I'd like to know what it is.

Bob, I'm not going to say anything about, or not much, about what happens below the ground here. I do think it's feasible for this work to contribute a lot of important knowledge, at least at the exposure level. And I'll leave it to the epidemiologists to work from there. So I think there's a good foundation, and it's feasible to complete this successfully.

I would suggest, and I think you probably already intend to do this, that you step back and re-scope your remaining efforts at this point. And from the program scenario I think Walter laid out the components that you need to think about quite well: wellhead concentrations, the interconnection scenarios, water use and then the system operation rules.

And with regard to the water distribution, both the large view I agree with Morris' breakdown and essentially the difficult problem is the interconnections, which others have mentioned here. In doing that I suggest that you should use a detailed hydraulic network model, an extended period simulation of that.

There's no sort of technical or cost problem with doing that. You already have it essentially. That you will need to extend your scenarios over potentially several months depending on what you see in the tanks because it can be a long time before the tanks clear out.

In all of the phases of the work above ground, we're going to need to have what you call a simple mixing model, but it's actually more complicated than that as Peter has mentioned. So we need to have what I call a well operation well supply model that will take into account if there are hydraulic effects on particular wells.

And I think you should develop an informed model of well operations, as informed as you can make it. It'll probably have to be stochastic at some point, but you should inform it as best you can with what you know about the way they operated, the wells.

I think you should use the super-position approach that Walter mentioned. It's essentially similar to the Murphy method that was portrayed. You know, he called it an exposure index. We call it transfer coefficients.

But that approach will allow a low cost and rapid recalculation of the exposure statistics which will happen because the groundwater people will come up with new numbers, and then the epidemiologists will ask for new thresholds. I know. I've been to the rodeo before so, and being able to recalculate this in a short time is really important.

I think it's okay. I think it's feasible and proper to be able to calculate your exposure statistics over a one-month period. That's been a real request from the epidemiologists, but I wouldn't go any shorter than that. I think you have to model a water distribution system on an hour to even -- EPA did a model of minutes if it has to get the convergence.

But you have to model in a short

period to get the dynamics of the system. You can roll it up to a month but no shorter, I think. ^ a quarter but because you need the resolution as long as you bear in mind there's some additional uncertainty.

With regard to the control theory approach, I thought it has a lot of use for developing confidence in the physically-based model, but that we should use a physically-based model for the basic work. And I think there's other reasons why the control theory approach isn't appropriate because we can't get a complete set of wellhead concentrations. But it really was sort of nice to see how well it agreed with the physically-based model. That was interesting.

Echoing what Peter said, you should focus on uncertainty at every step from start to finish. I won't try to tell you how to do that, but I think ultimately it has to be some kind of Monte Carlo numerical approach. At least make an analysis of sensitivities if you're not, if you're going to treat things as point values.

Overall, I want to say this. There's

hundred of thousands of people, and I guess Frank said potentially up to a million people that may have passed through this site during this period that are interested in this event and potentially exposed. And it's a bad thing that's happened, but we should do our best to learn from what happened and not repeat this mistake. And whatever we can gain medically and scientifically we should do that.

If this is done well, future people will make medi-analyses of these results with new information about the populations. So I think it's really, really worth committing the time and effort that are necessary to get this done right, whatever right means, but to get a good foundation in every spurt or step. I mean, the flow model is going to be the fundamental foundation that probably won't change all that much. And as you build up from it maybe some things will be refined, but I really do think it's worth it.

You need to take the time and the money to do that. With respect to time, I think a year for the water distribution modeling should be enough, and maybe you could do it faster. I mean, we've done similar things in a year. I think if you set your mind to it, you could do it faster, but there's a real value in rethinking things every once in awhile.

But do focus on the essentials, just what you essentially need to do to get the end result. Try to avoid digression into details where they aren't relevant. But I think you've done a real good job, and I really do appreciate the opportunity to be here with all the panel members and your tolerance.

DR. CLARK: Thank you, Ben.

Rao.

DR. GOVINDARAJU: I, too, would like to thank ATSDR and all of you for contributing to my learning. I really enjoyed all this. I have some recommendations, but they're not necessarily out of the charge that was laid down to us.

First, I would like to say that I found out that more data has become available very recently, 200 new ~~USG~~ [UST -ed.] reports and many other data coming online. And this data is not likely to be immediately ~~be~~ [-ed.]

used in a model. It's not in spreadsheet form and all cleaned up. So by the time all that data discovery from all this takes place, I suspect it will take some time and I do not know how large a team you have, how many person hours you can throw at it. So I'm going to suggest that December 2009 does not look likely to me, at least one more year and maybe more. But that's something I wouldn't be able to tell. So that is in terms of the timeline issue.

I'm also not comfortable, I would not like to answer the question and say can we promise a plus-minus half magnitude for concentrations, which actually may not be possible for such a complex system even with the best methods available and even if we had a lot of very good data. So I think what the focus should be on is trying to reduce one certainty to the extent possible using whatever that can be done. Use the best methods and so on. I think that would still be useful even if it did not meet this plus-minus half magnitude target.

I'd also like to say that I do not

think that all quantities that are produced, all the things that are predicted or hind-casted, let's say, they will be done equally reliably. Some things will be done better, and some things will not be done as well. So renewed concentrations I'm not sure we'll ever reproduce, but perhaps some we need to drop the averages or different averages you could do perhaps more reliably. So I feel that all the information that we have should be used ^ uncertainty which has been pointed out as being very crucial.

So right now we have uncertainty from the groundwater models which is reflecting, which is trying to predict concentrations in these wellheads, and then this is going to be translated or propagated into the distribution network. But in between there's a step at the treatment plant. I do not know how these concentrations ^, and I do not see much -- and we talked about it -- but I do not know what work has be done about that, but that's potentially useful.

Regarding the models I think the models that you have selected, which is

MODFLOW, ~~MPT~~, [MT3DMS -ed.]. the ^ [Ga. Tech -ed.] code for ~~solu~~ [solute -ed.] transport, EPANET, ^ [and -ed.] what have you. I think these are all fine models. I have no, I guess I have no objection to these models. Any simpler model you want to use that is fine, too, if it does the job well.

Now for the EPANET water distribution model, when you are trying to get concentrations at the endpoints, I think one of the greatest challenges is going to be to try to reconstruct how to disaggregate this one-month quantity that is being given to you from the groundwater side to a daily or an hourly time schedule like has been mentioned. ^ calibration work and with the expectation that patterns haven't changed, I feel it should be possible to reproduce the variability within the month.

I mean, you can consult that volume within a month but you appropriate so that you reproduce some of this variability. And then looking at this variability over time and perhaps over the front realizations which come from different concentration values from the groundwater, if you look at all of these, then I think some meaningful decisions can be made about what the exposure was, how likely the concentrations to have been exceeded over different time windows and so on. So a good statistical analysis I think could be done and could be quite revealing to the epi people.

Well, I think those are my oral comments. I see there is a lot of hard work that has been done by the ATSDR team, and I have a feeling there's quite a bit more to come also. Thank you.

DR. CLARK: Lenny.

DR. KONIKOW: Thank you. I'm going to keep my comments from the ground level down and focus basically on the one test. How do you get or reconstruct the concentrations unloading from the wellheads? And what I see is the task at hand is enormously difficult, and it's a challenging one, but it's very important.

And it's very important that you succeed, and I think you can succeed, but there'll be some errors and uncertainty associated with that. But if you recognize that I think we can pass that information on and let the next group above ground, they can do something with that.

As you go forward and develop the models and develop the insight, I think it's very important that you clearly indicate all the assumptions that underlie it and conceptual models that we use to formulate that. And I think that will help in your defense of it in the future, and it would help enable people to understand it.

Now, I've spent quite a bit of time in Scott's proverbial modeling sausage factory so I tend to see all these difficulties, and I get very concerned about them because they do affect the answers, and I have a few detailed comments related to that.

But the other kind of big picture thing I see here is that you've essentially completed the work at Tarawa Terrace, and I could nit pick a lot of little things in there, but basically, I think that was a successful effort. You did a good job there within its own right was a very complicated problem.

What concerns me here is that the Hadnot Point-Holcomb Boulevard I see another one or two orders of magnitude of complexity here, and so I do get concerned. Is this whole thing doable? And that's a reasonable question to ask. I don't have the definitive answer, but I do think you can do something. I think what you do can be useful.

I think basically, I think you can succeed within a certain framework, but maybe keeping in mind what was done and what was able to be done at Tarawa Terrace, what's able to be done and our success in groundwater science with groundwater flow modeling. Transport modeling again just is another level of complexity. So as I tell some people, the secret to successful ~~solu~~ [solute -ed.] transport modeling is to lower your expectations.

And I think that's something we have to do. We're just not, all the difficulty in groundwater flow modeling will have that, but we could do it. We're not going to be able to do as well with transport. There's too many other processes involved and there's too many additional unknowns. So what this gets at then, and I've worked in the sausage factory, but I'm also a sausage salesman, so I don't want to discourage you from this, and I'm trying not to discourage you.

I think it is a valuable path to follow, and you will learn a lot and on. But be that as it may, with this complex approach, as several of us have said earlier, it has to be supplemented with simpler approaches both to see if they could provide the necessary information as well as to provide cross-checks against the very concas (ph).

As we said again many times, no matter what we do with the models, there's still a very limited set of observations of concentrations against which we could compare the model results. So we have this enormous field of a couple of decades of no data on concentrations. So we've got to take a couple, you should take a couple of different paths.

The linear control theory I think is certainly worth pursuing and get as much out of that as you could. Other simple ways that we've talked about which would encompass some coupling of groundwater flow modeling with MODPATH modeling and with very simple interpolation extrapolation I think would be very useful also, and I think you could do a lot with that.

I think you could learn a lot from using MODPATH more than was done in the Tarawa Terrace approach. With this lack of data I think you have to keep mining, searching, doing what you can to get more data if it's out there, and if it's available. Because one extreme, and again, I don't want to sound like an academic researcher who just always wants more data, but one of the difficulties I've had in doing this review in constructing my comments was -- I think it was Dave mentioned -- it's very early in your phase.

And my focus really has been on the wellhead concentration, how we get there. And yet we've had no document on the hydrogeologic framework yet, no transient flow model yet, no transport model yet. So it's hard to comment on them because that's what's going to get us to the wellhead concentrations.

So one recommendation that was mentioned was that somewhere down the line when you get further into that, but not too far into it, get maybe a smaller group of expert peer panel to look over your shoulder and give you some advice and help maybe guide you in a more efficient -- and by more efficient I mean you're always going to have some deadline facing you. So you want to get this done as well as possible and in as short a time as possible. And I think peer review is a very useful way to help you do that.

On the data picture a lot of people don't like to hear this, but consider getting more data. I mean collecting more data so, but before you do that you've had an enormous amount of money spent on installation restoration programs there. Have you mined that for all the data that's available?

In the report I saw there was a 40-day tracer test done at one of the sites, which I can't remember. I mean, that should have gotten you some effective porosity and dispersivity data if they did it well. Is that data available to you and have you looked at it? They must have to do the kind of work they do, and they must have taken some cores. They must have looked at some of the clays and the confining layers.

Did they measure any hydraulic conductivities or porosities?

MR. FAYE: Was that rhetorical or do you want an answer?

DR. KONIKOW: I don't want an answer right now, but it wasn't rhetorical either. These are things I want you to think about, and I'm sure most of you've already thought about it, but these are things that are just kind of popping out of my mind now.

On the modeling and the work that's done so far, again, I'm very concerned about up to now -- I know it's preliminary still -- it's locking into one foot per day as a hydraulic conductivity for the clays and for all the clays.

I mean, that bothers me. One of the things we talked about doing sensitivity analysis. In your steady state, pre-development flow model, those heads are not going to be sensitive particularly to those values, but your transient flow model it will be, and in your transport model even more so, that value is so few.

Rely on locking it into those values based on the sensitivity test in your steady state flow model, you may be making a big mistake. And again, that's something I mentioned before is when you go beyond the steady state, you may have to re-examine almost everything because what worked there may not work for transport.

In a transport analyses again one of the things that has certainly been highlighted in the last 20 years or more is the control and the importance of spatial heterogeneity in the formations. And you're dealing with models at the moment.

You're assuming each layer, each unit, is homogeneous, and I'd like you to explore the data to see if there are ways to not only get at the spatial variability but other aspects of heterogeneity including channeling and connectivity of the sediments because every study where there was detailed data showed that this was the controlling factor on

~~solu~~ [solute -ed.] transport. So if at all possible, pay a little more attention to that.

Then there's all the uncertainty with reaction, ~~absorption~~ [adsorption -ed.], fate, you know, ~~absorption~~ [adsorption -ed.], decay and all those other terms which we don't want to get into right at the moment. But again, like I think it was Scott mentioned his concern about estimating the source terms. Again, what's more critical for ~~solu~~ [solute -ed.] transport model than how much gets in and when and where.

And I didn't see all the answers yet in the presentations here or how the approach that was taken and described will actually get to an estimate for the source term in the model and how they'll be done. At Tarawa Terrace you did a mass loading which I would much rather see defining a source concentration associated with the fluid that goes in the model. Because otherwise you get some conceptual inconsistencies that I think need to be explained. So this gets into other issues, but again be careful with that source term because that's very critical and very important.

So with that I guess I'll pass the mike.

DR. CLARK: Lenny, let me thank you very much.

Randall.

DR. ROSS: First, I'd like to thank ATSDR and Morris for the opportunity to come and be with such a talented group of individuals and learn. And I had a professor that once said water level maps are a figment of the artist's imagination. And I'd say the same could probably be said about groundwater modeling results. But with that in mind it's also the best that can be done. I don't want to say a necessary evil, but it is. It's the best answer that one can come up with with confidence. And I think that's true.

One of the things about data gaps, modeling, one of the benefits of modeling is it forces you to look at your data, look at what you have and identify your data gaps. And I think Scott hit on this a little bit. There may be some data gaps that come up in the initial parts of the modeling exercise that tell you where you need more information, have better control on the situation.

With regards to the charge, with respect to the question did the methods provide an adequate level of accuracy and precision, using Dr. Faye's definitions of precision and accuracy, I'd say for precision probably, for accuracy at Tarawa Terrace probably, for Hadnot Point I'll refrain from a final answer on that.

I'd say that the Tarawa Terrace exercise represented one of the best case scenarios that we've had an opportunity to see with respect to coming up with concentrations for exposure that will keep you folks happy. And that's one thing I have written down here is listen to the epi folks.

If you have another meeting like this I'd say the first 15 minutes should be the epi folks re-impressing upon all the people that work below ground and above what they're looking for. If it's enlightening to me to hear that high, middle and low are acceptable. And with that in mind I'd say whether or not you could reach the accuracy, probably. And that's a good thing.

Looking through the previous panel's comments after we made our comments I noticed there were a few things that we commented on that in particular Dr. Konikow identified in the last panel meeting that didn't seem to be fully addressed. And that leads me to the question of exactly what will become of the comments that were submitted today and how that will be addressed I guess.

Then I have a note here that says listen to the geology. To go back to what Dr. Hill said, basically. And this with respect to including two marginal aquifers and a confining unit in the same layer. I mean, that's a no-no, and I think pretty much all the modeling folks here, the hydrogeologists, kind of cringed when they saw that. And there was a reason for that because it flooded, the nodes were flooded I understand. But as Dr. Hill also said, don't do that. Fix it some other way I guess.

I would say it's, I had a comment here about the plus or minus three feet and the plus or minus 12 feet, and I'd say that if there are wells that haven't been surveyed, I think it's well worth surveying them now. These could provide valuable data in the future.

And along those same lines one of the recommendations that people get tired of hearing me suggest is the implementation of or deployment of pressure transducers. Yeah, they produce a whole lot of data, but at the same time they can provide a lot of insight into how the system reacts to pumps shutting on and off.

You can't do it in hindsight, but hindsight being 20-20, we can look ahead and say that might be a useful tool that could be deployed. Pressure transducers in select locations to give you a better understanding of how the system reacts, hydrogeologic system in general.

There were several comments I guess that I included in our written comments, but something then to consider with the, more of the worst-case scenario I guess which would be the whole Hadnot Point modeling exercise, not worst-case scenario but certainly not as friendly and nice. The looking at leakage from your domestic production lines, the water lines. Ten percent's not an uncommon number that you hear batted around the modeling community, but which could be a significant number.

Likewise for sewer lines, they pump a boatload of water out of the aquifer, well, if you lose ten percent or 20 percent of that usually the sanitary folks don't really care if they don't see it and if nobody's complaining that they're basements are flooding. That could be a significant input into the model as well and nobody measures it or likes to.

Degradation rates, you've got to be careful there. It's going to be completely different I believe than the exercise at Tarawa Terrace. There you really don't have evidence that the bugs were really happy. There's not a large quantity of -- at least I haven't seen -- VC, DCE and compounds like that, nor of the geochemical data that indicate that the bugs were happy for reducing conditions. I think there'll be a lot more of that associated with the DNAPL sites as I'm sure they are.

And that leads right into the source term. You've got bugs that are munching away at the dissolve[d -ed.] phase, but there's no doubt in my mind just looking at the numbers in a cursory manner that, I mean, you've got a -- I've used the term boatload three times now because I like it. There's an unknown, yet probably very large quantity of dense ^ [nonaqueous phase -ed.] ~~disphase*~~ liquid TCE and PCE in the subsurface especially below the dry cleaner. How that will be handled as a source, that'll be interesting, and I think will have a significant impact maybe. Maybe. It has an impact with respect to the longevity of the source and remediation talk, but maybe not necessarily on the high, middle and low concentrations that you folks are really looking for.

Echo what was said earlier about the bulk density issue. It looks like there was an error early on that was carried through. It could be a nomenclature issue, but going back to that original article and tracing it through the documents, I think there's a, the retardation factor in the model would be modified by about 25 percent probably, just a ballpark, back-of-the-envelope kind of calculation.

Source issues we've talked about transducers. Thank you for the opportunity to participate in this.

DR. HILL: Can I say three words?

DR. CLARK: Sure.

DR. HILL: Two significant digits.

DR. CLARK: Words to live by.

I'd really like to thank all the panel for your participation and your outstanding insights. It's been a pleasure to work with all of you. I'd certainly like to thank the audience, too. We had some very good input from a lot of the people who've been here and observers, Dr. Aral. We certainly appreciate the ATSDR staff and Liz, for all your help. So it's made it possible to do this.

Morris, would you like to say a word or two?

MR. MASLIA: Are you giving your recommendations?

DR. CLARK: Well, I can. I didn't know if I was allowed to do that as a panel member.

MR. MASLIA: Yes, definitely.

DR. CLARK: Very few. I thought everybody did an outstanding job in recommendations, and I support all that was said. The only things that I thought were worth maybe re-emphasizing for the fact that it seems to me that the epidemiological study should probably go beyond just child [and -ed.] in utero studies~~.~~ ~~That~~ [and -ed.] there's significant exposure to adults and that's just almost totally unknown.

And some of the levels that adults have been exposed to are almost unbelievable. I was looking at some of the vinyl chloride levels that were pumped from one of the wells in there, and when I was working on this sort of thing with EPA, this would have been frightening stuff. So I think that's something that probably needs to be explored.

I still think that some of the degradation byproducts issues have not been explored thoroughly and should be. I think ~~it's, like~~ the degradation ~~rate~~ [rates -ed.]

shown in the manual are a lot slower than would be of concern in [-ed.] [- ed.]in a distribution system, but it depends on where you start from.

And I think it's something we were always concerned with in our studies is just how fast did some of these compounds degrade the vinyl chloride in it. What would the implications for that be? It wouldn't take, wouldn't be [-ed.] very much vinyl chloride to really have an impact on the outcomes in an epidemiological study.

Another thing I wanted to mention was the fact that I think you've missed an opportunity to look at some direct exposure data in terms of CHMs [THMs]. I know I gave up on that earlier because I know Dave and ^ looked at it, and they didn't have the GC traces so they sort of pushed it aside. But looking at some of what I've seen, it seems to me that's an opportunity to actually look at direct exposure and transport in the distribution system. I would encourage you to go back and look at that very carefully and see if there isn't some way to reconstruct that. And I certainly would help you with some of my contacts at EPA when you get into some of the analytical chemistry issues. So with that I'll conclude and thank everybody.

And Morris, you want to make a few comments?

MR. MASLIA: I wanted to thank all the people who participated in the panel. It's obvious even the preliminary work is a large volume of information for you to digest in the short period that we gave you and then provide us with feedback that we can implement and use to carry the project forward to a successful completion, so thank you very much for your time and effort.

I also wanted to thank Bob Clark for stepping in at the last minute and chairing and guiding the panel, which he was not expecting to do just a couple of days ago. So that was a benefit to us. And I do agree. I think was it Lenny that made the suggestion and actually I was going to bring it up, but since you said it, it's good is to reconvene perhaps a smaller group as we get to different aspects or phases, and sort of looking over our shoulder and critiquing those aspects rather than waiting a whole long time and bringing a larger group together. And I think that probably will provide us with much more valuable input in a shorter time period. So I thank you for bringing that up. It's a very worthwhile suggestion.

And to answer Dr. Ross' question about what happens is we will put a draft report together similar to the one that we did. We tried to, I think actually this panel was much more succinct in their final recommendations than the first panel, which is easier for us to, and then we tried to implement it to the best of our ability both in technically as well as time and effort and money.

But again going back to Lenny's suggestion I think if we do have smaller groups of technical experts looking over every so often that's easier to make sure we don't miss anything or overlooking something that's important. So thank you to everybody, and thank you to all the administrative staff for assisting us and thank you to our technical staff who have spent at least the last months just administratively putting the panel together with all the material.

DR. BOVE: I want to thank all of you. I think this has been very valuable to the epidemiologists, both myself, Perri and I think the epidemiologists on the panel learned quite a bit today. So thank you very much. I think your input was great and I think will help the study immensely.

DR. HILL: Thank you.

DR. CLARK: With that the bus from the hotel comes at 3:30, doesn't it?

(Whereupon, the meeting was adjourned at 3:12 p.m.)

CERTIFICATE OF COURT REPORTER

STATE OF GEORGIA

COUNTY OF FULTON

I, Steven Ray Green, Certified Merit Court Reporter, do hereby certify that I reported the above and foregoing on the day of April 30, 2009; and it is a true and accurate transcript of the testimony captioned herein.

I further certify that I am neither kin nor counsel to any of the parties herein, nor have any interest in the cause named herein.

WITNESS my hand and official seal this the 19th day of July, 2009.

STEVEN RAY GREEN, CCR, CVR-CM, PNSC

CERTIFIED MERIT COURT REPORTER

CERTIFICATE NUMBER: A-2102

EXHIBIT 11

Expert Report

Prof. Mustafa M. Aral

Date: 10/23/2024

Prepared by,

Prof. Mustafa M. Aral, *GA-PE 15254*

Consultant, Environmental Modeling and Health Risk Analysis

https://www.researchgate.net/profile/M-Aral

Table of Contents

1. Background and Qualifications

I am a Professor Emeritus from the School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta Georgia USA and an independent consultant residing in 270 17th St NW, Unit 809, Atlanta, Georgia USA. I hold a Ph.D. degree in Environmental Water Resources Management and Modeling (1971) and a master's degree in water resources engineering from the School of Civil and Environmental Engineering (1969), Georgia Institute of Technology. I have a bachelor's degree in civil engineering (1967) from the Middle East Technical University, Ankara, Turkey. I am a Professional Engineer registered in the State of Georgia (PE-15254).

I joined the Georgia Institute of Technology faculty in 1978 where I served until 2018 as Professor and the Director of Multimedia Environmental Simulations Laboratory (MESL), a research center established in 1993. In 2018 I was appointed as Professor Emeritus at Georgia Institute of Technology. During my career I have published over 100 technical publications in peer reviewed journals, five books, ten book chapters, and numerous conference papers and technical reports. I served as the Chair of several International Conferences. Among these the most noteworthy activities are the NATO Advanced Study Institute that I organized in Antalya, Türkiye in 1995; the Environmental Exposure and Health Conference held in Atlanta, GA, USA in 2005 which I co-organized; and I was the Technical Chair of the ASCE/EWRI IPWE 2013 International Conference held in Izmir, Türkiye in January 7-9, 2013. I am the Past-President of the American Institute of Hydrology (AIH), and a Fellow of the American Society of Civil Engineers (ASCE), a professional organization that represents over 190,000 civil and environmental engineers in the USA. During 2009 I established the International Journal on "Water Quality, Exposure and Health" published by Springer Publishers. I was the Editor-in-Chief of this journal from 2009 to 2014. I am also on the Editorial Board of several technical journals and serve as a consultant and reviewer on European Framework programs.

During my career I received twenty-eight honor citations from scientific organizations. Among these the most noteworthy national (USA) and international recognitions are American Society of Civil Engineers (ASCE), Cuming Medal (2000); two times the recipient of American Academy of Environmental Engineers Best Environmental Health Research Award (2003 and 2015); Centers for Disease Control and Prevention (CDC) Excellence in Applied Environmental Health Research (2006); and ASCE-Environmental Water Resources Institute (EWRI) James R. Croes Medal (2011). Among these, the Grand Prize Award received in Environmental Engineering in Research category given by the American Academy of Environmental Engineers (AAEE, 2015) is particularly important to this case since it is based on the quality and substance of the research work done in the Camp Lejeune water modeling historical reconstruction project.

My expertise includes the development and application of mathematical modeling techniques to environmental and engineered systems to evaluate the origins and fate and transport of contaminants in natural and engineered environments. I have more than 50 years of relevant professional experience evaluating the timing of chemical releases, developing enviro-geochemical models in multimedia environments and conducting environmental forensic analysis in the context of mathematical modeling techniques, regulations and guidance or directives established by the relevant agencies. My Curriculum Vitae and a list of my publications are provided in Exhibit A of this report. I have not testified by deposition or at trial in the last four years.

2. Assignment

In August 2022, I was retained by Bell Legal Group on behalf of the *Camp Lejeune Water Litigation* Plaintiffs as an environmental modeling expert to testify regarding the ATSDR Environmental Water Modeling Study conducted at U.S. Marine Corps Base Camp Lejeune, North Carolina and such other opinions as may become relevant. I am being compensated $600 per hour for my work on this matter.

As an environmental modeling expert, I was tasked with the following:

- Provide a high-level explanation of the ATSDR's historical reconstruction process for both the Tarawa Terrace and Hadnot Point-Holcomb Boulevard study sites, including my involvement in it.
- Provide an explanation of the reported concentrations of contaminants in finished water at Camp Lejeune from 1953 to 1987.
- Provide an explanation of the calibration, sensitivity analysis, uncertainty analysis, and validation techniques used in the ATSDR study of the Camp Lejeune site.
- Summarize the conclusions and opinions included in the published ATSDR Reports.
- Provide additional opinions beyond those already included in the ATSDR published works.

Around the year 2000, the Multimedia Environmental Simulations Laboratory (MESL), a research center at the School of Civil and Environmental Engineering, Georgia Institute of Technology entered into a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR)/Centers for Disease Control and Prevention (CDC) to provide technical support to ATSDR in all aspects of the Camp Lejeune study for all three study areas on an as-needed basis. As the MESL research center director, I oversaw all aspects of this cooperative agreement at the Georgia Institute of Technology side. The cooperative agreement was extended to three five-year periods and ended in 2015. My involvement in the ATSDR Historical Reconstruction Project was supported by my graduate students at the MESL research center. There was no other faculty member involvement in the cooperative agreement from the Georgia Tech side. Over the 15-year period from 2000 to 2015, I and my team members worked with the other team members of the Exposure Dose Reconstruction Program (EDRP) at ATSDR to perform an analysis of the Tarawa Terrace, Holcomb Boulevard, and Hadnot Point study sites of the U.S. Marine Corps Base Camp Lejeune.

To conduct my evaluation and render my expert opinions, I relied on my education, research, professional experience, and the information base I accumulated over the years while working on the ATSDR Camp LeJeune study and other matters. The documents and information that I considered are of the type that can be reasonably relied upon to support my opinions and are regularly relied upon by practitioners in my field. The materials that I reviewed include, but are not limited to, published technical literature, reports, historic data sources, correspondence and meetings with state and regulatory agencies, participation in workshops and review of documents provided by independent experts at these gatherings. The list of documents I have considered and/or relied upon to render my opinions is provided in Section 8 of this Expert Report.

Opinions presented in this report were reached by applying accepted methods and information in the fields of hydrogeology, geochemistry, environmental sciences and mathematical and stochastic computational modeling. The opinions expressed in this report are my own and are based on my education, training, and experience, as well as the documents, public information, diagrams, data, and facts that were available to me at the time of writing. I hold these opinions to a reasonable degree of scientific and engineering certainty. I reserve the right to supplement and/or amend my opinions on this matter as necessary as additional documents, depositions or information are made available to me.

3. Introduction

U.S. Marine Corps Base Camp Lejeune, North Carolina was established in 1942. Groundwater is the sole source of water supply for Camp Lejeune. In the 1980s, Navy water testing at Camp Lejeune detected Volatile Organic Compounds (VOCs) in some water-distribution systems at the base. In 1982 and 1983, continued testing identified two VOCs—trichloroethylene (TCE), a metal degreaser, and tetrachloroethylene (PCE), a dry-cleaning solvent—in two water-distribution systems that served base housing areas, Hadnot Point and Tarawa Terrace. In 1984 and 1985 a Navy environmental program identified VOCs, such as TCE and PCE, in some of the individual wells serving the Hadnot Point and Tarawa Terrace water-distribution systems. Ten wells were subsequently removed from service.

The extent of subsurface contamination, its impact on groundwater, and the associated potential health risks of water contamination prompted the U.S. Environmental Protection Agency (USEPA or EPA) to place Camp Lejeune on the EPA CERCLA (Superfund) National Priority List for cleanup (remediation) in 1989, leading to Remedial Investigations / Feasibility Studies and ultimately to Records of Decisions (RODs) for remedial action (EPA, 1993 for Tarawa Terrace / ABC One Hour Cleaners; EPA, 1993 for Hadnot Point Industrial Area; and EPA 1994 for Hadnot Point Landfill).

Hadnot Point was the original water-distribution system, serving the entire base with finished water beginning in the early 1940s. The Hadnot Point water treatment plant (WTP) was constructed and began operations in the 1941–1942 timeframe. The Tarawa Terrace WTP began delivering finished water during 1952, and the Holcomb Boulevard WTP began delivering finished water during June 1972, Figure 1. The Tarawa Terrace WTP was closed in March 1987 due to contamination, leaving Hadnot Point WTP to supply water to the Hadnot Point area, and the Holcomb Boulevard WTP to supply water to the Holcomb Boulevard and Tarawa Terrace base housing areas. The Holcomb Boulevard water-distribution system is connected to the Hadnot Point water-distribution system at the Marston Pavilion valve and at booster pump 742. While booster pump 742 was removed during 2007, the two systems can still be interconnected by opening a valve at the same location based on water supply demand. For operational reasons, the two water-distribution systems were occasionally connected—exceptions being some connections that occurred during late spring and summer months of 1972–1986 and a continuous 8-day period of 28 January to 4 February 1985 (ATSDR, 2007a). Tarawa Terrace, Hadnot Point, and Holcomb Boulevard water-distribution systems historically supplied finished water to most family housing units, enlisted personnel barracks, workplaces, and other facilities at the base (ATSDR, 2013a).

Department of Defense (DOD) and North Carolina officials concluded that on and off-base sources were likely to have caused contamination (GAO, 2007). With respect to Tarawa Terrace, PCE contamination of finished water occurred because PCE, a common dry-cleaning solvent, leaked into groundwater that supplied the Tarawa Terrace drinking water system from a dry-cleaner (One-Hour ABC Cleaners) located outside the Camp Lejeune base. In 1987, the military base shut down the Tarawa Terrace water treatment plant because of PCE contamination of the drinking water (ATSDR, 2007a, e). The Hadnot Point water system, which provided water to both the Hadnot Point and Holcomb Boulevard service areas, was contaminated with TCE, PCE and refined petroleum products because of waste disposed of at a landfill and activities within an industrial area, including vehicle service and maintenance, warehousing, auto body painting and maintenance, and heavy equipment maintenance. Active underground storage tanks (USTs) and solvent storage areas were in the Hadnot Point Industrial Area (HPIA), where substantial volumes of liquid hydrocarbon fuels were lost due to leakage to the subsurface.

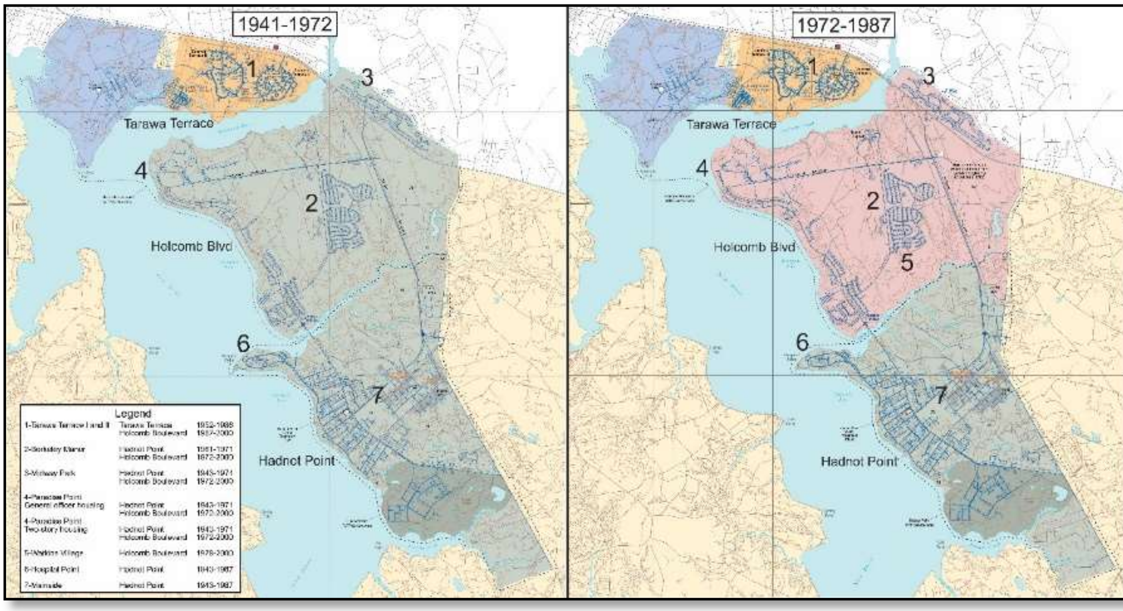

Figure 1: General map of U.S. Marine Corps Base Camp Lejeune in North Carolina (ATSDR, 2007a; ATSDR, 2013a)

The Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Department of Health and Human Services, conducted several studies to help Marines, civilians, health officials, and other interested parties understand more about the drinking water contamination at Camp Lejeune and whether it affected the health of persons living or working on the base during the period 1953-1987. The first was an epidemiological study to evaluate whether in-utero and infant exposures to volatile organic compounds in contaminated drinking water at Camp Lejeune were associated with specific birth defects and childhood cancers. The study included births occurring during the period 1968-1985 to women who were pregnant while residing in family housing at the base. Later, the epidemiologic studies were extended to cover other health effects as well. These epidemiologic studies and their findings are not within my expertise area.

Historical exposure data needed for the epidemiological case-control study were limited. To obtain estimates of historical exposure, ATSDR used water modeling techniques and the process of historical reconstruction to determine the extent of VOC-contamination at the site, to quantify historical concentrations of contaminants in the finished water, and to compute the level and duration of human exposure to the contaminated drinking water. The findings of the study were grouped in two series of reports: (a) Tarawa Terrace and Vicinity Study Reports (ATSDR-a/b/c/d/e/f/g/h/i, 2007); (b) Hadnot Point and Vicinity Study Reports (ATSDR-a/b/c/d/e/f/g/h/i/j/k/l, 2013), Figure 2. From this point forward these references will be quoted as (ATSDR, 2007) and (ATSDR, 2013) in bulk. From the context of the discussion, it will be clear which chapter is under consideration. In some references specific chapter references will also be given when necessary.

The ATSDR water modeling team was guided by an external ATSDR Expert Panel, whose members contributed significantly to the quality of the modeling effort. The members of the ATSDR Expert Panels are well-known and respected scientists in the field; their names are listed in the Expert Panel reports

(Maslia, 2005; Maslia, 2009). These are also available on the ATSDR website (https://www.atsdr.cdc.gov/sites/lejeune/expert-panels.html).

Water modeling enabled ATSDR to estimate monthly mean contaminant levels in drinking water within the Tarawa Terrace, Hadnot Point and Holcomb Boulevard water treatment plant service areas for the period 1942-2008. This work in turn helped ATSDR epidemiologists determine if populations were exposed to contaminants, at what levels and when they were exposed during the period 1953-1987 (ATSDR, 2007; ATSDR, 2013).

Table A2. Summary of ATSDR chapter reports on topical subjects of water-modeling analyses and the historical reconstruction process, Tarawa Terrace and vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[ATSDR, Agency for Toxic Substances and Disease Registry; VOC, volatile organic compound; PCE, tetrachloroethylene; WTP, water treatment plant]

Report chapter	Author(s)	Chapter title and reference citation	Topical summary
A	Maslia ML, Sautner JB, Faye RE, Suárez-Soto RJ, Aral MM, Grayman WM, Jang W, Wang J, Bove FJ, Ruckart PZ, Valenzuela C, Green JW Jr, and Krueger AL	Summary of Findings; Maslia et al. 2007 (this report)	Summary of detailed technical findings (found in Chapters B–K) focusing on the historical reconstruction analysis and present-day conditions of groundwater flow, contaminant fate and transport, and distribution of drinking water
B	Faye RE	Geohydrologic Framework of the Castle Hayne Aquifer System; Faye (In press 2007a)	Analyses of well and geohydrologic data used to develop the geohydrologic framework of the Castle Hayne aquifer system at Tarawa Terrace and vicinity
C	Faye RE, and Valenzuela C	Simulation of Groundwater Flow; Faye and Valenzuela (In press 2007)	Analyses of groundwater flow including developing a predevelopment (steady state) and transient groundwater-flow model
D	Lawrence SJ	Properties of Degradation Pathways of Common Organic Compounds in Groundwater; Lawrence (In press 2007)	Describes and summarizes the properties, degradation pathways, and degradation by-products of VOCs (non-trihalomethane) commonly detected in groundwater
E	Faye RE, and Green JW Jr	Occurrence of Contaminants in Groundwater; Faye and Green (In press 2007)	Describes the occurrence and distribution of PCE and related contaminants within the Tarawa Terrace aquifer and the Upper Castle Hayne aquifer system at and in the vicinity of the Tarawa Terrace housing area
F	Faye RE	Simulation of the Fate and Transport of Tetrachloroethylene (PCE); Faye (In press 2007b)	Historical reconstruction of the fate and transport of PCE in groundwater from the vicinity of ABC One-Hour Cleaners to individual water-supply wells and the Tarawa Terrace WTP
G	Jang W, and Aral MM	Simulation of Three-Dimensional Multi-species, Multiphase Mass Transport of Tetrachloroethylene (PCE) and Associated Degradation By-Products; Jang and Aral (In press 2007)	Descriptions about the development and application of a model capable of simulating three-dimensional, multispecies, and multiphase transport of PCE and associated degradation by-products
H	Wang J, and Aral MM	Effect of Groundwater Pumping Schedule Variation on Arrival of Tetrachloroethylene (PCE) at Water-Supply Wells and the Water Treatment Plant; Wang and Aral (In press 2007)	Analysis of the effect of groundwater pumping schedule variation on the arrival of PCE at water-supply wells and the Tarawa Terrace WTP
I	Maslia ML, Suárez-Soto RJ, Wang J, Aral MM, Sautner JB, and Valenzuela C	Parameter Sensitivity, Uncertainty, and Variability Associated with Model Simulations of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water; Maslia et al. (In press 2007b)	Assessment of parameter sensitivity, uncertainty, and variability associated with model simulations of groundwater flow, contaminant fate and transport, and the distribution of drinking water
J	Sautner JB, Valenzuela C, Maslia ML, and Grayman WM	Field Tests, Data Analyses, and Simulation of the Distribution of Drinking Water; Sautner et al. (In press 2007)	Field tests, data analyses, and simulation of the distribution of drinking water at Tarawa Terrace and vicinity
K	Maslia ML, Sautner JB, Faye RE, Suárez-Soto RJ, Aral MM, Grayman WM, Jang W, Wang J, Bove FJ, Ruckart PZ, Valenzuela C, Green JW Jr, and Krueger AL	Supplemental Information; Maslia et al. (In press 2007a)	Additional information such as synoptic maps showing groundwater levels, directions of groundwater flow, and the distribution of PCE based on simulation; a complete list of references; and other ancillary information and data that were used as the basis of this study

Table A1. Summary of ATSDR chapter reports and supplemental information sections, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[ATSDR, Agency for Toxic Substances and Disease Registry; PCE, tetrachloroethylene; TCE, trichloroethylene; LNAPL, light nonaqueous phase liquid; IRP, Installation Restoration Program; WTP, water treatment plant; RCRA, Resource Conservation and Recovery Act of 1976; BTEX, benzene, toluene, ethylbenzene, and xylenes]

[1]Report chapter	[2]Authors and reference	Chapter or supplemental information section title	Topical summary
A	Maslia ML, Suárez-Soto RJ, Sautner JB, Anderson BA, Jones LE, Faye RE, Aral MM, Guan J, Jang W, Telci IT, Grayman WM, Bove FJ, Ruckart PZ, and Moore SM (Maslia et al. 2013)	Summary and Findings	Summary of detailed technical findings (found in Supplements 1–8 and Chapters B–D) focusing on historical reconstruction analyses and present-day conditions of groundwater flow, contaminant fate and transport, and distribution of finished water
A–Supplement 1	Sautner JB, Anderson BA, Suárez-Soto RJ, and Maslia ML (Sautner et al. 2013a)	Descriptions and Characterizations of Data Pertinent to Water-Supply Well Capacities, Histories, and Operations	A comprehensive listing and analysis of historical through June 2008 water-supply wells, their capacities, operational histories, and supply of finished water
A–Supplement 2	Telci IT, Sautner JB, Suárez-Soto RJ, Anderson BA, Maslia ML, and Aral MM (Telci et al. 2013)	Development and Application of a Methodology to Characterize Present-Day and Historical Water-Supply Well Operations	Describes a method that uses recorded data, other ancillary information, and a training algorithm to synthesize monthly water-supply well operations, 1942–2008
A–Supplement 3	Faye RE, Jones LE, and Suárez-Soto, RJ (Faye et al. 2013)	Descriptions and Characterizations of Water-Level Data and Groundwater Flow for the Brewster Boulevard and Castle Hayne Aquifer Systems and the Tarawa Terrace Aquifer	Describes water-level data for the Brewster Boulevard and Castle Hayne aquifer systems and Tarawa Terrace aquifer, analyzes water-level trends, and presents a potentiometric surface map derived from the water-level data and resulting groundwater-flow directions
A–Supplement 4	Suárez-Soto RJ, Jones LE, and Maslia ML (Suárez-Soto et al. 2013)	Simulation of Three-Dimensional Groundwater Flow	Describes the application and calibration of a three-dimensional groundwater-flow model used to simulate steady-state (predevelopment) and transient groundwater flow for the period 1942–2008

Table A1. Summary of ATSDR chapter reports and supplemental information sections, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[ATSDR, Agency for Toxic Substances and Disease Registry; PCE, tetrachloroethylene; TCE, trichloroethylene; LNAPL, light nonaqueous phase liquid; IRP, Installation Restoration Program; WTP, water treatment plant; RCRA, Resource Conservation and Recovery Act of 1976; BTEX, benzene, toluene, ethylbenzene, and xylenes]

[1]Report chapter	[2]Authors and reference	Chapter or supplemental information section title	Topical summary
A–Supplement 5	Guan J, Anderson BA, Aral MM, and Maslia ML (Guan et al. 2013)	Theory, Development, and Application of Linear Control Model Methodology to Reconstruct Historical Contaminant Concentrations at Selected Water-Supply Wells	Describes the model developed using linear control theory that is capable of reconstructing historical contaminant concentrations using limited geohydrologic and aquifer information; model is applied to water-supply well HP-651 in the Hadnot Point landfill area
A–Supplement 6	Jones LE, Suárez-Soto RJ, Anderson BA, and Maslia ML (Jones et al. 2013)	Source Characterization and Simulation of Fate and Transport of Selected Volatile Organic Compounds in the Vicinities of the Hadnot Point Industrial Area and Landfill	Describes the application and calibration of three-dimensional models of contaminant fate and transport used to reconstruct historical groundwater concentrations of PCE, TCE, and benzene in the vicinity of the Hadnot Point Industrial Area and landfill area for the period 1942–2008
A–Supplement 7	Jang W, Anderson BA, Suárez-Soto RJ, Aral MM, and Maslia ML (Jang et al. 2013)	Source Characterization and Simulation of the Migration of Light Nonaqueous Phase Liquids (LNAPLs) in the Vicinity of the Hadnot Point Industrial Area	Describes the estimation of LNAPL volume in the subsurface and the development and application of a three-dimensional contaminant fate and transport model used to simulate LNAPL and dissolved-phase benzene in the vicinity of the Hadnot Point Industrial Area for the period 1942–2008
A–Supplement 8	Sautner JB, Grayman WM, Telci IT, Maslia ML, and Aral MM (Sautner et al. 2013b)	Field Tests, Data Analyses, and Simulation of the Distribution of Drinking Water with Emphasis on Intermittent Transfers of Drinking Water Between the Hadnot Point and Holcomb Boulevard Water-Distribution Systems	Describes field tests conducted and data gathered during 2004 for the Hadnot Point and Holcomb Boulevard water-distribution systems and simulations of the intermittent supply of Hadnot Point finished water to the Holcomb Boulevard water-distribution system during the period 1972–1985
B	Faye RE (Faye 2012)	Geohydrologic Framework of the Brewster Boulevard and Castle Hayne Aquifer Systems and the Tarawa Terrace Aquifer	Describes detailed analyses of well, borehole, and geophysical data used to develop the geohydrologic framework of the Brewster Boulevard and Castle Hayne aquifer systems and the Tarawa Terrace aquifer; hydraulic characteristics for several geohydrologic units are tabulated; hydraulic conductivity maps are included
C	Faye RE, Anderson BA, Suárez-Soto RJ, and Sautner JB (Faye et al. 2010)	Occurrence of Selected Contaminants in Groundwater at Installation Restoration Program Sites	Detailed accounting of the occurrences of contaminants of concern and their related degradation products in groundwater at IRP sites within the service areas of the Hadnot Point and Holcomb Boulevard WTPs
D	Faye RE, Suárez-Soto RJ, and Maslia ML (Faye et al. 2012)	Occurrence of Selected Contaminants in Groundwater at Above-Ground and Underground Storage Tank Sites	Summaries of RCRA investigations with detailed accounting of the occurrence and distribution of BTEX components, such as benzene, within the soil and groundwater at selected RCRA sites within the service areas of the Hadnot Point and Holcomb Boulevard WTPs

[1]Letter designation of chapters for series, "Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina;" supplemental information sections are part of Chapter A, provided on CD–ROM

[2]See References section for complete reference citation

Figure 2. Summary of ATSDR reports on Camp Lejeune site (ATSDR, 2007; ATSDR, 2013)

Over the past years several agencies and organizations have reviewed ATSDR's studies and the outcomes that were reported by ATSDR (ATSDR, 2007; ATSDR, 2013). One review was provided by the National Academy of Sciences - National Research Council (NRC, 2009a), which was sponsored by the U.S. Department of the Navy. My contemporaneous response to this review was submitted to ATSDR on June 27, 2009, which became an internal document for ATSDR. The contents of this document is set forth in Section 7 of this report.

The government accountability office also reviewed the ATSDR studies and the NRC review. In their conclusions the following point was referenced (GAO, 2007).

- Members of the expert panel that the National Academy of Sciences convened generally agreed that many parameters of ATSDR's current study are appropriate, including the study population, the exposure time frame, and the selected health effects (GAO, 2007).

At the time (GAO, 2007), ATSDR's epidemiology studies were ongoing. Since then, these studies have been concluded. The findings of these studies are given in ATSDR epidemiology reports which are beyond my expertise area.

ATSDR study of the Camp Lejeune site also went through the critical review of an Expert Panel organized by another branch of CDC outside the EDRP/ATSDR group working on the study. The Tarawa Terrace ATSDR study underwent extensive external peer review by an expert panel of leading scientists as documented in Maslia et al. 2009 (Appendix B, P. 46, (https://www.atsdr.cdc.gov/sites/lejeune/expert-panels.html)), as was the Hadnot Point and Holcomb Boulevard study (Maslia et al., 2009; Maslia et al., 2013, P. A98). The scientists on these panels have international reputations as leaders in this field. EDRP/ATSDR program took several steps to respond and adapt to the recommendations of the Expert Panel throughout the study.

The rigorous peer review done by the ATSDR expert panels was followed with another level of peer review in the published journal articles, and a major national award by American Academy of Environmental Engineers (AAEE, 2015) which recognized the quality of ATSDR work product completed at the Camp Lejeune site. This further substantiates the general acceptance of ATSDR's modeling and reconstruction methodology in the pertinent scientific community.

As stated above, an additional level of scrutiny of ATSDR's modeling work came from publication of the Tarawa Terrace and the Hadnot Point/Holcomb studies in two separate peer-reviewed articles published in high quality Q1 (top quartile) journals as given below:

- Maslia, M.L. et al. 2009(b). "Reconstructing Historical Exposures to Volatile Organic Compound-Contaminated Drinking Water at a U.S. Military Base." *Water Quality, Exposure, and Health*. 2009, 1, 49-68.
- Maslia, M.L. et al., 2016. "Reconstructing Historical VOC Concentrations in Drinking Water for Epidemiological Studies at a U.S. Military Base: Summary of Results." *Water*. 2016, 8, 449, 1-23.

This is the summary background of the water modeling studies that have been conducted at the Camp Lejeune site by ATSDR.

4. Principles of Water Modeling and Application at Camp Lejeune

4.1 Water Modeling

In the absence of historical and continuous water quality sampling data, environmental scientists commonly rely on modeling to both predict future contaminant levels and to reconstruct historical contamination at a site. The use of modeling for historical reconstruction is an accepted methodology to predict past exposure or contamination levels, as demonstrated both in the scientific literature (Reif et al. 2003; Maslia et al., 2005; Sahmel et al., 2010) and in site specific studies such as Jacksonville, FL Naval Air Station (USGS, 2003); Tucson International Airport / Hughes Aircraft Facility (EPA, 1988); Oak Ridge National Lab (ATSDR/ChemRisk, 2000); Hanford Site (PNL, 1991); and Toms River / Dover Township (ATSDR, 2000). In its study of the Camp Lejeune site, the ATSDR created four interlinked models using scientifically valid, state of the art modeling tools that are based on fundamental groundwater flow and contaminant migration principles that are widely accepted and routinely utilized in practice for predicting contaminant movement (e.g., during natural spread or enhanced cleanup scenarios) and/or for historical reconstruction efforts such as at Camp Lejeune and other sites (Sahmel et al., 2010; Anderson et al., 2015; Bedient et al., 1999).

My opinions, within a reasonable degree of scientific and engineering certainty, on modeling techniques, their principles, and their application to the Camp Lejeune site include the following:

- Water Modeling (environmental modeling) is a science-based approach to describe and develop domain-based knowledge on contaminant migration within and across domains to understand environmental responses to natural or human perturbations.
- A scientific model (in this case Water Modeling) can be defined as an abstraction of some real system - an abstraction that can be used for decision making and management purposes. Development of a scientific model may include physical, mathematical and statistical procedures. In ATSDR studies of the Camp Lejeune site both mathematical and statistical procedures were used.
- Since all models are an abstraction of the real system, they need to be presented and analyzed in a computational or physical environment which may include an analysis of calibration, validation (section 6.7), uncertainty and variability before they are used in simulation to predict future or past conditions at a site. In ATSDR studies of the Camp Lejeune site all aspects of these computational procedures were successfully employed using computational methods.
- As such, Water Modeling is a reliable and widely accepted method of reconstructing historical contamination in natural and engineered environmental systems. Natural environmental systems may include surface, subsurface and air media; and engineered systems may include water distribution systems, constructed water ways and harbors, etc.
- Under all circumstances, trying to fit a physical system to an available off-the-shelf model approach should be avoided in water modeling. In all cases the best models that describe the system adequately should be used or developed when necessary (USEPA 2009, p. 31).
- The models and techniques used by the ATSDR for historical reconstruction, including fundamental equations, input parameters, parameter estimates, calibration, uncertainty and sensitivity analyses, were and remain reliable, scientifically valid and state of the art procedures that are consistent with standard practices used and are generally accepted in this field.
- The model results show finished water at U.S. Marine Corps Base Camp Lejeune was contaminated with varying levels of TCE, PCE, 1,2-tDCE, benzene and vinyl chloride from 1953 to 1987.

- The simulated monthly mean concentrations of TCE, PCE, 1,2-tDCE, benzene and vinyl chloride at Tarawa Terrace, Hadnot Point and Holcomb Boulevard included (tabulated or in figures) in ATSDR reports are reliable and represent, within a reasonable degree of scientific and engineering certainty, the contaminant levels in finished water at Camp Lejeune from 1953 to 1987.
- The analyses published in all ATSDR chapter reports (ATSDR, 2007; ATSDR, 2013) and supplemental information regarding Camp Lejeune (see Figure 2), including the conclusions and monthly concentration data, were all done applying proper scientific and engineering methodologies and remain to this day to be mathematically reliable, statistically accurate and correct.

4.2 Basis of Opinions

The basis of my opinions outlined in this expert report is my 50 years of work in this field and my fifteen years of Camp Lejeune related work providing technical assistance to ATSDR under a cooperative agreement established between the Centers for Disease Control and Prevention (CDC) and Georgia Tech and my fifty years of expertise and knowledge in this area of research as an educator, researcher and engineer. I have reviewed and relied on published literature, reports, historic data sources, correspondence and participation in meetings with state and regulatory agencies, participation in workshops and the review of documents provided by independent experts at these gatherings, as documented in this report (Section 8).

My opinions are based on my understanding of sound science, engineering, mathematical and statistical formulations that follow the current technology, scientific and engineering methodology that is used in archival literature.

5. Models used in ATSDR Study at Camp Lejeune

The Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Department of Health and Human Services, was requested to conduct an epidemiological study to evaluate health issues at U.S. Marine Corps Base Camp Lejeune, North Carolina. The scientific protocol on these studies received approval from the Centers for Disease Control and Prevention Institutional Review Board and the U.S. Office of Management and Budget.

Historical water contamination data needed for the epidemiological study were limited. To obtain estimates of historical exposure, ATSDR used water modeling techniques and the process of historical reconstruction of contamination levels at the base. These methods are used to quantify concentrations of contaminants in finished water at the base and to compute the level and duration of human exposure to contaminated drinking water.

Owing to the complexity, uniqueness, and the number of topical subjects included in the historical reconstruction process of each study area, several reports were prepared that provide comprehensive descriptions of information, data, and methods used to conduct historical and present-day analyses at both Tarawa Terrace (TT) and Hadnot Point–Holcomb Boulevard (HP-HB), Figure 2.

These reports provide comprehensive descriptions of modeling results used to reconstruct historical contaminant concentration levels and timing of contaminant movement at Camp Lejeune. The study represents the efforts of about 20 experts whose combined expertise from a variety of scientific and engineering disciplines spans every relevant area and specialty involved in water modeling. This body of work forms the foundation for many of the opinions I have included in this report. In this report, I am also offering a more in-depth level of detail on some of those opinions when necessary. To allow the reader the easiest access to this extensive body of work as it relates to this expert report, some of the figures and tables were copied/reproduced from these reports and included here with proper references to the source of the information.

5.1 Modeling Tools

The methods and approaches used to complete the historical reconstruction process for the Tarawa Terrace, Hadnot Point and Holcomb Boulevard study areas, the ATSDR study included the following steps of analysis:

i. Information discovery, field study, data mining and data analysis.
ii. Three dimensional, steady-state (predevelopment) and transient groundwater-flow modeling application using **MODFLOW**-2005. This study included a trial-and-error calibration of the model which also included the use of objective parameter estimation technique using **PEST-12**.
iii. Determining historical water-supply well scheduling and operations using **TechWellOp** and **PSOpS**, a sub-model developed by MESL, Ga Tech.
iv. Three-dimensional dissolved phase groundwater fate and transport modeling of VOCs using **MT3DMS**-5.3.
v. Estimating the volume of light nonaqueous phase liquid (LNAPL) released to the subsurface at the Hadnot Point Industrial Area using **TechNAPLVol**, a sub-model developed by MESL, Ga Tech.
vi. LNAPL and dissolved phase fate and transport analysis using **TechFlowMP**, a sub-model developed by MESL, Ga Tech.

vii. Reconstruction of water-supply well concentrations at the Hadnot Point landfill area using the linear control theory model (LCM) **TechControl**, a sub-model developed by MESL, Ga Tech.

viii. Computation and analysis of flow-weighted average concentrations of VOCs assigned to finished water delivered by the water treatment plants using a volumetric mass balance analysis (simple mixing).

ix. Extended period simulation of hydraulics and water quality in the water-distribution system using **EPANET 2**.

x. Probabilistic analysis of intermittent connections (1972–1985) of the Hadnot Point and Holcomb Boulevard water-distribution systems using the **TechMarkovChain**, a sub-model developed by MESL, Ga Tech.

xi. Calibration and sensitivity analysis of hydraulic and fate and transport models, and numerical-model parameters.

xii. Uncertainty analysis of model simulations.

xiii. The result of the historical reconstruction process included the estimation of monthly mean concentrations of selected VOCs in finished water distributed to Tarawa Terrace housing areas and vicinity, and for the Hadnot Point and Holcomb Boulevard study areas of Camp Lejeune served by the TTWTP, HPWTP and HBWTP.

The models and techniques used by the ATSDR to complete the historical reconstruction process for the Tarawa Terrace, Hadnot Point, and Holcomb Boulevard study areas were and remain reliable, state of the art and consistent with standard engineering practices used in the field of water modeling. The governing mathematical and statistical methods and models used in these applications are standard techniques that are used in technical literature and are well established (Anderson et al., 2015; Aral, 2010; Bedient et al., 1999, Rao, 1996).

Modeling tools (software) used for multiphase flow and multi-species transport in the subsurface and engineered systems at the site include the following public-domain applications developed by the US government agencies:

- The **MODFLOW**-2005.5 application, a three-dimensional finite-difference groundwater-flow model developed by the U.S. Geological Survey (USGS) that is used in groundwater modeling, (https://igwmc.princeton.edu/modflow/).

- **MT3DMS**, a public domain application developed by USGS. **MT3DMS** is a three-dimensional multi-species solute transport model used for solving advection, dispersion, and chemical reactions of contaminants in saturated groundwater flow systems. **MT3DMS** interfaces directly with the U.S. Geological Survey finite-difference groundwater flow model **MODFLOW** for the groundwater flow solution and supports the hydrologic and discretization features of **MODFLOW**. **MT3DMS** contains multiple transport solution techniques in one code, which can often be important, including for model calibration. (https://pubs.usgs.gov/publication/70189204).

- The **HSSM.5** application, a one-dimensional semi-analytical model developed by the U.S. Environmental Protection Agency to estimate volume of spills at contaminated sites. (https://www.epa.gov/water-research/hydrocarbon-spill-screening-model-hssm).

- Developed by USEPA, **EPANET** application is a software application that is used throughout the world to model water distribution systems. It was developed as a tool for understanding the movement and fate of drinking water constituents within water distribution systems and can be used for many different types of applications in water distribution systems analysis. It can also be used to model contamination threats and evaluate resilience to security threats or natural disasters relevant to water distribution systems. (https://www.epa.gov/water-research/epanet).

The applications listed above are all in the main core of tools used in the ATSDR studies of the Camp Lejeune site. They are all accepted methodologies and software that were used in similar studies at other sites by government agencies and consulting firms.

In addition to the above listed standard applications used in the water modeling field, ATSDR needed to investigate in more detail some of the questions that were raised by the expert panel convened by ATSDR/CDC. For that purpose, MESL research program capabilities were used to supplement the main core applications described above.

These supportive (sub-model) applications used in the ATSDR study of the Camp Lejeune site include:

- The **TechFlowMP** application is a multiphase flow and multispecies contaminant transport model developed in MESL studies (Jang, W. and Aral, MM, 2005; Jang, W. and Aral, MM, 2007; ATSDR 2007h; Jang, W. and Aral, MM, 2008: a, b; Jang, W. and Aral, MM, 2011). In **TechFlowMP** model the coupled equations for flow of water, gas, and NAPL phases and transport of multispecies contaminants in saturated and unsaturated subsurface systems and heat energy transport were formulated and analyzed. To solve those equations, a three-dimensional finite element numerical model (software) was developed. The origin of these studies at MESL research program dates to 1997. **TechFlowMP** model has been verified using analytical solutions and experimental data that are published and available in the literature. To investigate the fate and transport of VOCs in the subsurface, the model was used in conducting numerical analysis on the following other topics in other MESL studies: (i) multiphase flow and contaminant transport in subsurface environments; (ii) biological transformations of contaminants in multiphase environments; (iii) in-situ air sparging analysis (IAS); and, (iv) thermally enhanced venting (TEV) that is used in contaminated groundwater treatment processes. In these numerical studies, the **TechFlowMP** model successfully simulated the migration of contaminants between phases and between the unsaturated/saturated zones of a subsurface system, the dynamic movements of gas phases in the unsaturated zone, and remedial processes under in-situ air sparging (IAS) and thermally induced remediation (TEV) studies of the MESL program.

  This application was used to explore saturated and unsaturated zones and vapor phase contaminant distributions at the Camp Lejeune site. It also served the purpose of independent reconfirmation of the predictions of the calibrated multiphase subsurface models used by ATSDR at the Camp Lejeune site as described above (Figure 11). The ATSDR water modeling team first utilized the **MODFLOW** and **MT3DMS** codes in its groundwater simulations and analysis at the Camp Lejeune site. These two models are widely accepted public domain codes that have been tested and verified in other studies and are universally used in the modeling field for the analysis of groundwater flow and fate and transport of contaminants in subsurface systems (see above cited web sites). In addition to these studies, to enhance the understanding of conditions at the site, ATSDR extended its analysis. The ATSDR water modeling team applied the **TechFlowMP** software to understand and evaluate the unsaturated zone injection and migration conditions at the site. **TechFlowMP** is a public domain code that can be accessed from the Georgia Tech website for individual use (http://mesl.ce.gatech.edu/, MESL 2017).

The **TechFlowMP** code has been tested and verified against other applications in the literature. The details of verification analysis developed for **TechFlowMP** model can be found in the following references (Jang, W. and Aral, MM, 2005; Jang, W. and Aral, MM, 2007; ATSDR 2007h; Jang, W. and Aral, MM, 2008: a, b; Jang, W. and Aral, MM, 2011). This list of peer reviewed publications provides detailed information on the verification of this model in subsurface application. The application of the **TechFlowMP** model to Camp Lejeune site and calibration, sensitivity and reliability analysis can be found in the references (ATSDR, 2007g; ATSDR, 2013a) and in, http://mesl.ce.gatech.edu/PUBLICATIONS/Publications.html).

- The **TechNAPLVol** sub-model: This is a spilled LNAPL volume estimation model which is based on the USEPA **HSMM.5** analysis mentioned above. In this case the USEPA **HSSM.5** procedures are extended to three-dimensional analysis and used to estimate the volume of spilled BTEX compounds at the Camp Lejeune site.

  For the overall project, the area of interest was the entire Hadnot Point–Holcomb Boulevard (HPHB) study area (Figures A1 and A12 in ATSDR, 2013a, Figure 1). The focus for the modeling and analyses of LNAPL volume estimates is in an area of the Base designated as the Hadnot Point Industrial Area (HPIA). Various fuels, solvents, and other chemicals were stored, used, and inadvertently released to the environment during routine operations at the HPIA. Of particular interest in this study was the historical presence and subsequent fate and transport of subsurface light nonaqueous phase liquid (LNAPL) associated with fuel storage system releases at the HPIA. Results from the analyses are integrated with the results from other models and approaches as a part of the overall project objective to produce estimates and uncertainty bounds for the concentration of contaminants over time in selected water-supply wells and water-distribution systems.

  The objectives of the LNAPL volume estimate analysis were to:

  i. Investigate the migration and distribution of fuel-related LNAPL released into the unsaturated zone above a shallow aquifer for a hypothetical scenario.
  ii. Estimate the volume and distribution of LNAPL in the subsurface at the HPIA using historical field data for LNAPL (free product) thicknesses measured over time in site monitoring wells; and,
  iii. Analyze the dissolution of benzene and total xylenes from the LNAPL source areas and the subsequent dissolved phase fate and transport of these contaminants under unsteady hydrologic and variable water supply well pumping conditions in the underlying groundwater system at the HPIA.

  The purpose of the hypothetical scenario used is to illustrate and explore the behavior of LNAPL in a multiphase environment and provide insight about the potential variability of results involving LNAPL movement. LNAPL movement is just one component of the overall fate and transport process for the applied analysis at the HPIA. For the HPIA analysis, LNAPL movement and estimates of LNAPL distribution in soil were also integrated with the **TechFlowMP** model including the LNAPL dissolution process and subsequent transport of the dissolved phase contaminants in the groundwater. The goal of the integrated analysis is to evaluate contaminant arrival over time at water-supply wells in the area.

The **HSSM** and **TechFlowMP** models were used in parallel to investigate the migration of LNAPL in the unsaturated zone and at the water table and to explore the distribution of LNAPL saturation in soil over time. Using LNAPL thickness data measured in monitoring wells, the **TechNAPLVol** model code was used to estimate the spatial distribution of LNAPL saturation and the volume of LNAPL in a three-dimensional subsurface domain within the HPIA. The **TechFlowMP** model used saturation profiles from the LNAPL analysis as a starting point for modeling the dissolution of benzene and total xylenes from free-phase LNAPL and the subsequent fate and transport of dissolved phase benzene and total xylenes in the underlying groundwater system.

Technical details of this analysis which follows the USEPA methods of analysis (Farr et al, 1990; USEPA, 1986) are given in (ATSDR, 2013, Chapter A–Supplement 7), Figure 3. This approach is used in ATSDR study to estimate volume of spilled contaminants at the Camp Lejeune site. As indicated in the ATSDR study reports the results confirm the observed data at the site (ATSDR, 2013a, Tables A15, A16). These comparisons are given in Figure 3.

Table A15. Estimates of fuel loss, free product in the subsurface, and fuel recovery at the Hadnot Point Industrial Area fuel farm, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[USMCB, U.S. Marine Corps Base; HPFF, Hadnot Point fuel farm; ATSDR, Agency for Toxic Substances and Disease Registry]

Type of estimate	Volume, in gallons	Reference
	Fuel-loss estimates	
USMC documentation of known release from underground fuel line in 1979	20,000–50,000	Water and Air Research, Inc. (1983)
USMC documentation of known fuel releases and inventory losses during 1979–1987	23,150–33,150	O'Brien and Gere Engineers, Inc. (1988, 1990), CH2M HILL (2001)
	Model-derived estimates	
[1]SpillCAD™ model estimate of free product (LNAPL) in the subsurface using free product measurements collected during 1988–1995	830,324–1,061,901	UST Management Web Portal Files (2010–2012)[2]
Order-of-magnitude estimate of total fuel in the subsurface based on available documentation as of 2001 (specific methodology not described)	400,000–1,100,000	CH2M HILL (2001)
	Fuel recovery estimate	
Reported total fuel recovery from HPFF/Building 1115 area remediation systems as of July 2010	414,118	[3]USMCB Camp Lejeune (July 2010)

[1]SpillCAD™ was developed by Environmental Systems & Technologies (1993)

[2]Draft report by Baker Environmental, Inc., contained in UST Management Web Portal File #01185, p. 526–562

[3]From information presented at the ATSDR-DON Data Mining & Discovery Technical Work Group Meeting, USMCB Camp Lejeune, July 21–22, 2010

Table A16. Estimated volumes of light nonaqueous phase liquid in the subsurface, using semi-analytical solutions and numerical integration, Hadnot Point Industrial Area fuel farm, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.[1]

[1]Method and model (scheme number)	[2]Light nonaqueous phase liquid (LNAPL) volume, in gallons		
	Minimum	Maximum	Mean
[3]Analytical solution using depth of LNAPL in wells; TechNAPLVol model; (Scheme 1)	939,000	1,408,000	1,174,000
Numerical integration of three-dimensional domain using LNAPL depth in wells (apparent thickness); TechNAPLVol model; (Scheme 2)	939,000	1,409,000	1,174,000
Numerical integration of three-dimensional domain using LNAPL depth in soil (actual thickness); TechNAPLVol model; (Scheme 3)	1,079,000	1,618,000	1,348,000

[1]Results listed are a summary of multiple simulation scenarios. Refer to Jang et al. (2013) for details and descriptions of each scheme; see Jang et al. (2013, Tables S7.6 and S7.7) for full range of results and seven different simulation scenarios; also see Jang et al. (2013, Figure S7.12)

[2]Volumes reported are for fresh gasoline; for aged gasoline, minimum volumes increase about 20 percent

[3]Analytical solution derived by Farr et al. (1990)

Figure 3. Spill volumes reported by other agencies (Table A15, pp. A49, ATSDR, 2013a) and Spill volumes estimated by **TechNAPLVol** application (Table A16, pp. A50, ATSDR, 2013a)

- The **Pumping Schedule Optimization System, PSOpS** sub-model: To complement ATSDR's historical contamination reconstruction studies, the pumping schedule variation analysis was conducted to describe the effect of groundwater pumping schedule variations on the arrival times of Tetrachloroethylene (PCE) and other by-products at water-supply wells and the water treatment plant (WTP).

  During the historical reconstruction study, the groundwater flow and fate-and-transport of contaminants in the Tarawa Terrace area of the Camp Lejeune base and its vicinity have been simulated to evaluate the contaminant concentration in the WTP. Due to the uncertainty residing in the reconstructed input data used in these simulations, uncertainty may be present in the simulated contaminant concentrations in the water-supply wells and the WTP, and hence in the times for contaminant concentrations to reach the maximum contaminant level (MCL) at these locations. A contributor to this uncertainty is the uncertainty in pumping schedules used in the ATSDR model, therefore, in this study the focus was on the uncertainty associated with the pumping schedules. The study included the development of a simulation and optimization (S/O) procedure identified as **PSOpS** (**P**umping **S**chedule **Op**timization **S**ystem), which combines field data, simulation models and optimization techniques to optimize the pumping schedules to identify maximum or minimum contaminant concentrations in the WTP consistent with the reported pumping schedules. Based on the optimized pumping schedules, variations of PCE concentration and the maximum contaminant level (MCL, PCE) arrival time at water-supply wells and the WTP were evaluated (Wang and Aral, 2008).

  The MESL-Georgia Tech research group developed **PSOpS** sub-model, an optimization application to yield answers to specialized uncertainty-related question raised by the ATSDR Expert Panel (March 2005) (https://www.atsdr.cdc.gov/sites/lejeune/expert-panels.html). The analysis is based on the **MODFLOW** family of codes in the generation of the database used to solve an optimization problem. The question ATSDR Expert Panel members raised in this case was related to the uncertainty of a pumping-schedule operation that may be implemented at the site and the characterization of its effects on the study outcome. The **PSOpS** model that was developed for the purposes of this analysis and used in the ATSDR water modeling study to address this question became part of the peer reviewed PhD thesis of a graduate student at Georgia Tech. The detailed documentation of this model, which uses the principles of optimization (Rao, 1996) can be found in the PhD thesis of Dr. J. Wang, which is public domain information (Wang, 2008). The overall methodology that used these applications are set forth in detail in the series of reports published by ATSDR, (ATSDR, 2007a, h; ATSDR, 2013a and S2).

- The **TechMarkovChain** sub-model: As described earlier (see Section 3), the Tarawa Terrace WTP was closed in March 1987 due to contamination. During this period, Hadnot Point WTP supplied water to the Hadnot Point area, and Holcomb Boulevard WTP supplied water to the Holcomb Boulevard and Tarawa Terrace base housing areas. The Holcomb Boulevard water-distribution system is connected to the Hadnot Point water-distribution system at the Marston Pavilion valve and at booster pump 742. While booster pump 742 was removed during 2007, the two systems can still be interconnected by opening a valve that exists at the same location based on water demand conditions. For operational reasons, the two water-distribution systems were occasionally connected (depending on water demand)—exceptions being connections that occurred during late spring and summer months of 1972–1986 and a continuous 8-day period of 28 January to 4 February 1985 (ATSDR, 2007a, ATSDR, 2013 S8). Because the information pertaining to times when interconnection events occurred is limited and for some years unknown (e.g., 1972–1977, Figure S8.37; ATSDR, 2013), a Markov process (Ross, 1997) was applied by using available field data and information to estimate the probability and number of monthly interconnection events that occurred during the months of April–August for 1972–1985.

A Markov process (a stochastic process) analyzes the tendency of one event to be followed by another event based on the data available on a sequence of events during a calibration period. By using this analysis, one can generate a new sequence of random but related events, which will be statistically correlated to the original calibration data. The stream of events generated is called a Markov Chain.

In this study, a probabilistic approach based on Markov Chain simulations was used to estimate the yearly numbers of booster pump/valve openings. For the calculation of transition probabilities of this Markov Chain model, the conditional probabilities of transfer events given the temperature, precipitation, or delivered finished-water volume value in a day were calculated using Kernel density estimator and Bayes' theorem. Also, the probabilities of transfer were conditioned on the values of pairs of parameters by using the Copula concept. The Markov analysis first estimates the number of historical booster pump opening events on a yearly basis. Next, the numbers of events are distributed among the dry months (April–August) during each year. Graphical techniques and data analyses (of daily recordings of temperature, precipitation, and raw-water volume in the HBWTP) were then used to estimate the occurrence of daily finished-water transfers during individual months. Table S8.20 (ATSDR, 2013, S8) lists the number of recorded interconnection events, and the number of monthly events predicted by using a Markov Chain analysis for the period 1972–1985.

This methodology is an efficient and effective way of utilizing the available data to predict the number of booster pump/valve openings monthly (Ross, 1997; Rao, 1996). The results show that predictions made using the Markov methodology analysis are statistically correlated and mimic the historical operations within a statistical confidence interval (Table S8.20, ATSDR, 2013, S8). These outcomes are used in contaminant fate and transport simulations for the Holcomb Boulevard and Hadnot Point water-distribution systems in ATSDR study. The details of the Markov analysis methodology are given in Appendix S8.4 (ATSDR, 2013a, S8).

- **TechControl** sub-model: A linear control theory model and software developed by MESL, Ga Tech. It is used to address the question of the application of simpler models to predict contaminant concentrations at certain locations of the Camp Lejeune site (HPLF) (ATSDR,2013, S5). The development of the software was based on a request that was initiated by the ATSDR Expert Panel of scientists (Expert Panel 2005) (https://www.atsdr.cdc.gov/sites/lejeune/expert-panels.html).

- The **Linear Control Theory**, **LCT** analysis**:** Linear Control Theory is a scientific methodology of the field of control engineering and applied mathematics. The methodology deals with the control of dynamical systems in engineered processes. In the case of ATSDR study of the Camp Lejeune site, the methodology was applied to groundwater contaminant transport analysis as a simple application to predict concentration values at a specific point in space and time based on limited data available at the site (ATSDR,2013, S5). This study was requested by the expert panel (Expert Panel 2005) which reviewed the ATSDR Camp Lejeune site study and provided scientific advice.

- The **TechWellOp** sub-model**:** A subsurface pumping well estimation model and software developed by MESL, Ga. Tech. The methodology uses the daily data in the Training Period to determine the monthly operational behavior of the water supply wells at the Camp Lejeune site that would satisfy the total water volume delivered to the water treatment plants. Once the average monthly working days in the Training Period are estimated for each calendar month, they are utilized in the prediction stage which is based on the same principle of satisfying the total monthly flow delivered to the treatment plant at those periods. This methodology is an efficient and effective way of integrating the available data in recent years to the prediction process for the past years. The development of the software was based on a discussion that was initiated by the ATSDR Expert Panel of scientists (Maslia, et al., Expert Panel 2005, ATSDR, 2007a; ATSDR, 2013, S2).

The use and application of specialized codes to address specific problems that standard codes such as **MODFLOW** and **MT3DMS** cannot address is an accepted methodology. As stated in the U.S. Environmental Protection Agency report, "Guidance on the Development, Evaluation, and Application of Environmental Models" (USEPA 2009, p. 31): "However, the Agency acknowledges there will be times when the use of proprietary models provides the most reliable and best-accepted characterization of a system." The point being made in this statement is that the most appropriate model should be applied to characterize a system, not necessarily, the most popular or often-used off-the-shelf models. This is the modeling philosophy and approach that ATSDR took when applying the **TechFlowMP**, **TechNAPLVol, TechWellOp, TechControl**, **TechMarkovChain** and **PSOpS** models that were used at the Camp Lejeune site.

5.2 Multimedia Environmental Simulation Laboratory (MESL) involvement in the ATSDR study

In Figure A2, the first in Figure 4 below (ATSDR, 2007; ATSDR, 2013), the components of the Tarawa Terrace modeling study are shown. The red arrows on this figure indicate the areas where the MESL team was involved, and the yellow arrows indicate where the MESL team provided an oversight of the study components. In Figure A2, the second in Figure 4 below (ATSDR, 2007; ATSDR, 2013), the components of the Hadnot Point – Holcomb Boulevard modeling study are shown. The red arrows on this figure indicate the areas where the MESL team was involved, and the yellow arrows indicate where the MESL team provided an oversight of the study components.

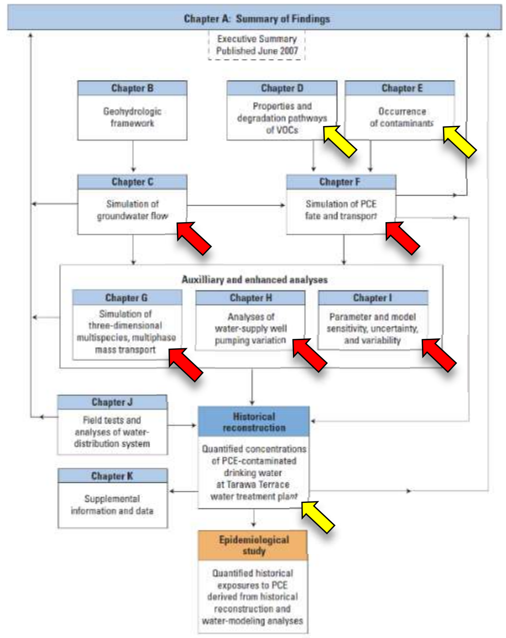

Figure A2. Relation among Chapter A report (Summary of Findings), Chapters B–K reports, historical reconstruction process, and the ATSDR epidemiological case-control study, Tarawa Terrace and vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina. [VOCs, volatile organic compounds; PCE, tetrachloroethylene]

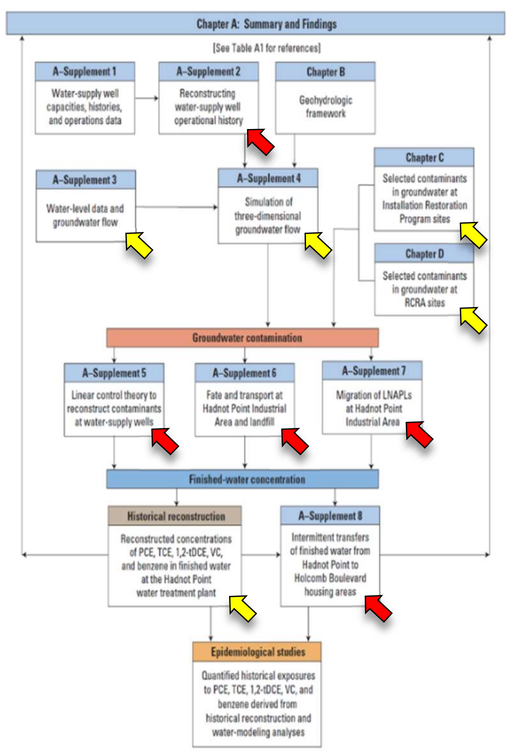

Figure A2. Relation among Chapter A report (Summary and Findings), Chapter A supplements (1–8), Chapters B–D reports, historical reconstruction process, and the ATSDR epidemiological studies, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina. [RCRA, Resource Conservation and Recovery Act of 1976; LNAPL, light nonaqueous phase liquid; PCE, tetrachloroethylene; TCE, trichloroethylene; 1,2-tDCE, *trans*-1,2-dichloroethylene; VC, vinyl chloride]

Figure 4. MESL involvement in ATSDR modeling tasks at TT and HP/HB Camp Lejeune site (ATSDR, 2007; ATSDR, 2013)

6. Evaluation of ATSDR Camp Lejeune Study Results

6.1 Environmental Modeling Processes used in ATSDR Study

A scientific model can be defined as being an abstraction of some real system - an abstraction that can be used for prediction and management purposes. Thus, the purpose of a scientific model is to make some predictions on the modeled system. While making these predictions, a scientific model also enables the analyst to determine how one or more changes in various aspects of the modeled system may affect the other aspects of the system, the system itself, and the results predicted, in a cost-effective manner. Because models are an abstraction of the real system and cannot be a complete depiction of the real system, they need to be presented and analyzed in a computational environment which includes an analysis of uncertainty, variability, calibration and validation.

Uncertainty analysis may take the form of sensitivity analysis, or for more complicated applications, statistical uncertainty analysis may be utilized. It is important to distinguish the difference between the terms “uncertainty” and “variability.” As expected, they refer to two different and distinct concepts (Aral, 2010).

Uncertainty is a measure of knowledge of the magnitude of a parameter. Thus, uncertainty can be reduced by further research, i.e. the parameter value can be refined through further experimentation or further data collection. Variability on the other hand is a measure of the heterogeneity of a parameter, event or the inherent variability in a chemical property at a site. Variance cannot be reduced by further research, but a model can be developed such that it would mimic the variability of the parameter or event used in the model. Statistical variability analysis is a common approach used in modeling studies to envelope these variations at a site and understand its effects on the outcome. This analysis provides some degree of confidence in model output.

Models include parameters that need to be associated with values. These parameter values are used as input to mathematical models to produce numerical output. Ideally, these parameters should have a good definition and a physical basis for the environmental system under study. Usually, these parameters either are calculated using the mathematical representation of their physical basis, or they are measured in field or laboratory studies. Often, however, the values of these parameters are unknown or only known approximately. Thus, a range of these parameters can be input into a model to yield the best outcome when compared to an observation made in a field or laboratory study. Appropriate values of the parameters are needed in the model to achieve the appropriate output that is observed at a site. Thus, calibration of models is necessary. Calibration of a model can then be defined as the stage where we adjust the parameters of the mathematical model such that the model agreement is maximized with respect to the observation data we have on the modeled system output. In this sense, model calibration is fine tuning the model to a set of parameter data on the modeled system. Calibration procedures used in the ATSDR study for all models considered adhere to the standards used in the technical literature (Bedient, 2003; Anderson, 2015, Mei 2023).

The calibration process followed by validation of complex systems is another important aspect of model development and use as it is implemented in ATSDR studies. The seemingly complex definitions of these two terms may get further complicated when several models are used in environmental applications where overlapping models are necessary to describe the behavior of the complex system. In complex system analysis several interlinked modeling phases are used to describe the behavior of the system modeled. Thus, as a typical example, the calibration and validation procedures used in a simple steady state groundwater modeling application will be different than an interlinked study of a complex system. A complex system may include a steady/unsteady groundwater flow model that is linked to a transient contaminant transport model which is further linked to a water treatment plant condition that is linked to a water distribution system analysis. Since these phases are not independent and occur within the same envirosphere and time frame of analysis, one should not ignore the integrated calibration and validation processes involved in these applications. In complex systems the interlinked behavior of the models used is the key response that is in question which is sometimes ignored, overlooked or not properly understood. The ATSDR study of the Camp Lejeune site represents such a complex system where steady groundwater flow, unsteady groundwater flow, unsteady multispecies multiphase contaminant transport and the engineered water treatment and water distribution system applications are all components of the same envirosphere and operate within the same time frame. As such, calibration and validation processes should be considered as interlinked processes.

Having described the definition of the calibration process above, validation is another contended modeling concept that was and still is debated in scientific literature. For example, in Konikow and Bredehoeft (1992) it is stated that: "Ground-water models are embodiments of scientific hypotheses. As such, the models cannot be proven or validated, but only tested and invalidated," or "…The absolute validity of a model can never be determined" (NRC, 1990). This is partly a semantic issue and partly a philosophical one. In the main text of this report, I will not go into the details of the philosophical discussions on this subject although I believe they have merit within the context the authors describe the process in their scientific discussions. However, I will evaluate this process within the context of complex systems analysis in Section 6.7 of this expert report to bring clarity to the definition of this process as it is used in the Camp Lejeune study. In this expert report I will adopt the standard (traditional) definition of validation of a model. In traditional definition, validation is understood as a process that results in an explicit statement about the behavior of a model in an application. That is, the common definition of validation is the demonstration that a model, within its domain of applicability, possesses satisfactory accuracy consistent with the intended application of the model (Sargent, 1984; Curry et al., 1989; Konikow and Bredehoeft, 1992). This demonstration builds confidence in the model and indicates that the model is acceptable for use. As such, validation procedures used in the ATSDR study for all models considered adhere to the standards used in technical literature (Aral, 2010, Bedient, 2003; Anderson, 2015, Sargent, 1984; Curry et al., 1989; Konikow and Bredehoeft, 1992; Mei, 2003).

The calibration, validation, uncertainty and sensitivity analysis concepts used in the ATSDR study are clearly described on page 23 of Chapter A report (ATSDR, 2007a; Fig. A9) Figure 5. In these definitions, the hierarchical approach to calibration and validation is conceptually described in terms of the Venn or set diagrams (Borowski and Borwein 1991), Figure 5. Such diagrams are useful for showing logical relations between sets or groups of like items and are shown in Figure A9 for each hierarchical calibration level. What is meant by this description is that at level 1 (Figure *A9a, Figure 5),* there may be many combinations of parameters that yield solutions to the predevelopment groundwater-flow calibration conditions. However, only a smaller set of these feasible solutions, the subset of solutions indicated by circle "A" in Figure A9a yields an acceptable combination of parameters for a calibrated transient groundwater flow condition. Viable solutions are indicated by circle "B" (Figure *A9b*, ATSDR, 2007a), Figure 5*.* Only those solutions that successfully simulate both predevelopment and transient groundwater flow conditions can be accepted and classified as resulting in calibrated transient and predevelopment groundwater flow models. As such, the next level modeling used not only serves as the independent validation of the previous level application, but it is also used in the iterative recalibration process of the previous system if validation process does not yield satisfactory outcome. Similarly, the next level of modeling phase, which is the transient contaminant transport analysis serves as the next independent validation of groundwater flow models, but it is also used in the recalibration of the complete system up to that stage. Thus, in all levels, the last level serves as an independent validation of the previous level and sometimes necessitates the recalibration of all the previous system levels. This is an important distinction which needs to be considered in complex system analysis and modeling as opposed to simple modeling applications.

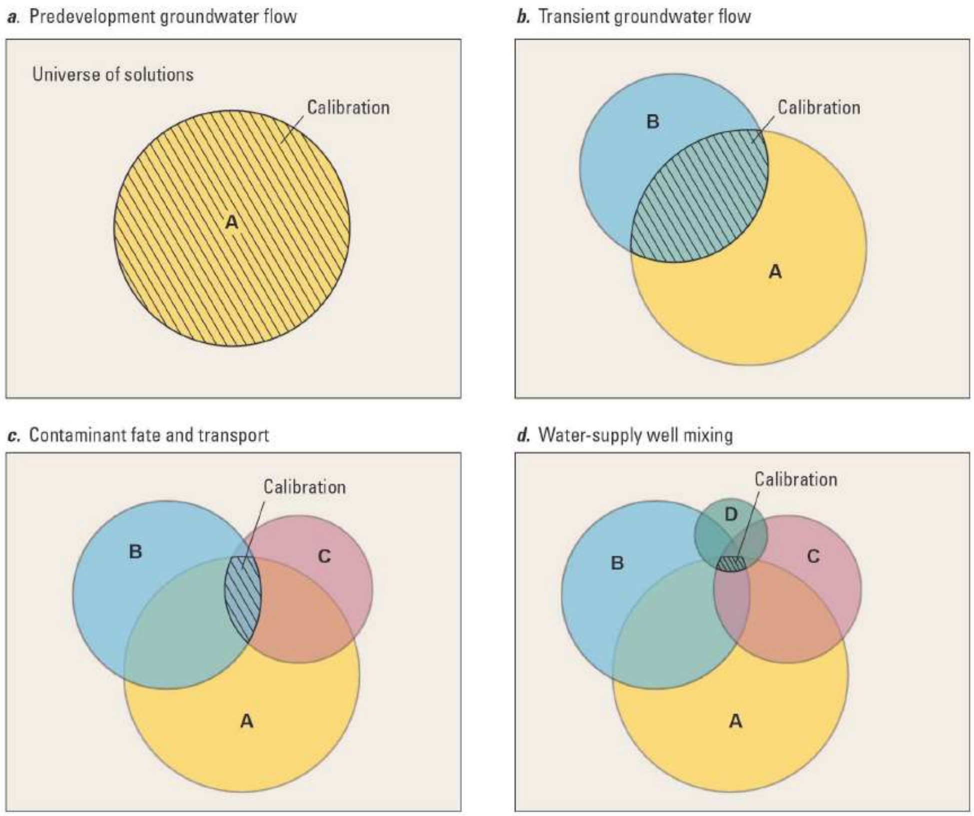

Figure A9. Venn diagrams showing hierarchical approach of model calibration used to estimate concentration of finished water: *(a)* predevelopment groundwater flow, *(b)* transient groundwater flow, *(c)* contaminant fate and transport, and *(d)* water-supply well mixing, Tarawa Terrace and vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina.

Figure 5. Venn diagram representations (Figure A9, page A23, ATSDR, 2007a)

The ATSDR study of the Camp Lejeune site falls into the category of a “Complex System” as defined above. Thus, iterative calibration and validation of all models used in the ATSDR study adhere to the standards used in the technical literature within the concept of complex system analysis (Aral, 2010).

It is my opinion that these concepts are properly and successfully developed and employed in the models that are used in ATSDR studies for the Camp Lejeune site (ATSDR, 2007a; ATSDR, 2013a).

6.2 Contaminants Studied at the Camp Lejeune Site

The specific VOCs that ATSDR studied at the Camp Lejeune site (TT, HP-HB sites), include:

- trichloroethylene (TCE),
- tetrachloroethylene (PCE),

- *trans* 1,2-dichloroethylene, (1,2-tDCE),
- vinyl chloride (VC), and
- benzene or BTEX compounds.

Trichloroethylene: Trichloroethylene (TCE) is a volatile, colorless liquid organic chemical. TCE does not occur naturally in the environment and is created by chemical synthesis. It is used primarily to make refrigerants and other hydrofluorocarbons and as a degreasing solvent for metal equipment. TCE is also used in some household products, such as cleaning wipes, aerosol cleaning products, tool cleaners, paint removers, spray adhesives, carpet cleaners and spot removers. Commercial dry cleaners also use trichloroethylene as a spot remover. (extracted from: https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/trichloroethylene).

Tetrachloroethylene: Tetrachloroethylene is a nonflammable colorless liquid. It is widely used for dry cleaning of fabrics; hence it is sometimes called "dry-cleaning fluid". It also has its uses as an effective automotive brake cleaner. Other names for tetrachloroethylene include perchloroethylene, PCE, PERC, tetrachloroethene, and perchlor. (extracted from: https://en.wikipedia.org/wiki/Tetrachloroethylene).

Trans-1,2-dichloroethylene: Trans-1,2-dichloroethylene is a colorless liquid, with a sharp, harsh odor, and is highly flammable. The primary uses for trans-1,2-dichloroethylene are as a solvent in processing and in formulations for cleaning and degreasing.

Vinyl chloride: Vinyl chloride is a colorless gas that burns easily. It does not occur naturally and must be produced industrially for its commercial uses. Vinyl chloride is used primarily to make polyvinyl chloride (PVC), a hard plastic resin used to make a variety of plastic products, including pipes, wire and cable coatings, and packaging materials (extracted from: https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/vinyl-chloride).

BTEX: A group of VOCs, collectively known as BTEX, comprising benzene (**B**), toluene (**T**), ethylbenzene (**E**) and xylene (**X**) (often expressed as total xylenes) are important industrial solvents and frequently encountered in petroleum products.

Benzene: Benzene is a colorless or light-yellow liquid chemical at room temperature. It is used primarily as a solvent in the chemical and pharmaceutical industries, as a starting material and an intermediate in the synthesis of numerous chemicals, and in gasoline. Benzene is produced by both natural and man-made processes (extracted from: https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/benzene).

The contamination conditions based on these chemicals at the Tarawa Terrace, Hadnot Point and Holcomb Boulevard areas will be examined in more detail in the following sections of this expert report.

6.3 Contaminants Observed at the Camp Lejeune Site

Contamination vs *Pollution* are two synonymous terms that are commonly used in technical literature and in the common language that is associated with environmental studies and health risk analysis. Contamination that is present in the environment at low concentrations and thus does not cause adverse environmental or health effects should not be confused with pollution. It is when these contaminant levels exceed a certain threshold and cause health effects is of concern in health studies. When that happens, contaminants at a site are classified as environmental pollution (Meharg, 2005; Aral, 2010).

In this context it is important to reference the reported (observed) PCE concentrations in water supply wells in Tarawa Terrace study area reports. In Table A9, page A27, we see the elevated PCE concentrations in water supply wells (ATSDR, 2007a), Figure 6. In this table, the numbers in the fourth column are all observed PCE levels in water supply wells; the MCL level for PCE is 5 μg/L.

Table A9. Summary of model-derived values and observed data of tetrachloroethylene at water-supply wells, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.[1]

[PCE, tetrachloroethylene; μg/L, microgram per liter; J, estimated; ND, nondetect]

Model-derived value		Observed data				
Month and year	**PCE concentration, in μg/L**	**Sample date**	**PCE concentration, in μg/L**	**Detection limit, in μg/L**	**Calibration targets[2], in μg/L**	**Sample number[3]**
		Supply well TT-23				
January 1985	254	1/16/1985	132	10	41.7–417	1
February 1985	253	2/12/1985	37	10	11.7–117	2
February 1985	253	2/19/1985	26.2	2	8.3–82.9	3
February 1985	253	2/19/1985	ND	10	1–10	4
March 1985	265	3/11/1985	14.9	10	4.7–47.1	5
March 1985	265	3/11/1985	16.6	2	5.2–52.5	6
March 1985	265	3/12/1985	40.6	10	12.8–128	7
March 1985	265	3/12/1985	48.8	10	15.4–154	8
April 1985	274	4/9/1985	ND	10	1–10	9
September 1985	279	9/25/1985	4J	2	1.3–12.6	10
July 1991	191	7/11/1991	ND	10	1–10	11
		Supply well TT-25				
February 1985	7.3	2/5/1985	ND	10	1–10	12
April 1985	9.6	4/9/1985	ND	10	1–10	13
September 1985	18.1	9/25/1985	0.43J	10	0.14–1.4	14
October 1985	20.4	10/29/1985	ND	10	1–10	15
November 1985	22.8	11/4/1985	ND	10	1–10	16
November 1985	22.8	11/12/1985	ND	10	1–10	17
December 1985	25.5	12/3/1985	ND	10	1–10	18
July 1991	72.7	7/11/1991	23	10	7.3–72.7	19
		Supply well TT-26				
January 1985	804	1/16/1985	1,580.0	10	500–4,996	20
January 1985	804	2/12/1985	3.8	10	1.2–12	21
February 1985	798	2/19/1985	64.0	10	20.2–202	22
February 1985	798	2/19/1985	55.2	10	17.5–175	23
April 1985	801	4/9/1985	630.0	10	199–1,992	24
June 1985	799	6/24/1985	1,160.0	10	367–3,668	25
September 1985	788	9/25/1985	1,100.0	10	348–3,478	26
July 1991	670	7/11/1991	350.0	10	111–1,107	27
		Supply well TT-30				
February 1985	0.0	2/6/1985	ND	10	1–10	28
		Supply well TT-31				
February 1985	0.17	2/6/1985	ND	10	1–10	29
		Supply well TT-52				
February 1985	0.0	2/6/1985	ND	10	1–10	30
		Supply well TT-54				
February 1985	6.0	2/6/1985	ND	10	1–10	31
July 1991	30.4	7/11/1991	ND	5	1–5	32
		Supply well TT-67				
February 1985	4.1	2/6/1985	ND	10	1–10	33
		Supply well RW1				
July 1991	0.0	7/12/1991	ND	2	1–2	34
		Supply well RW2				
July 1991	879	7/12/1991	760	2	240–2,403	35
		Supply well RW3				
July 1991	0.0	7/12/1991	ND	2	1–2	36

[1]Model-derived values for water-supply wells based on simulation results obtained from the fate and transport model MT3DMS (Zheng and Wang 1999); see the Chapter F report (Faye In press 2007b) for details

[2]Calibration targets are ±½-order of magnitude for observed data; when observed data are indicated as ND, upper calibration target is detection limit and lower calibration target is 1 μg/L

[3]See Figure A11

Figure 6. The reported (observed) PCE concentrations at the Tarawa Terrace study area water supply wells (column four Table A9, page A27, Tarawa Terrace site, ATSDR, 2007a.)

Similarly, the reported (observed) TCE, PCE, 1,1-DCE, 1,2-tDCE, 1,2-cDCE, Total 1,2-DCE, and VC concentrations at Hadnot Point – Holcomb Boulevard study area are given in Figure 7. In this table, the numbers highlighted in red are all observed levels that are above the detection limits for the compound identified in the header of the table; the MCL level for TCE and PCE is 5 μg/L.

Table A4. Water-supply wells with reported detections of tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), *trans*-1,2-dichloroethylene (1,2-tDCE), *cis*-1,2-dichloroethylene (1,2-cDCE), total 1,2-dichloroethylene (total 1,2-DCE), or vinyl chloride (VC), Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.[1]

[<, constituent is less than the detection limit. Number following the "<" is the detection limit; —, constituent concentration not determined in laboratory analysis; ND, constituent not detected; J, estimated concentration; D, sample diluted for analysis]

Well name	Sample date	[2]Concentration, in micrograms per liter						
		PCE	TCE	1,1-DCE	1,2-tDCE	1,2-cDCE	Total 1,2-DCE	VC
HP-602	7/6/1984	<1.9	<1.4	<1.3	7.8	—	—	<0.9
	11/30/1984	24	1,600	2.4J	630	—	—	18
	12/10/1984	<500	540	<500	380	—	—	<500
	12/13/1984	3.2	300	—	110	—	—	—
	12/14/1984	<50	340	<50	230	—	—	<50
	2/4/1985	1.5J	38	<10	74	—	—	<10
	11/12/1986	<4.1	2.2	<2.8	14	—	—	<4.9
	1/22/1991	<5.0	0.7J	<5.0	—	—	12	<10
HP-603	12/4/1984	<10	4.6J	<10	<10	—	—	<10
	12/12/1984	<10	<10	<10	<10	—	—	<10
	1/16/1985	<10	<10	<10	<10	—	—	<10
	8/11/1988	<10	<10	<10	<10	—	—	<10
	6/26/1990	<5.0	<5.0	<5.0	—	—	—	<10
	1/22/1991	<5.0	1.0J	<5.0	—	—	<5.0	<10
	9/20/1995	<0.50	3.0	<0.50	<0.50	2.4	—	<0.50
HP-608	12/4/1984	<10	110	<10	5.4J	—	—	<10
	12/10/1984	<10	13	<10	2.4J	—	—	<10
	2/4/1985	<10	9.0	<10	<10	—	—	<10
	11/12/1986	<4.1	66	<2.8	8.5	—	—	<4.9
HP-610	2/4/1985	<10	<10	<10	<10	—	—	<10
	10/1/1992	<1.0	37	—	—	—	—	<2.0
HP-634	12/4/1984	<10	<10	<10	<10	—	—	<10
	12/10/1984	<10	<10	<10	2.3J	—	—	<10
	1/16/1985	10	1,300	<10	700	—	—	6.8
	11/12/1986	<4.1	<1.9	<2.8	2.9	—	—	<4.9
	1/22/1991	<5.0	<5.0	<5.0	—	—	1.0J	<10
HP-637	12/4/1984	<10	<10	<10	<10	—	—	<10
	12/10/1984	<10	<10	<10	<10	—	—	<10
	1/16/1985	<10	<10	<10	<10	—	—	<10
	1/22/1991	<5.0	0.90J	<5.0	—	—	<5.0	<10
	8/26/1992	<5.0	<5.0	<5.0	<5.0	<5.0	—	<5.0
HP-651	1/16/1985	386	3,200	187	3,400	—	—	655
	2/4/1985	307	17,600	<200	8,070	—	—	179
	2/4/1985	400	18,900	<200	7,580	—	—	168
	11/12/1986	45	32	7.0	140	—	—	140
	1/22/1991	53	13	2.0J	—	—	75	70
HP-652	1/16/1985	<10	9.0	<10	<10	—	—	<10
	11/12/1986	<3.0	<3.0	<2.8	<1.6	—	—	<1.0
	1/22/1991	<5.0	<5.0	<5.0	—	—	<5.0	<10
	9/20/1995	<0.50	<0.50	<0.50	<0.50	<0.50	—	<0.50
	12/11/2001	<0.50	<0.50	<0.50	<0.50	<0.50	—	<0.50
HP-653	1/16/1985	<10	5.5	<10	<10	—	—	<10
	11/12/1986	<4.1	2.6	<2.8	<1.6	—	—	<4.9
	1/22/1991	<5.0	<5.0	<5.0	—	—	<5.0	<10
HP-660	12/4/1984	5.0J	210	<10	88	—	—	<10
	12/10/1984	4.4J	230	<10	99	—	—	<10
	1/16/1985	<10	26	<10	88	—	—	<10
	11/12/1986	<4.1	<1.9	<2.8	<1.6	—	—	<4.9
	1/22/1991	<5.0	1.0J	<5.0	—	—	2.0J	<10

[1] See Faye et al. (2010) for a complete tabulation of contaminants in water samples collected at water-supply wells in the Hadnot Point–Holcomb Boulevard study area

[2] Concentrations above the detection limit are highlighted in red

Figure 7. The reported (observed) TCE, PCE, 1,1-DCE, 1,2-tDCE, 1,2-cDCE, Total 1,2-DCE, VC concentrations at Hadnot Point – Holcomb Boulevard study area (Table A4, pp. A21, HP/HB Camp Lejeune site, ATSDR, 2013a)

Similarly, the reported (observed) BTEX concentrations at Hadnot Point – Holcomb Boulevard study area are given in Figure 8. The numbers highlighted in red are all concentrations above detection levels for the compound identified in the header of the table; the MCL level for Benzene is 5 μg/L.

Table A5. Water-supply wells with reported detections of benzene, toluene, ethylbenzene, or total xylenes, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.[1]

[<, constituent is less than the detection limit. Number following the "<" is the detection limit; —, constituent concentration not determined in laboratory analysis; ND, constituent not detected; J, estimated concentration]

Well name	Sample date	[2]Concentration, in micrograms per liter			
		Benzene	Toluene	Ethylbenzene	Total xylenes
Hadnot Point Water Treatment Plant Service Area					
HP-602	7/6/1984	380	10	8.0	—
	11/30/1984	120	5.4J	<10	—
	12/10/1984	720	<500	<500	—
	12/13/1984	<1.0	<1.0	<2.0	—
	12/14/1984	230	12J	<50	—
	2/4/1985	<10	<10	<10	—
	11/12/1986	50	<6.0	<7.2	<12
	1/22/1991	17	<5.0	<5.0	<5.0
HP-603	12/4/1984	<10	<10	<10	—
	12/10/1984	<10	<10	<10	—
	1/16/1985	<10	<10	<10	—
	8/11/1988	<10	<10	<10	<10
	6/26/1990	<5.0	<5.0	<5.0	<5.0
	1/22/1991	<5.0	<5.0	<5.0	<5.0
	9/20/1995	<0.50	<0.50	<0.50	<0.50
HP-608	12/4/1984	3.7J	<10	<10	—
	12/10/1984	4.0J	<10	<10	—
	2/4/1985	1.6	<10	<10	—
	11/12/1986	<4.4	<6.0	<7.2	<12
HP-651	1/16/1985	<10	<10	<10	—
	2/7/1985	<10	<10	<10	—
	11/12/1986	<4.4	<6.0	<7.2	<12
	1/22/1991	<5.0	0.9J	<0.5	<0.5
Holcomb Boulevard Water Treatment Plant Service Area					
HP-645	2/4/1985	<10	<10	<10	—
	11/6/1986	20	7.5	ND	ND
	2/17/1987	290	15	38	36
HP-706	9/19/1995	0.60	<0.50	<0.50	<0.50
	1/13/1998	6.1	—	—	—

[1] See Faye et al. (2010) for a complete tabulation of contaminants in water samples collected at water-supply wells in the Hadnot Point–Holcomb Boulevard study area

[2] Concentrations above the detection limit are highlighted in red

Figure 8. The reported (observed) BTEX concentrations at Hadnot Point – Holcomb Boulevard study area (Table A5, pp. A22, HP/HB Camp Lejeune site, ATSDR, 2013a).

As seen in the tables above, the observed and modeled contaminant levels of TCE, PCE, their by-products and BTEX compounds at the Camp Lejeune site are all at elevated levels (ATSDR, 2007; ATSDR, 2013).

6.4 Dissolved phase pollution vs NAPL, LNAPL and DNAPL pollution.

Nonaqueous phase liquids (NAPLs) are hydrocarbons that exist in a subsurface environment as a separate, immiscible (nonmixing) phase when in contact with water and/or air. Differences in the physical and chemical properties of water and NAPL result in the formation of a physical interface between the liquids which prevents the two fluids from mixing. Nonaqueous phase liquids are typically classified as either light nonaqueous phase liquids (LNAPLs) which have densities less than that of water, or dense nonaqueous phase liquids (DNAPLs) which have densities greater than that of water (Newell et al., 1995).

Upon release to the environment, NAPL (i.e., LNAPL or DNAPL) will migrate downward under the force of gravity. If a small volume of NAPL is released to the subsurface, it will move through the unsaturated zone where a fraction of the hydrocarbon will be retained by capillary forces as residual globules in the soil pores, thereby depleting the contiguous NAPL mass until movement ceases. If sufficient LNAPL is released, it will migrate until it encounters a physical barrier (e.g., low permeability strata) or is affected by buoyancy forces near the water table. Once the capillary fringe is reached, the LNAPL may move laterally as a continuous, free-phase layer along the upper boundary of the water-saturated zone due to gravity and capillary forces (Newell et al., 1995). DNAPL pollution on the other hand, because its density is higher than that of water, will continue its downward motion under the force of gravity in a water saturated subsurface system.

Modeling techniques used for each of these contamination types and dissolved phase modeling techniques are distinctly different from one another. The governing equations, mathematical definitions of migration and diffusion-dispersion processes differ from one another and a model developed for one case cannot represent the contaminant fate and transport in the other case.

A NAPL phase which is in physical contact with ground water will dissolve (solubilize, partition) into the aqueous phase. The solubility of an organic compound is the equilibrium concentration of the compound in water at a specified temperature and pressure. For all practical purposes, solubility represents the maximum concentration of that compound in water at a given temperature. At the maximum concentration, the solution is said to be saturated and thus the NAPL phase exists. Thus, to distinguish NAPL pollution from dissolved phase pollution at a site, the relative magnitude of solubility of the alien substance and the concentrations observed at a site can be used. If the concentrations of the alien substance observed at a site is less than ~10% of the solubility range of the alien substance, then the alien substance plume can be identified as a dissolved phase plume rather than an NAPL plume (Hulling and Weaver, 1991).

Characterization of tetrachloroethylene (PCE) contamination in groundwater at the ABC One-Hour Cleaners site and at Tarawa Terrace base housing as a "free-phase" or "pure-phase" DNAPL plume (NRC 2009, p. 38) contradicts and misrepresents the concentration data presented in ATSDR and in other reports and documents in the water phase. Those reports and documents describe the PCE in groundwater in the vicinity of ABC One-Hour Cleaners as "dissolved-phase" PCE (Shiver 1985, Roy F. Weston, Inc. 1992, 1994, Faye and Green 2007). The solubility limit of PCE in water occurs at a concentration of at least 210,000 μg/L (Pankow and Cherry, 1996, Lawrence 2007). PCE solubility is given in the range 150,000 μg/L – 1,503,000 μg/L at 25 °C in (Fetter, 1998: page 163). PCE in groundwater that occurs at concentrations much less than the solubility limit is, by the definition given above, a dissolved-phase PCE plume. The ATSDR conceptualization of groundwater flow and of dissolved-phase PCE conditions at ABC One-Hour Cleaners and the Tarawa Terrace base housing area is shown below in Figure 9. PCE-concentration data presented in ATSDR reports (Faye and Green 2007, Tables E5 and E7) indicate that concentrations of PCE in groundwater at Tarawa Terrace and vicinity occur at much less than 10% of the solubility limit. Thus, the characterization of the PCE plume in the vicinity of ABC One-Hour Cleaners as a dissolved phase plume is the most appropriate characterization of conditions at the site.

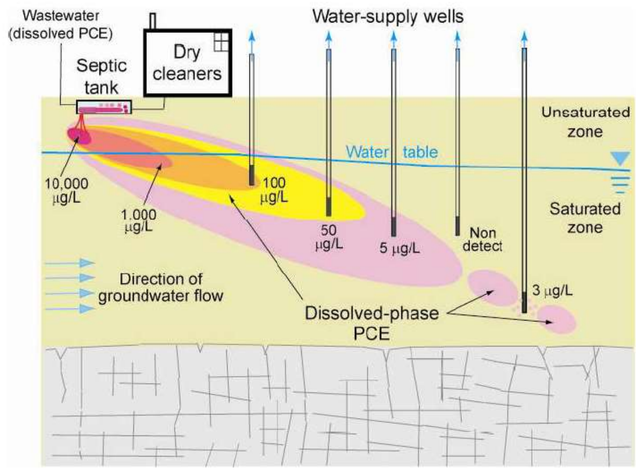

Figure 9. Conceptual model of groundwater flow and dissolved-phase PCE transport at, and in the vicinity of, ABC One-Hour Cleaners (solubility of PCE is at least 210,000 µg/L, Pankow and Cherry 1996, Lawrence 2007)

Further, the processes selected to remediate free-phase DNAPL PCE plume in groundwater are totally different from processes used to remediate dissolved-phase PCE plume in groundwater. The remediation process at the ABC One-Hour Cleaners and at Tarawa Terrace was coordinated under the auspices (directives) of the U.S. Environmental Protection Agency (USEPA). The remediation process selected was approved by the North Carolina Department of Environment and Natural Resources (NCDENR) and is correctly described as "groundwater extraction by wells and treatment by air stripping (i.e., pump-and-treat process)." This remediation process is appropriate only for dissolved phase PCE contamination and not for DNAPL phase PCE plume (NCDENR 2003, Weston Solutions Inc. 2005, 2007).

Given the definitions and data presented above, it is my opinion that the dissolved phase plume characterization used in the ATSDR study of the Tarawa Terrace area is appropriate and consistent with the definitions given above.

6.5 Tarawa Terrace Study

The construction of the Tarawa Terrace housing area dates to 1951. The area was subdivided into housing areas I and II which contained a total of 1,846 housing units and accommodated a resident population of about 6,000 people (fluctuating), Figure 10.

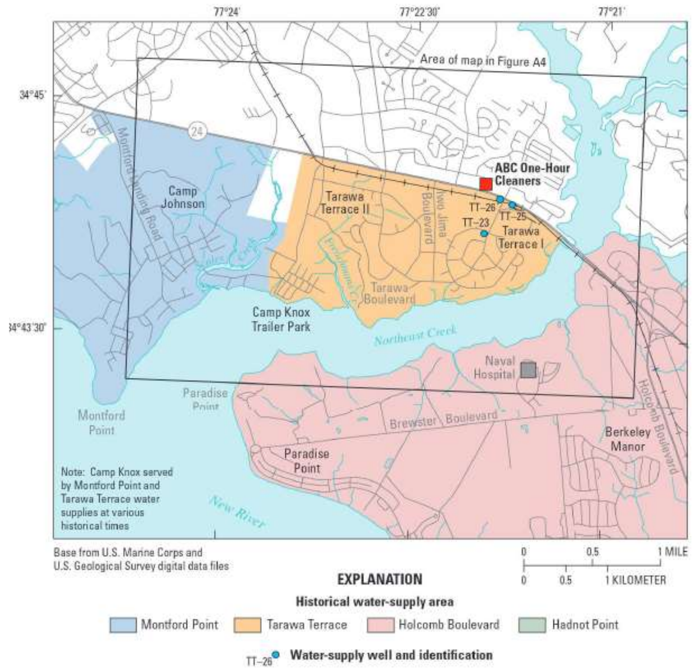

Figure A1. Selected base housing and historical water-supply areas, Tarawa Terrace and vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina.

Figure 10. Tarawa Terrace study area, location of ABC One Hour Cleaners and geographic boundaries of the site. (Figure A1, page A3, ATSDR, 2007a)

Groundwater is the sole source of water supply at the Tarawa Terrace site. To analyze and reconstruct contaminant concentrations and the timeline of contaminant movement at the site, a series of modeling techniques were used by the EDRP/ATSDR modeling group. These are:

- The analysis of predevelopment (steady state) groundwater flow conditions at the site (**MODFLOW**);
- The analysis of transient (pumping) groundwater flow conditions at the site (**MODFLOW**);
- The analysis of fate and transport of PCE and its by-products from its source at ABC One-Hour Cleaners to water-supply wells (**MT3DMS and TechFlowMP**);
- The analysis of concentration of PCE and its by-products in finished water at the Tarawa Terrace WTP were determined by using a material mass balance model (**Mass Balance, simple mixing**), where the flow-weighted average concentration of the aforementioned contaminants was calculated. The water from the Tarawa Terrace WTP was delivered to residents living in family housing; and,
- Assessment of parameter sensitivity, variability, and uncertainty associated with model simulations of groundwater flow, contaminant fate and transport, and water-distribution system analyses were also conducted (ATSDR, 2007).

For the implementation of these stages proper sub-models developed by MESL were also used as appropriate. The details of these sub-models were described earlier in this report (see Section 5). The calibration and validation analyses were successfully completed for all the modeling stages given the complex system analysis techniques described earlier in this expert report (see Section 6.1). The details of this analysis can be found in (ATSDR, 2007) which will not be repeated here.

After calibration and validation analyses were successfully completed the simulation results of PCE and its by-products at the WTP were generated. These results are summarized in Figure 11.

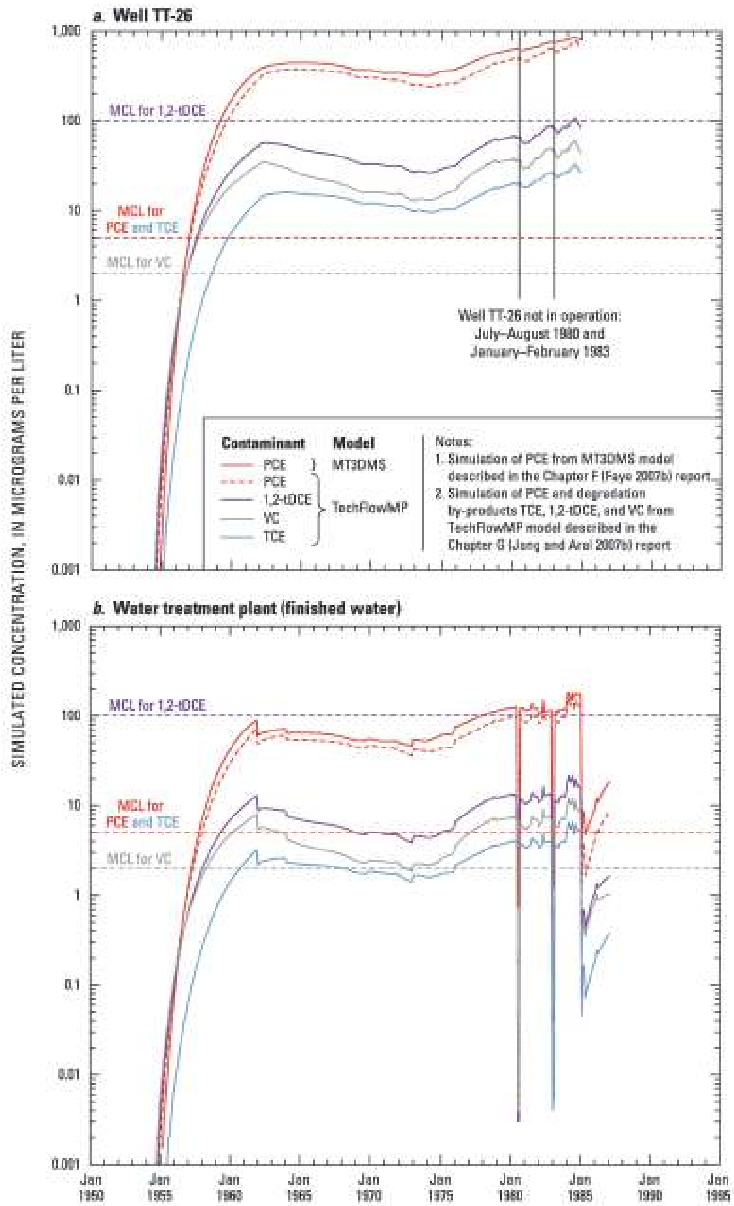

Figure A19. Simulated concentration of tetrachloroethylene (PCE) and degradation by-products trichloroethylene (TCE), *trans*-1,2-dichloroethylene (1,2-tDCE), and vinyl chloride (VC) *(a)* at water-supply well TT-26 and *(b)* in finished water from water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina. [MCL, maximum contaminant level]

Figure 11. Simulated PCE concentrations and its by-products at water supply well TT-26 and the WTP of Tarawa Terrace site (Figure A19, page A43, ATSDR, 2007a)

Uncertainty and sensitivity analyses were also successfully completed for the Tarawa Terrace study. The uncertainty analysis included the porous media parameter uncertainty, contaminant property uncertainty, model setup uncertainty and environmental factor uncertainty as described in Figure 12a. The parameter uncertainties were introduced using two stage Monte Carlo simulations (MCS). Pumping schedule uncertainties were introduced using sub-models developed by MESL program (see section 5.1) The results of this analysis yielded the outcome given in Figure 12b for PCE. In this figure the range of PCE concentrations derived from the probabilistic analysis using MCS is shown as a band of solutions and represents 95% of all possible results. The current MCL for PCE (5 µg/L) was first exceeded in finished water during October 1957-August 1958; these solutions include November 1957, the date determined using the calibrated fate and transport model (ATSDR, 2007b)-a deterministic modeling analysis approach. The PCE concentration in Tarawa Terrace WTP finished water during January 1985, simulated using the probabilistic analysis, ranges from 110-251 µg/L (95 percent of Monte Carlo simulations). This range includes the maximum calibrated value of 183 µg/L (derived without considering uncertainty and variability using MT3DMS (ATSDR, 2007b) and the maximum measured value of 215 µg/L. The red line trend includes the variability observed when pumping schedule uncertainty is included in the analysis. Therefore, the probabilistic analysis results-obtained by using two stage Monte Carlo simulation-provide a sense of confidence in the historically reconstructed deterministic PCE concentrations that were delivered to residents of Tarawa Terrace in finished water from the WTP.

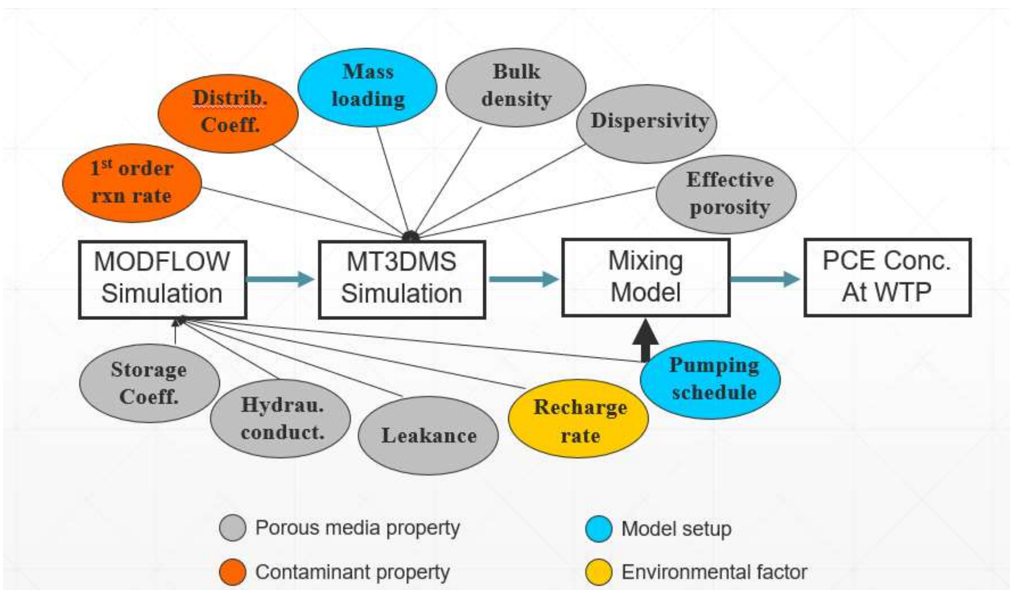

Figure 12a. The parameter uncertainty, model setup uncertainty and environmental factor uncertainty analysis structure used in ATSDR study of the Camp Lejeune site.

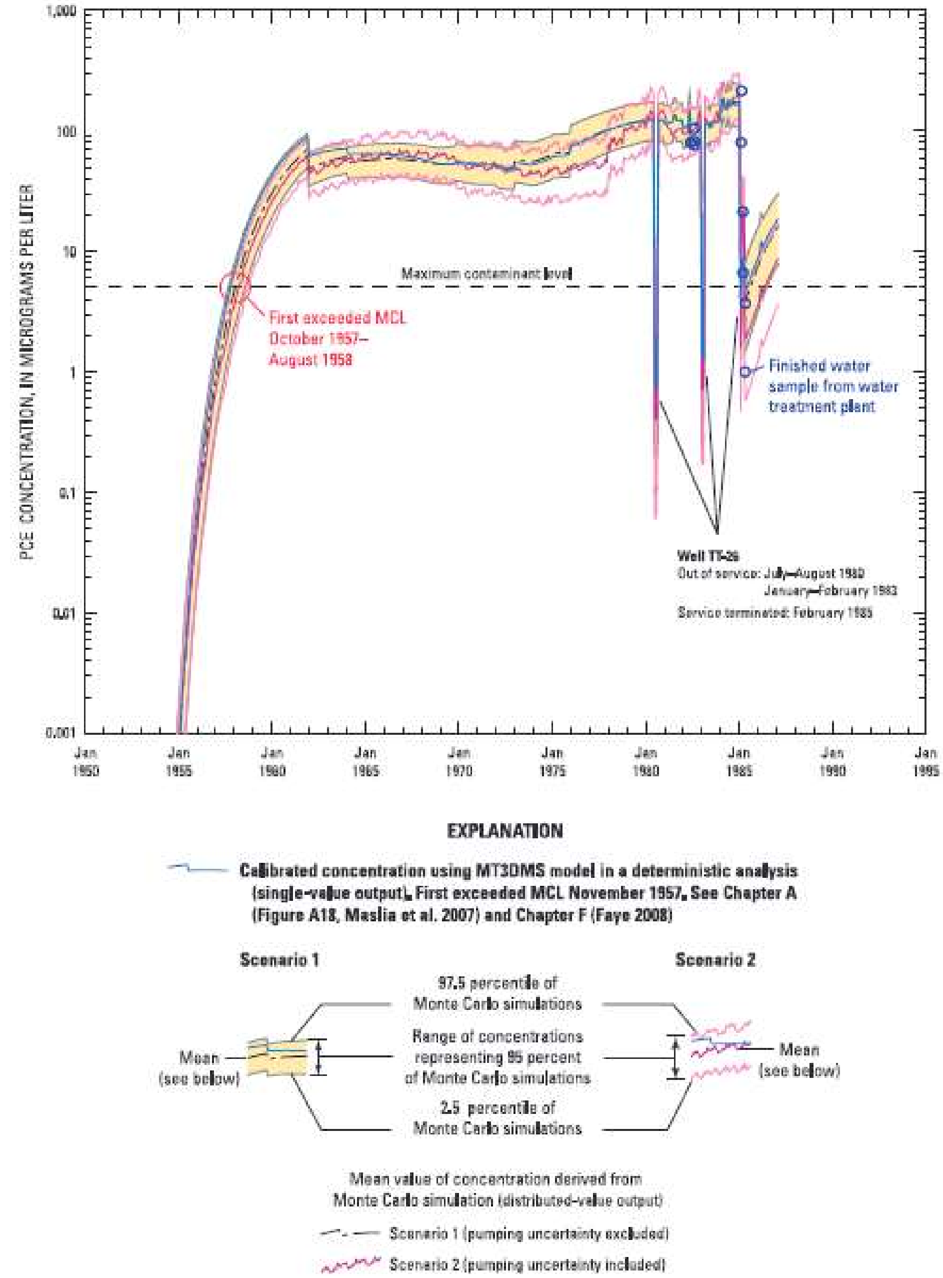

Figure I29. Concentrations of tetrachloroethylene in finished water at the water treatment plant derived from scenario 1 (pumping uncertainty excluded) and scenario 2 (pumping uncertainty included) probabilistic analyses using Monte Carlo simulation, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina. [See Appendix I5 for tabular listing; PCE, tetrachloroethylene; MCL, maximum contaminant level]

Figure 12b. Reconstructed drinking water concentrations at the Tarawa Terrace Water Treatment Plant including parameter uncertainty and pumping uncertainty, (Figure I29, page I55, ATSDR, 2007i)

Tabulated results of computed versus observed PCE concentrations at WTP were also given in Chapter F report, Figure 13. Third column in Table F14 indicates that the predicted values were all in calibration range except for four predicted values which indicates good capture of the observed values at the WTP. Detailed analysis of sensitivity analysis is also included in (ATSDR, 2007i) which will not be repeated here.

Table F14. Computed and observed tetrachloroethylene (PCE) concentrations in water samples collected at the Tarawa Terrace water treatment plant and calibration target range, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[µg/L, microgram per liter; TTWTP, Tarawa Terrace water treatment plant; ND, not detected]

Date	PCE concentration, in µg/L		Calibration target range, in µg/L
	Computed[1]	Observed	
[2]TTWTP Building TT-38			
5/27/1982	148	180	25–253
7/28/1982	112	[3]104	33–329
7/28/1982	112	[3]76	24–240
7/28/1982	112	[3]82	26–259
2/5/1985	176	[3,4]80	25–253
2/13/1985	3.6	[5]ND	0–10
2/19/1985	3.6	[6]ND	0–2
2/22/1985	3.6	[5]ND	0–10
3/11/1985	8.7	[6]ND	0–2
3/12/1985	8.7	[6,7]6.6	2.1–21
3/12/1985	8.7	[6,8]21.3	6.7–67
4/22/1985	8.1	[5]1	0.3–3.2
4/23/1985	8.1	[5]ND	0–10
4/29/1985	8.1	[5]3.7	1.2–11.7
5/15/1985	4.8	[5]ND	0–10
7/1/1985	5.5	[5]ND	0–10
7/8/1985	5.5	[5]ND	0–10
7/23/1985	5.5	[5]ND	0–10
7/31/1985	5.5	[5]ND	0–10
8/19/1985	6.0	[5]ND	0–10
9/11/1985	6.0	[5]ND	0–10
9/17/1985	6.0	[5]ND	0–10
9/24/1985	6.0	[5]ND	0–10
10/29/1985	6.0	[5]ND	0–10
[2]TTWTP Tank STT-39			
2/11/1985	176	[5]215	0–10

[1]Weighted-average computation

[2]See Plate 1, Chapter A report, for location (Maslia et al. 2007)

[3]Detection limit is unknown

Figure 13. Reconstructed drinking water concentrations at the Tarawa Terrace Water Treatment Plant and a comparison with the observed concentrations at the WTP during the period (1982 – 1985), (Table F14, page F42, ATSDR, 2007f)

Modeling results for Tarawa Terrace show that former Marines and their families who lived in Tarawa Terrace family housing units from November 1957 through February 1987 received finished water primarily contaminated with Tetrachloroethylene (PCE), a dry-cleaning solvent. Levels of PCE in finished water during this period exceeded the amount currently allowed by the Environmental Protection Agency (USEPA) under the Safe Drinking Water Act, known as the Maximum Contaminant Level (MCL), which was set at 5 µg/L in 1992 (ATSDR, 2007a). PCE concentrations first exceeded the MCL in

November 1957 and routinely exceeded it, except for two "two-month" periods when Well TT-26 was not in operation, until February 1987, when the water treatment plant was finally decommissioned.

In summary, based on field data, modeling results, and the historical reconstruction process, the following observations can be made with respect to water contamination at Tarawa Terrace (ATSDR, 2007):

- Simulated PCE concentrations exceeded the current MCL of 5 µg/L at water-supply well TT-26 for 332 months—January 1957–January 1985; the maximum simulated PCE concentration was 775 µg/L; the maximum measured PCE concentration was 1,580 µg/L during January 1985.
- Simulated PCE concentrations exceeded the current MCL of 5 µg/L in finished water at the Tarawa Terrace WTP for 346 months—November 1957–February 1987; the maximum simulated PCE concentration in finished water was 176 µg/L; the maximum measured PCE concentration in finished water was 215 µg/L during February 1985 (Figure 13).
- Simulation of PCE degradation by-products—TCE, *trans*-1,2-dichloroethylene (1,2-tDCE), and vinyl chloride—indicated that maximum concentrations of the degradation by-products generally were in the range of 10 –100 µg/L at water-supply well TT-26; measured concentrations of TCE and 1,2-tDCE on January 16, 1985, were 57 and 92 µg/L, respectively (Figure A19, 2007a).
- Maximum concentrations of the degradation by-products in finished water at the Tarawa Terrace WTP generally were in the range of 2–15 µg/L; measured concentrations of TCE and 1,2-tDCE on February 11, 1985, were 8 and 12 µg/L respectively. Max TCE 7 µg/L and max 1,2 tDCE 22 µg/L levels were simulated as given in Table A13, page A44 (ATSDR, 2007a).
- PCE concentrations in finished water at the Tarawa Terrace WTP exceeding the current MCL of 5 µg/L could have been delivered as early as December 1956 and no later than December 1960. Based on probabilistic analyses, the most likely dates that finished water first exceeded the current MCL ranged from October 1957 to August 1958 (95 percent probability), with an average first exceedance date of November 1957.
- PCE and PCE degradation by-products contamination in finished water ceased after February 1987; the Tarawa Terrace WTP was closed March 1987.

Based on the Tarawa Terrace study results (ATSDR, 2007) the following conclusions can be drawn for the PCE contamination of finished water at Tarawa Terrace:

- PCE concentrations in the finished water at Tarawa Terrace first exceeded MCL level of 5 µg/L during the period 1957-1958.
- During the period 1957 – 1962, the PCE concentrations in the finished water at Tarawa Terrace continued to increase sharply from 5 µg/L to a range of 42 µg/L – 92 µg/L, Figures 11 and 12b.
- During the period 1962 – 1987, the PCE concentrations in the finished water at Tarawa Terrace continued to gradually increase from 42 µg/L – 92 µg/L range to a range of 110 µg/L – 250 µg/L, Figures 11 and 12b, except for two "two-month" periods when Well TT-26 was not in operation.
- Similar observations can be made for the degradation by-products of PCE from Figure 11.
- The simulated monthly mean concentrations and confidence boundaries given in ATSDR reports and the conclusions reported above are reliable and represent, within reasonable scientific and engineering certainty, the contaminant levels in finished water at Camp Lejeune from 1953 to 1987.

I confirm that the conclusions I summarized above and others that exist in ATSDR reports were reached by applying generally accepted methods in the fields of hydrogeology, geochemistry, environmental sciences, engineering and mathematical and stochastic computational modeling. These conclusions are my own and are based on my education, training, and experience, as well as the documents, public information, diagrams, data, and facts that were available to me at the time of writing. I hold these conclusions to a reasonable degree of scientific and engineering certainty. I reserve the right to supplement and/or amend my conclusions on this matter as necessary as additional documents or information are made available to me.

6.6 Hadnot Point – Holcomb Boulevard Study

The Hadnot Point Water Treatment Plant (HPWTP) (building 20) was likely constructed during 1941 and 1942, along with much of the original infrastructure of the Base, Figure 14.

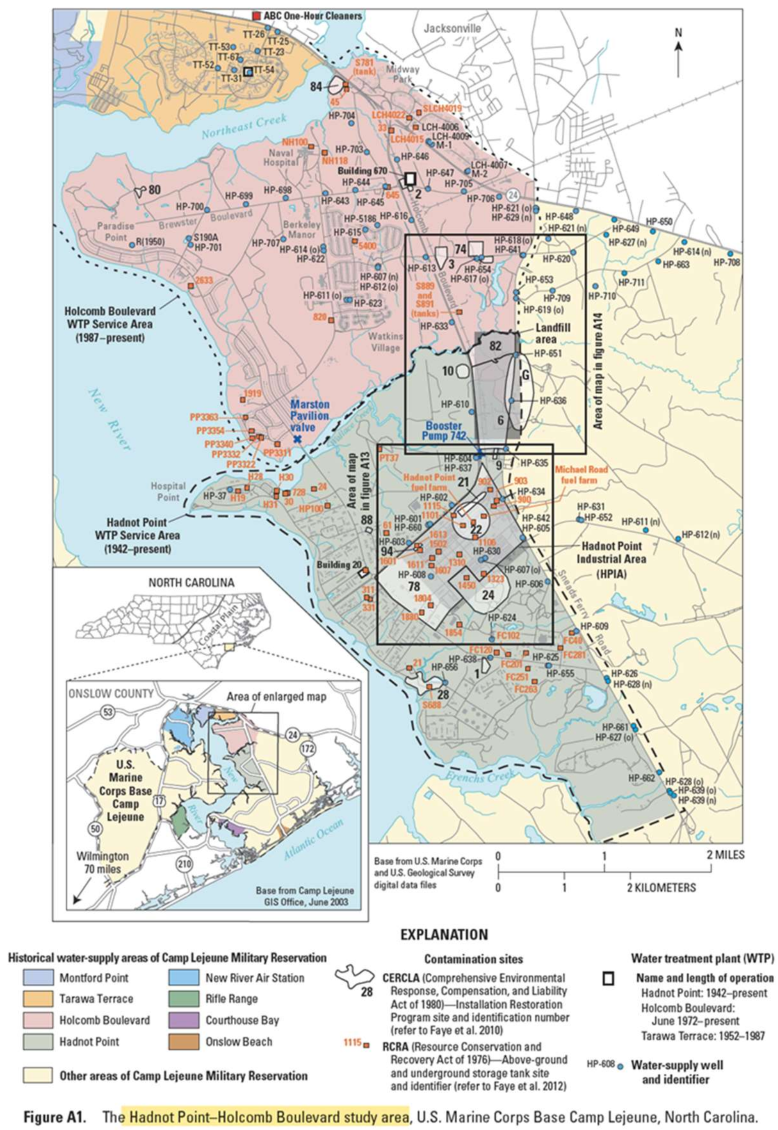

Figure A1. The Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

Figure 14. Hadnot Point Holcomb Boulevard study area and geographic boundaries. (Figure A1, ATSDR, 2013a)

The original capacity of HPWTP is unknown. However, July 21, 1954, USMCB Camp Lejeune property record card indicates a capacity of 5 million gallons per day (MGD) (Scott R. Williams, USMCB Camp Lejeune, written ATSDR communication, February 22, 2012).

During 1942, the 21 original water-supply wells at Camp Lejeune (HP-601 to HP-621) were placed into operation and provided a total combined capacity of 7.3 MGD (CLHDW CDR File #2292, p. 1). Throughout the years, additional water-supply wells were brought online to increase system capacity or to replace abandoned wells. Some of the water-supply wells were removed from service and eventually were abandoned because of contaminants found in groundwater at nearby disposal sites and in the supply wells themselves (ATSDR, 2013a). As of June 2008, 27 wells were supplying groundwater to HPWTP with a total combined capacity of about 5.9 MGD and a delivered groundwater (raw water) flow rate of 2.2 MGD (ATSDR, 2013a).

Until the summer of 1972, all finished water distributed to bachelor and family housing units and all other facilities within the Hadnot Point-Holcomb Boulevard study area were supplied by the HPWTP (Building 20). After June 1972, finished water distributed to Berkeley Manor, Midway Park, Paradise Point, and Watkins Village family housing areas was supplied by the HBWTP. Also included in the HBWTP service area are the current U.S. Naval Hospital (from 1983), the USMCB Camp Lejeune high school, and the Brewster Boulevard junior high school. The Holcomb Boulevard water-distribution system is linked to the Hadnot Point water-distribution system near McHugh Boulevard and Wallace Creek (Marston Pavilion valve) and near Holcomb Boulevard and Wallace Creek at booster pump 742. For operational reasons, the two water-distribution systems were occasionally connected—exceptions being some documented connections that occurred during the late spring and early summer months of 1972–1986 (ATSDR, 2013a).

The historical reconstruction analysis of the Hadnot Point and Holcomb Boulevard area is more complex than the Tarawa Terrace study area described above. This is because there are multiple contamination sources and multiple contaminants at the site. The study also includes a water distribution system analysis, and the study area is much larger than the Tarawa Terrace study area. Accordingly, the historical reconstruction analyses discussed herein will focus on two general areas (within the Hadnot Point-Holcomb Boulevard study area) that contributed most substantially to water-supply well contamination. These are the Hadnot Point Industrial Area (HPIA) and the Hadnot Point landfill (HPLF) area.

The Hadnot Point-Holcomb Boulevard historical reconstruction covers the period 1942–2008. The first year, 1942, was chosen because operations at USMCB Camp Lejeune began in late 1941. The last year, 2008, was chosen to take advantage of more recent water-supply well operational data and contaminant concentration data to assist with model calibration.

As is the case with the Tarawa Terrace site, groundwater is the sole source of water at this site. Of critical need, in terms of historical reconstruction, was information and data on the monthly raw water production of supply wells (to enable computation of flow-weighted finished-water concentrations) and the distribution of finished water to family housing areas. The supply of finished water for the Hadnot Point-Holcomb Boulevard study area was composed of the following: (1) supply of water from groundwater wells to the HPWTP (1942–present) and the HBWTP (1972–present), (2) delivery of finished water from the WTPs through a network of pipelines and storage tanks to housing areas and other facilities, and (3) intermittent transfers of Hadnot Point finished (contaminated) water through connecting pipelines to the Holcomb Boulevard water-distribution system during late spring and early summer months for years 1972–1985.

Groundwater is the sole source of water supply at the site. To reconstruct contaminant concentrations and the timeline of contaminant movement at the site a series of modeling techniques were implemented. These are:

- To simulate predevelopment groundwater-flow conditions, the **MODFLOW** code was used. In addition to the trial-and-error calibration procedures, the estimates of model parameter values were supplemented using the objective parameter estimation code **PEST-12** (Doherty 2003, 2010).
- To simulate the transient (unsteady) effects caused primarily by the onset and continued operation of water-supply wells in the study area, historical water-supply well operating schedules were developed and again the **MODFLOW** code was used. The operating schedules of water supply wells was accomplished for the period 1942–2008 using **TechWellOp** and **PSOpS** sub-models described earlier (Section 5.1).
- Groundwater contaminant fate and transport analysis of TCE and benzene were simulated using **MT3DMS** and **TECHFLOWMP**. In addition, the fate and transport of PCE and TCE from source areas in the HPLF area to water-supply well HP-651 was simulated using the **MT3DMS**, **TechFlowMP**, and **LCM-TechCONTROL** code (Section 5.1).
- The occurrence of benzene as an LNAPL in the subsurface in the vicinity of the Hadnot Point Fuel Farm (HPFF) and HPIA is described in (ATSDR, 2013) and in Section 6.4. Estimates of subsurface LNAPL volume were developed using historical measurements of LNAPL thickness over time—monitor well data—in the HPIA combined with the **TechNAPLVol** code that uses semi-analytical and numerical methods in a three-dimensional domain (ATSDR, 2013). The resulting saturation profile from the LNAPL volume analysis was used within the **TechFlowMP** model code to simulate the dissolution of LNAPL constituents and the fate and transport of dissolved phase benzene (Section 5.1).
- An alternative method, a linear state-space representation of a contaminated aquifer system designated as the linear control model (**LCM**) methodology, was developed to reconstruct contaminant concentrations in water-supply wells (ATSDR, 2013). Using the model code **TechControl**, this simplified approach was used to reconstruct historical contaminant concentrations, including PCE, TCE, 1,2-tDCE, and VC, in water-supply well HP-651 in the HPLF area. A description of this code is given in Section 5.1 of this report. A more detailed description of the methodology can be found in (ATSDR, 2013; Guan, 2009). Results from the LCM application at water-supply well HP-651 were compared to simulated PCE and TCE concentrations obtained using the **MT3DMS** numerical fate and transport code later when the **MT3DMS** study was completed. The comparisons of these solutions and the analytical analysis of these comparisons are discussed extensively in (ATSDR, 2013, Chapter A supplement 5) for the results of the **TechControl** application at the HP-HB site which will not be repeated here.
- Reconstructed (simulated) monthly mean concentrations of PCE, TCE, 1,2-tDCE, VC, and benzene for finished water at the HPWTP were determined by using a materials mass balance model (**Mass Balance, simple mixing**) to compute the flow-weighted average concentration of the aforementioned contaminants. The use of the material mass-balance method is justified because all raw water from water-supply wells within the HPWTP service area was mixed at the HPWTP prior to treatment and distribution.
- Intermittent operations of booster pump 742 and the opening of the Marston Pavilion valve transferred contaminated Hadnot Point finished water to Holcomb Boulevard family housing areas and other facilities. Owing to missing data related to pump and valve operations, probabilistic analyses of the intermittent water transfers during the period 1972–1985 were conducted

using a Markov analysis (Ross 1977) and the code **TechMarkovChain** (Section 5.1). Results provided probabilistic estimates of the intermittent transfer of contaminated Hadnot Point finished water to the Holcomb Boulevard family housing areas.

- Using the reconstructed monthly mean concentrations of PCE, TCE, 1,2-tDCE, VC, and benzene in finished water from the HPWTP and the Markov analysis to estimate the occurrence of intermittent water transfers, extended period simulations of hydraulics and water quality for the water-distribution system serving the Holcomb Boulevard housing areas and other facilities were conducted. **EPANET 2** (Rossman 2000) was used for the water distribution system analysis.
- Assessment of parameter sensitivity, variability, and uncertainty associated with model simulations of groundwater flow, contaminant fate and transport, and water-distribution system analyses were also conducted (ATSDR, 2013).

The calibration and validation analyses were successfully completed for all these modeling stages following the complex system analysis techniques described earlier in this expert report (see Section 6). The details of this analysis can be found in (ATSDR, 2013) which will not be repeated here. After successful completion of calibration and validation analyses the simulation results of contaminants at WTP were generated. These results are summarized in Figure 15, 16 and 17 as Tables and Figures.

Table A18. Selected measured and reconstructed (simulated) concentrations of tetrachloroethylene (PCE), trichloroethylene (TCE), *trans*-1,2-dichloroethylene (1,2-tDCE), vinyl chloride (VC), and benzene at the Hadnot Point water treatment plant, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[µg/L, microgram per liter; J, estimated]

Contaminant	[1]Measured data		[2]Reconstructed (simulated)		[2]Reconstructed (maximum value)	
	Sample date	Concentration, in µg/L	Simulation date	Concentration, in µg/L	Simulation date	Concentration, in µg/L
PCE	5/27/1982[3]	15	May 1982	21	Nov. 1983	39
	7/27/1982[4]	100	July 1982	27		
	12/4/1984[6]	3.9J	Nov. 1984	31		
	2/5/1985[7]	7.5J	Jan. 1985	16		
TCE	5/27/1982[3]	1,400	May 1982	438	Nov. 1983	783
	7/27/1982[5]	19	Aug. 1982	670		
	7/27/1982[6]	21	Aug. 1982	670		
	12/4/1984[5]	46	Nov. 1984	639		
	12/4/1984[6]	200	Nov. 1984	639		
	12/12/1984[6]	2.3J	Dec. 1984	43		
	12/19/1984	1.2	Dec. 1984	43		
	2/5/1985[7]	429	Jan. 1985	324		
1,2-tDCE	12/4/1984[6]	83	Nov. 1984	358	Nov. 1983	435
	12/4/1984[5]	15	Dec. 1984	26		
	12/12/1984[6]	2.3J	Dec. 1984	26		
	2/5/1985[7]	150	Jan. 1985	163		
VC	2/5/1985[7]	2.9J	Jan. 1985	31	Nov. 1983	67
Benzene	11/19/1985[7,8,9]	2,500	Nov. 1985	3	Apr. 1984	12
	12/10/1985[7]	38	Dec. 1985	3		
	12/18/1985[7]	1.0	Dec. 1985	3		

[1] Data from Faye et al. (2010, Tables C11 and C12)

[2] Simulation results represent the last day of each month (e.g., May 31); results reported for simulation month nearest the sample date; refer to Appendix A7 for complete listing of reconstructed finished-water concentrations

[3] Water sample collected at Building NH-1; data reported as unreliable

[4] Water sample collected at Building FC-530

[5] Untreated water

[6] Treated water

[7] Treatment status unknown

[8] Laboratory analysis noted with: "Sample appears to have been contaminated with benzene, toluene, and methyl chloride" (JTC Environmental Consultants 1985)

[9] Data noted with: "Not Representative" (U.S. Marine Corp Base Camp Lejeune Water Document CLW #1356)

Figure 15. Selected simulation results for TCE, PCE and other by-products at HPWTP. More detailed results and their analysis can be found in (ATSDR, 2013a).

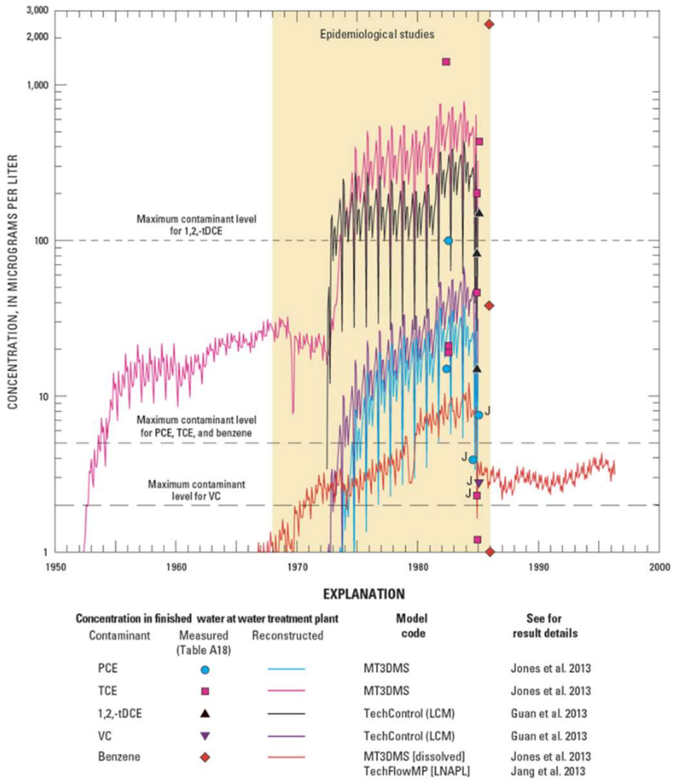

Figure A27. Reconstructed (simulated) finished-water concentrations of tetrachloroethylene (PCE), trichloroethylene (TCE), *trans*-1,2-dichloroethylene (1,2-tDCE), vinyl chloride (VC), and benzene, and measured concentrations, Hadnot Point water treatment plant, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina. (Note: See Appendix A7 for monthly mean finished-water concentration and Table A3 for detailed list of current maximum contaminant levels.) [J, estimated; LCM, linear control model; LNAPL, light nonaqueous phase liquid]

Figure 16. Selected simulation results for the HP and HB areas. More detailed results and their analysis can be found in (ATSDR, 2013a).

Results provided in Figure 16 and summary statistics provided in Figure 15 indicate a reasonable capture of the concentrations at the WTP.

Table A14. Summary statistics for reconstructed contaminant concentrations at selected water-supply wells and the Hadnot Point water treatment plant, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.[1,2]

[MCL, maximum contaminant level; TCE, trichloroethylene; PCE, tetrachloroethylene; VC, vinyl chloride; 1,2-tDCE, *trans*-1,2-dichloroethylene; N/A, not applicable; µg/L, microgram per liter]

Water-supply identification (contaminant)	Reconstructed (simulated) concentration, in micrograms per liter: [3]July 1942–June 1996: Maximum (date of maximum)	Mean	Standard deviation	Range during health study period of interest (January 1968–February 1985)	[2]Duration in months exceeding MCL (month and year first exceeding MCL)	Date well stopped pumping in model
[4]Hadnot Point Industrial Area (HPIA)						
HP-602 (TCE)	658 (Jan. 1959)	359	222	357–499	390 (Oct. 1951)	Dec. 1984
HP-608 (TCE)	50 (Sept. 1972)	25	20	28–50	307 (Aug. 1957)	Dec. 1984
HP-634 (TCE)	659 (Oct. 1968)	391	170	212–659	283 (Aug. 1960)	Dec. 1984
HP-602 (benzene)	236 (Nov. 1984)	53	65	48–236	309 (July 1958)	Dec. 1984
HP-603 (benzene)	179 (May 1996)	29	43	6–129	345 (Aug. 1967)	June 1996
HP-608 (benzene)	11 (Sept. 1979)	4	4	6–11	201 (June 1966)	Dec. 1984
[4]Hadnot Point landfill (HPLF)						
HP-651 (PCE)	353 (Dec. 1982)	249	122	[5]0–353	142 (Apr. 1973)	Feb. 1985
HP-651 (TCE)	7,135 (Dec. 1978)	5,831	2,071	[5]1–7,135	150 (Aug. 1972)	Feb. 1985
HP-651 (1,2-tDCE)	4,037 (Dec. 1984)	3,284	572	[5]69–4,037	150 (Aug. 1972)	Feb. 1985
HP-651 (VC)	660 (Nov. 1984)	391	173	[5]8–660	151 (July 1972)	Feb. 1985
[6]Hadnot Point water treatment plant (HPWTP)						
HPWTP (PCE)	39 (Nov. 1983)	4	8	0–39	114 (Aug. 1974)	N/A
HPWTP (TCE)	783 (Nov. 1983)	107	180	0–783	374 (Aug. 1953)	N/A
HPWTP (1,2-tDCE)	435 (Nov. 1983)	53	95	0–435	128 (Nov. 1972)	N/A
HPWTP (VC)	67 (Nov. 1983)	6	13	0–67	144 (Nov. 1972)	N/A
HPWTP (benzene)	12 (Apr. 1984)	2	3	0–12	63 (Jan. 1979)	N/A

[1] For periods of time when concentrations are equal to or exceed the current MCLs for TCE, PCE, and benzene; non-rounded concentration values used to calculate statistics

[2] Current MCLs are as follows: vinyl chloride, 2 µg/L; PCE, TCE, and benzene, 5 µg/L; 1,2-tDCE, 100 µg/L (see Table A3)

[3] Statistics are computed solely for periods of operation

[4] See Appendix A3 for complete listing

[5] Water-supply well HP-651 did not start pumping until July 1972; values shown represent dates of July 1972–February 1985

[6] Finished-water concentrations; see Appendix A7 for complete listing

Figure 17. Summary statistics for reconstructed contaminant concentrations at selected water-supply wells and the Hadnot Point water treatment plant, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina

Based on field data, uncertainty and sensitivity analyses, and the historical reconstruction process, the following conclusions are made with respect to groundwater and finished-water contamination of the Hadnot Point–Holcomb Boulevard (HPHB) study area.

For the Hadnot Point water treatment plant (HPWTP):

- Within the HPWTP, TCE routinely exceeded its current MCL during the period (1955–1985). TCE concentrations in finished water at the HPWTP ranged from about 10 to 30 µg/L for the period 1955–1972, prior to the onset of pumping from water-supply well HP-651 (Figure A27, ATSDR, 2013). After the onset of pumping of water-supply well HP-651 during July 1972, finished-water concentrations increased to a maximum computed value of 670 µg/L during August 1982 (Table A18, ATSDR 2013). Measured concentrations of PCE, TCE, 1,2-tDCE, VC, and benzene and historical reconstruction (simulated) results for the HPWTP are listed in Table A18 (ATSDR, 2013a).
- The reconstructed contamination of finished water exceeding the current maximum contaminant level (MCL) for TCE was 374 months (August 1953–January 1985) (Table A14, ATSDR, 2013a) Figure 17. With the onset of pumping at well HP-651 during July 1972, the concentration of TCE in well HP-651 affected the resulting finished-water concentrations of TCE at the HPWTP, which exceeded 750 µg/L during November 1983 (Table A14, ATSDR, 2013). Measured TCE concentrations in finished water at the HPWTP during the period May 1982 through February 1985 ranged from 1.2 µg/L to 1,400 µg/L (Faye et al. 2010, Table C11, ATSDR, 2013).
- The reconstructed contamination of finished water exceeding the current MCL for PCE was 114 months (August 1974–January 1985) (Table A14), Figure 17, also a consequence of the onset of pumping of well HP-651. The maximum reconstructed finished-water concentration of PCE was about 39 µg/L during November 1983 (Table A14, ATSDR, 2013a). Measured PCE concentrations at the HPWTP ranged from below detection limits (1–10 µg/L) to 100 µg/L during the period May 1982–February 1985 (Faye et al. 2010, Table C11, ATSDR, 2013).
- The reconstructed duration of contamination of finished water exceeding the current MCL for benzene was 63 months (January 1979–November 1984) (Table A14, ATSDR, 2013a), Figure 17.
- The maximum reconstructed finished water concentration of benzene was about 12 µg/L during April 1984 (Table A14, ATSDR, 2013). Measured benzene concentrations at the HPWTP ranged from below detection limits (10 µg/L) to 38 µg/L during the period December 1984–December 1985. An unexplained value of 2,500 µg/L of benzene was measured on November 11, 1985 (Faye et al. 2010, Table C12, ATSDR, 2013).

For the Holcomb Boulevard housing area:

- When this housing area was serviced by the HPWTP (prior to June 1972), the maximum reconstructed (simulated) monthly mean TCE concentration in finished water (January 1968–December 1985) was 32 µg/L during August 1968 and August 1969 (Appendix A7, ATSDR, 2013a). The minimum reconstructed (simulated) monthly mean TCE concentration in finished water (January 1968–December 1985) was 8 µg/L (September and October 1969). TCE concentrations in finished water first exceeded the MCL during August 1953 (Appendix A7, ATSDR, 2013).
- After June 1972 when the Holcomb Boulevard water treatment plant (HBWTP) came online to service this housing area, an interconnection analysis indicates that the maximum reconstructed

(simulated) TCE concentration in finished water was 66 µg/L during February 1985 for the Paradise Point area (Figure A29(H), ATSDR, 2013a).

- After June 1972 when the HBWTP came online to service this housing area, the maximum reconstructed (simulated) monthly concentrations for PCE, 1,2-tDCE, and VC in finished water for the Holcomb Boulevard housing area occurred during February 1985 and were 3 µg/L, 33 µg/L, and 6 µg/L, respectively (Table A21(H), ATSDR, 2013a). The maximum reconstructed (simulated) monthly concentration for benzene was 3 µg/L, occurring during January, February, April, May, and June 1972 (Table A21(H), ATSDR, 2013a).

For the Hadnot Point Industrial Area (HPIA):

- The maximum reconstructed (simulated) monthly mean TCE concentrations at water-supply wells HP-602, HP-608, and HP-634 were 658 µg/L during January 1959, 50 µg/L during September 1972, and 659 µg/L during October 1968, respectively (Table A14, ATSDR, 2013a). Measured TCE concentrations at well HP-602 ranged from an estimated 0.7 µg/L to 1,600 µg/L during the period of record, July 1984 to January 1991 (Table A4(H), ATSDR, 2013a). Corresponding concentrations at well HP-608 ranged from 9 µg/L to 110 µg/L during the period of record, December 1984 to November 1986. In well HP-634 between December 1984 and January 1991, TCE concentrations ranged from less than detection limits to 1,300 µg/L.
- Substantial volumes of liquid hydrocarbon fuels were lost due to leakage to the subsurface within the Hadnot Point Industrial Area (HPIA). This area contained as many as 10 active water-supply wells. Despite the large volumes lost, finished-water concentrations of benzene only exceeded the current MCL of 5 µg/L in some of the wells during the period 1980–1985.
- At water-supply wells with measured benzene concentrations exceeding detection limits (HP-602 and HP-608), the maximum reconstructed (simulated) monthly benzene concentration was 236 µg/L at well HP-602 during November 1984 and 11 µg/L at well HP-608 during September 1979 (Table A14, Appendix A3, ATSDR, 2013). Measured benzene concentrations at well HP-602 during the period of record, July 1984 to January 1991, ranged from less than 1.0 µg/L to 720 µg/L. Measured benzene concentrations at well HP-608 during the period of record, December 1984 to November 1986, ranged from 1.6 µg/L to an estimated 4.0 µg/L. All measured benzene concentrations in well HP-603 were below detection limits (Table A5(H), ATSDR, 2013a).

For the Hadnot Point landfill (HPLF) area:

- The maximum reconstructed (simulated) monthly mean TCE concentration at water-supply well HP-651 was 7,135 µg/L during December 1978 (Table A14, ATSDR, 2013a), Figure 17. Measured TCE concentrations during the period of record, January 1985 to January 1991, ranged from 13 µg/L to 18,900 µg/L (Table A4(H), ATSDR, 2013a).
- The maximum reconstructed (simulated) monthly PCE concentration at water-supply well HP-651 was 353 µg/L during December 1982 (Table A14, ATSDR, 2013), Figure 17. Measured PCE concentrations during the period of record, January 1985 through January 1991, ranged from 45 µg/L to 400 µg/L (Table A4(H), ATSDR, 2013a).
- The maximum reconstructed (simulated) monthly mean 1,2-tDCE concentration at water-supply well HP-651 was about 4,037 µg/L during December 1984 (Table A14), Figure 17. Measured 1,2-tDCE concentrations during the period of record, January 1985 to November 1986, ranged from 140 µg/L to 8,070 µg/L (Table A4(H), ATSDR, 2013a).

- The maximum reconstructed (simulated) monthly mean VC concentration at water-supply well HP-651 was 660 μg/L during November 1984 (Table A14, ATSDR, 2013), Figure 17. Measured VC concentrations during the period or record, January 1985 to January 1991, ranged from 70 μg/L to 655 μg/L (Table A4(H), ATSDR, 2013a).

In summary:

- The historical reconstruction process results show that finished water at U.S. Marine Corps Base Camp Lejeune was contaminated with varying levels of TCE, PCE, 1,2-tDCE, vinyl chloride and benzene from 1953 to 1987, (ATSDR, 2013).
- TCE contamination at the HP-HB finished water first exceeded MCL level of 5 μg/L during the period 1954 – 1955, Figure 16.
- During the period 1954 – 1973, the TCE contamination at the HP-HB finished water gradually increased from 5 μg/L to a range of 19 μg/L – 26 μg/L, Figure 16.
- During the period 1973 – 1985 there is a sharp increase in the TCE contamination at the HP-HB finished water from a range of 19 μg/L – 26 μg/L to a range of 380 μg/L – 620 μg/L, Figure 16.
- PCE contamination at the HP-HB finished water first exceeded MCL level of 5 μg/L during the period 1974 – 1975, Figure 16.
- During the period 1974 – 1985 there is a sharp increase in PCE contamination at the HP-HB finished water from 5 μg/L to a range of 20 μg/L – 30 μg/L, Figure 16.
- 1,2-tDCE contamination at the HP-HB finished water first exceeded MCL level of 100 μg/L during the period 1973 – 1974, Figure 16.
- During the period 1973 – 1985 there is a sharp increase in 1,2-tDCE contamination at the HP-HB finished water from 100 μg/L to a range of 220 μg/L – 390 μg/L, Figure 16.
- VC contamination at the HP-HB finished water first exceeded MCL level of 2 μg/L during the period 1972 – 1973, Figure 16.
- During the period 1972 – 1985 there is a sharp increase in VC contamination at the HP-HB finished water from 2 μg/L to a range of 34 μg/L – 52 μg/L, Figure 16.
- Benzene contamination at the HP-HB finished water first exceeded MCL level of 5 μg/L during 1980, Figure 16.
- During the period 1980 – 1985 there is a sharp increase in Benzene contamination at the HP-HB finished water from 5 μg/L to a range of 7 μg/L – 12 μg/L, Figure 16.
- The simulated monthly mean concentrations and confidence boundaries given in ATSDR reports and the conclusions reported above are reliable and represent, within reasonable scientific and engineering certainty, the contaminant levels in finished water at Camp Lejeune from 1953 to 1987.

I confirm that the conclusions I summarized above and others that exist in ATSDR reports were reached by applying generally accepted methods in the fields of hydrogeology, geochemistry, environmental sciences and engineering and mathematical and stochastic computational modeling. These conclusions are my own and are based on my education, training, and experience, as well as the documents, public information, diagrams, data, and facts that were available to me at the time of writing. I hold these conclusions to a reasonable degree of scientific and engineering certainty. I reserve the right to supplement and/or amend my conclusions on this matter as necessary as additional documents or information are made available to me.

6.7 Confidence in Validity of Historical Reconstruction Results

It is generally accepted that properly selected models that have been calibrated to site-specific conditions are appropriate for environmental management and decision-making – frequently there is no other form of guidance. While proper model calibration, sensitivity and uncertainty analyses improve confidence in model predictions, additional validation steps can increase confidence in simulation results. (Anderson et al., 1992; Bredehoeft and Konikow, 1993; Oreskes et al., 1994; Aral, 2010; Sahmel et al., 2010, Mei, 2003).

In an ideal world, the modeler would have an abundance of data. In that scenario, a portion of the data can be used to calibrate the model. The calibrated model can then be used to simulate values for comparison with the remaining independent data. This is the classical definition of model validation. In literature there are other definitions of validation as well. For example, IAEA (1982) defines validation as "A conceptual model and the computer code derived from it are validated when it is confirmed that the conceptual model and the computer code provide a good representation of the actual processes occurring in the real system." Or Schlesinger et al. (1979) defines validation as "substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model." Or in Konikow and Bredehoeft (1992) it is stated that: "Ground-water models are embodiments of scientific hypotheses. As such, the models cannot be proven or validated, but only tested and invalidated." Or "…The absolute validity of a model can never be determined" (NRC, 1990).

Frequently, an abundance of data is unavailable (Maslia and Aral, 2004), and alternate validation means must be considered. In such situations, Sahmel et al. (2010) recommend alternative means to increase confidence (help validate) simulated exposure levels, including assessing:

i. ***Were the data used to formulate and calibrate the model taken from dependable and appropriate sources?***
   In my opinion, the ATSDR Camp Lejeune studies went to extraordinary measures to identify and collect all the dependable and appropriate sources of data for model calibration from Camp Lejeune archives.
ii. ***Has variability in the outcomes been considered?***
   There is abundant evidence in the ATSDR study that extensive analysis of stochastic uncertainty and sensitivity analysis was performed in the ATSDR study.
iii. ***Where possible, have multiple simulation approaches been utilized and generated similar results?***
   There were two additional modeling efforts employed in the ATSDR study which provided the reconfirmation of the results obtained from the standard applications that exist in public domain. These are the **TechControl** application that uses Linear control model and **TechFlowMP** application that is used to investigate the fate and transport processes at the Camp Lejeune site. These are two independent codes used in the analysis that satisfies the above criteria. One should also recognize the fact that two independent study groups implemented these parallel simulation approaches which yielded similar results. The comparisons of these solutions and the analytical analysis of these comparisons are discussed extensively in (ATSDR, 2013, Chapter A supplement 5) for the results of the **TechControl** application at the HP-HB site and in (ATSDR, 2007g) for the results of the **TechFlowMP** application (Figure 11) at the Tarawa Terrace site which will not be repeated here.

As philosophical discussion on validation concepts and definitions continues, as engineers working on the Camp Lejeune study, we believe being as close as possible to an observed system's behavior in modeling yields satisfactory answers to most practical problems that await immediate solutions. Having introduced some of the secondary philosophical discussions on validation concepts above, one must also recognize the following traditional validation step employed in ATSDR study as well. This step, described below, was completed for the models used in the ATSDR study of the Camp Lejeune site. I also notice that the completion of this step as an extra effort was not recognized or understood by some of the experts of the government in this case (see Dr. Dan Waddill's deposition, Tuesday, August 6, 2024).

As discussed in Sections 5 and 6 of this report, the ATSDR reconstruction model is a complex system and consists of five stages: i. pre-development (pre-pumping); ii. transient (pumping); iii. contaminant migration; and iv. production well mixing at the treatment plant; and v. the water distribution system analysis. The reconstructed sequence of model's ability to fit the independent data available for finished water (supplied to the consumer) at WTP (see Figures 12, 13 and 15) provides internal model validation that all four levels are accurately capturing the system behavior. For example, only those solutions that successfully simulate predevelopment (pre-pumping) and transient groundwater flow conditions can successfully capture the contaminant migration processes that would yield the independent data values we have at the WTP. Thus, in the final stage when WTP data is captured accurately, it requires that all three previous stages have been accurately incorporated into the model and validated appropriately. Thus, successful capture of the independent measured data at the WTP, as occurred here for Tarawa Terrace and Hadnot Point/Holcomb Boulevard, provides an internal validation of the **MT3DMS** model and the coupled complex modeling ensemble.

In summary, as stated by Dr. Robert Clark, Chair of the Expert Review Panel for the ATSDR Camp Lejeune studies, the ATSDR appropriately used the data sets that were available to it, and validated its model using the best approach under the circumstances:

> *"From a scientific viewpoint it would be ideal to have independent data sets. One set could be used to calibrate the models, and the second data set used for validation. If one is developing a model based on experimental data this approach can be built into the combined experimental and modeling effort. However, it has been my experience that such an ideal situation rarely exists in "real world" situations. Therefore, in my opinion, the best approach is to use available datasets in conjunction with sound engineering principles and the investigator's best judgment to establish the validity of the exposure models."* Dr. Robert M. Clark, Chair Expert Review Panel, Maslia (Editor), 2009a, p. 76.

I concur with Dr. Clark's assessment given above. It is my opinion that ATSDR used the best available datasets, sound science and engineering principles, and professional judgment to establish the best possible reconstructed values of historical contaminant concentrations, and that, within a reasonable degree of scientific and engineering certainty, these were the contaminant levels delivered to Tarawa Terrace, Hadnot Point, and Holcomb Boulevard.

This assessment is reinforced by the successful peer review of ATSDR results in two top-tier journals (Maslia et al., 2009(b) for Tarawa Terrace and Maslia et al., 2016 for Hadnot Point-Holcomb Boulevard) along with the Grand Prize for Excellence in Environmental Engineering and Science Research (2015) from the prestigious American Academy of Environmental Engineering and Science for ATSDR's exemplary work at Camp Lejeune.

7. The NRC report

On June 27, 2009, I submitted a memorandum to EDRP/ATSDR which included my response to the NRC review comments on the Camp Lejeune study. The memorandum became an internal document for the Camp Lejeune study at ATSDR/CDC and was not released to the public. This section of my expert report includes both the contents of this memorandum and additional observations.

7.1 Comments on the NRC Report

The National Research Council (NRC) was requested to conduct a review by the Department of Navy (DON), under a mandate by the U.S. Congress (Public Law 109-364, Section 318). The U.S. Navy requested the NRC review to address whether adverse health outcomes are associated with past drinking-water contamination at U.S. Marine Corps (USMC) Base Camp Lejeune, North Carolina. The NRC review included an assessment of the Agency for Toxic Substances and Disease Registry's (ATSDR) overall study and in particular, the water modeling analyses and findings at Tarawa Terrace and vicinity. The NRC report released on July 13, 2009 (NRC 2009) covers a wide range of topics that include: (i) conceptual topics of exposure analysis and source characterization that are based on expert opinions of NRC committee members; (ii) water modeling based on observations of NRC committee and a critique of the science-based tools and analyses that are described in ATSDR technical reports on Tarawa Terrace and vicinity (Maslia et al., 2007; ATSDR, 2007); and, (iii) a critique of findings and interpretation of water-modeling study results that were completed by ATSDR at Tarawa Terrace and vicinity at Camp Lejeune.

On June 27, 2009, my responses to the NRC review were respectfully submitted to ATSDR to document my scientific evaluation of the findings of the NRC report. **Exhibit B** is the header of my original response to the NRC report.

To accurately respond to the comments made under each category I have identified above, the review comments I am providing below are grouped under two specific headings. This is in an effort so as not to confuse the reader and mix-and-match the review comments reported by the NRC committee which range from "conceptual topics" to the "comments on actual data reported" in the ATSDR water modeling study. I am confident that this approach will provide the reader with a clear picture of a range of topics critiqued in the NRC report. Accordingly, the discussion included in my review comments below will cover the range from "conceptual" perspectives on exposure analysis to "water modeling analysis" and "application specific" topics that are addressed in the NRC report.

It is important to note that the review comments I am providing below are only associated with the water modeling aspects of the ATSDR health study and the NRC report, and do not cover any epidemiologic study aspects since those topics are outside my expertise areas. All references to the "NRC report" refer to the NRC report titled, "Contaminated Water Supplies at Camp Lejeune: Assessing Potential Health Effects" and cited as NRC (2009) in the Reference section of this expert report. Furthermore, the reader should recognize that sentences in "italic font" under the heading "**Comment on…**" are extracted verbatim from the NRC report and statements in "regular font" under the heading "**Response**" are my responses to the specific NRC report statements.

7.2 Comments on the NRC report associated with conceptual topics of exposure analysis and site characterization.

Comment on p. 29: *Exposure assessment for epidemiologic studies of the effects of water-supply contamination includes two components. The first is estimation of the magnitude, duration, and variability of contaminant concentrations in water supplied to consumers. An important consideration is hydrogeologic plausibility: an association between a contaminant source and exposure of an individual or population cannot exist unless there is a plausible hydrogeologic route of transport for the contaminant between the source and the receptor (Nuckols et al., 2004). The second component is information on individual water use patterns and other water-related behaviors that affect the degree to which exposures occur, including drinking-water consumption (ingestion) and dermal contact and inhalation related to the duration and frequency of showering, bathing, and other water-use activities. Water use is an important determinant of variability of exposure to water-supply contaminants, particularly if it varies widely in the study population. Ideally, exposure-assessment strategies include both components, but in practice it may be difficult to obtain either adequately.*

Response: In this comment, which also includes a reference to the work of one of the committee members (Nuckols et al. 2004), the NRC committee is providing the reader with their understanding of the components of an exposure study that is associated with pollutants that may exist in an aquatic pathway at a contaminated site. The aquatic exposure analysis framework described in this statement is a conceptual statement and represents a very restrictive view of the exposure pathway analysis that needs to be considered at contaminated sites given the current understanding of the interaction between environmental pathways and the behavior of chemicals along those pathways. Current knowledge in this scientific field recognizes that in an aquatic exposure study the environment must be considered as a whole, and scientific and regulatory approaches alike must consider complex interactions between multimedia and intermedia interactions that exist in a multitude of potential environmental pathways at a site. In my opinion one should not emphasize only the concept of a "hydrogeologic connection" between the contaminant source and the exposure point as put forth by the NRC committee. This conceptual suggestion made by the NRC committee would be a very elementary and restrictive exposure analysis framework.

As specialists in this field, we know pollutants released to an aquatic environment are distributed among environmental media such as air, water, soil, vegetation etc., because of complex physical, chemical and biological processes. Thus, environmental pollution is a multi-pathway problem and environmental exposure assessment methods require that we carefully consider the transport, fate and accumulation of pollutants in the environment as a whole, (Cohen 1986; Aral, 2010). Methods that are proposed to evaluate environmental migration or exposure characterization in this envirosphere must consider all potential pathways and the interactions between these pathways. In scientific literature, the multi-pathway approach to environmental exposure analysis is identified as Total Exposure Characterization (TEC).

Elements of this multi-pathway analysis for an aquatic contamination source are imbedded in the ATSDR water modeling studies that were conducted for the Tarawa Terrace area of the Camp Lejeune site as much as possible. The specific pathways and processes considered in the ATSDR water modeling study are: (i) saturated groundwater; (ii) unsaturated groundwater; (iii) vapor emissions; (iv) multispecies analysis of contaminants in these three pathways; (v) mixing in the water treatment system; and (vi) estimates of contaminants in the water-distribution system. This was followed by proper epidemiologic studies that are not considered in this expert report.

In this analysis framework it is also important to recognize that one should not try to fit a physical problem to a model that may be readily available for use. Instead, appropriate models should be selected or developed that would fit the characterization of the physical problem at hand. Thus, selection of appropriate modeling tools to complete such an analysis is very important and is considered in sufficient detail in the ATSDR study. This is a very important point, which was either completely ignored in the NRC report or, steps taken by the ATSDR water modeling team to address these issues in a sound scientific and engineering manner were criticized by the NRC committee without providing any supporting evidence that is traceable to technical literature. I will revisit this issue in more detail in my comments below while providing case-specific public domain data and public domain information.

Comment on p. 33: *At a typical waste site, spent VOCs are present in the unsaturated zone (a partially saturated soil layer above the water table) in the form of dense nonaqueous-phase liquids (DNAPLs)....... (…* after a lengthy discussion of what DNAPL is and how DNAPL-based contaminants behave in the subsurface and what the consequences of such a source are, the NRC report continues in this section with the following remarks linking DNAPL presence to the aquifers at Camp Lejeune.*) ..... The presence of low-permeability units (such as the Castle Hayne confining unit or any clay units) would limit vertical migration of both DNAPL and dissolved contaminants.....*

Response: The NRC report does not provide any information for the justification of this conceptualization of the contamination source at the ABC One-Hour Cleaners site and Tarawa Terrace and vicinity other than providing a reference to a source concentration of 12,000 μg/L, reported in Chapter E of the ATSDR Tarawa Terrace report series (Faye and Green 2007, p. 38). This is followed by a reference to a number "110,000 μg/L" (p. 38 of the NRC report, second paragraph from bottom of page). As indicated in the NRC report, this is the highest possible concentration of tetrachloroethylene (PCE) in water. Because this reference value is given in the NRC report without a reference citation, I question the credibility of this reference value. The NRC report also does not discuss the importance of this number in their conceptualization of the contaminant source as a DNAPL. Furthermore, the NRC report does not refer to a data source on the solubility levels of PCE in water like those data sources reported in Chapter D of the ATSDR Tarawa Terrace report series (Lawrence, 2007). The NRC report does not refer to or cite a database that may exist in USMC files at Camp Lejeune, unknown to the ATSDR water modeling team, that NRC committee members may have had access to, that would indicate the presence of DNAPL-phase PCE at the site. The NRC report also does not refer to a systematic dry-cleaner disposal procedure that is reported in the documents they have reviewed for handling the disposal of the chemical PCE as a pure phase PCE at the ABC One-Hour Cleaners site.

In the NRC report, the highest concentration of dissolved PCE, 110,000 μg/L, must imply the NRC committee's understanding of the solubility level of PCE in water. Because a reference is not provided, I could not confirm this number. However, our references indicate that the solubility of PCE in water is around 200,000 μg/L (= 200 mg/L) at 15°C or higher. In Chapter D of the ATSDR Tarawa Terrace report series (Lawrence 2007, p. D12, Table D9), solubility of PCE is reported to be 210, 000 μg/L (=210 mg/L) at 25°C, which is the solubility number I would like to work with for my analysis below. There are other references in the literature that report the solubility of PCE at much higher concentrations as well, which are not referenced here. This is because I would like to focus on what is reported in the ATSDR Tarawa Terrace series of reports (ATSDR, 2007a).

The 12,000 μg/L concentration reported in NRC report (and in Chapter E of the ATSDR Tarawa Terrace report series [Faye and Green 2007]) as a justification for the presence of a DNAPL phase is about 5.7%

to 6% of the solubility level of PCE (12,000/200,000 = 6% or 12,000/210,000 = 5.7%). The 12,000 μg/L concentration is the dissolved-phase PCE concentration in the groundwater at ABC One-Hour Cleaners as reported by ATSDR (Faye and Green 2007). Although this is a high concentration, this value is much less than PCE's solubility limit in water (200,000 μg/L at 15°C or 210,000 μg/L at 25°C). Even at the lowest solubility value reported by USEPA 150,000 μg/L this concentration level is at 8% of the solubility level (USEPA, 2024). The location of the highest concentration sample within Tarawa Terrace and vicinity can be used to identify the source location at the site. High concentrations at a site may suggest the possibility of non-aqueous phase (NAPL) PCE (PCE in form of NAPL) presence but this does not guarantee a NAPL presence at the site, because in this case, 12,000 μg/L is 6% or less of the solubility limit of PCE (see Section 6.4 of this expert report).

Thus, the conceptual DNAPL contaminant source characterization that is provided in the NRC report without any justification and without any field data support is bothersome. This reference to the presence of a DNAPL-phase contaminant source at the site not only appears in this comment on NRC report page 33, but it is repeatedly referred to in other pages of the NRC report which is not clear and correct understanding of the source conceptualization (see discussion of "Dissolved phase pollution vs NAPL, LNAPL and DNAPL pollution" in Section 6.4). In my opinion the NRC committee needs to provide further technical and field data evidence in support of their DNAPL conceptualization. Also reporting the solubility of PCE in water at about half the value of the data reported in the ATSDR Chapter D report (Lawrence 2007) without providing a reference (page 38 of the NRC report) is not scientifically acceptable. Short of citing field data evidence and an appropriate reference for the solubility level of PCE as reported in the NRC report, I would question the scientific basis of this conceptualization. Further, without field data evidence, the NRC review is based on hypothetical conditions and assumptions that are extracted from the scientific work of others (Figure 2-3 of the NRC report) which is based on studies that are conducted at other sites. It is my opinion that these sites have no relevance to the ABC One-Hour Cleaners site or Tarawa Terrace and vicinity. The purpose of this assertion (PCE as DNAPL source conceptualization) and misrepresentation of the site data by the NRC committee is not clear to me.

During the NRC committee review process, the question of the characterization of the source was brought to the attention of ATSDR water modeling team members in a request for information by an NRC committee member (Email communication from P. Clement to M.L. Maslia, ATSDR, May 5-11, 2008). At that time, ATSDR water modeling team members provided the NRC with data ATSDR had on the subject matter clearly showing why the modeling team elected to simulate the PCE source as a dissolved-phase source.

Furthermore, the modeling team clearly identified why the dissolved-phase injection procedure applied in the models used for the ATSDR water modeling analyses. The information that was provided to the NRC was based on data from several remedial investigation reports, site reports, and other DON and USMC files (Shiver 1985, Roy F. Weston 1992, 1994). In these field study reports, there is no recorded data reported by DON and USMC consultants that would provide evidence of, or substantiate the existence of, the presence of a DNAPL source at ABC One-Hour Cleaners or Tarawa Terrace. If the DNAPL source conceptualization that appears in the NRC report is based solely on the data source and information we provided to the NRC committee, then I do not agree with the NRC's source characterization. I, therefore, consider this to be a misinterpretation of the conditions at the site. If this conceptualization is based on any other information or data that I was not aware of, and if this information was provided to NRC by DON, the USMC, or their consultants, the modeling team should have been provided with that information and data. Because the reference to a DNAPL-phase in the aquifers underlying ABC One-Hour Cleaners and Tarawa Terrace and vicinity appears in several places within the NRC report, I will revisit this topic again in my discussions below.

In the statement on page 33 of the NRC report, I also noticed that the NRC committee acknowledged that the PCE source was discharged to the unsaturated zone of the aquifer underlying ABC One-Hour Cleaners and Tarawa Terrace and vicinity. However, given that observation, the NRC committee fails to provide a justifiable critique of the use of the **MODFLOW** family of codes that only considers a saturated groundwater zone to analyze the physical problem at the site. On the contrary, the NRC committee considers the **MODFLOW** family of codes to be an acceptable modeling choice throughout the NRC report. This is probably because the NRC committee considers the **MODFLOW** codes as accepted state-of-the-art tools for typical groundwater pathway modeling. This is an example of a typical case of fitting a physical problem to a code "concept" I referenced in my response statement "7.2" above, which the ATSDR water modeling team tried to avoid as much as possible (see the discussion in section 6.1 and **TechFlowMP** application in section 5.1).

In recognition of this problem and in recognition of the general perception that prevails in the scientific community that the **MODFLOW** family of codes is an accepted procedure, the ATSDR water modeling team first utilized the **MODFLOW** and **MT3DMS** codes in their simulations. In addition, to enhance our understanding of conditions at the site, ATSDR extended its analyses. The ATSDR water modeling team applied the **TechFlowMP** software to understand and evaluate the unsaturated zone injection conditions that are implemented at the site. **TechFlowMP** is a public domain code that can be accessed from the Georgia Tech website for individual use without a fee (http://mesl.ce.gatech.edu/). The NRC report attempts to discredit this extra effort and the steps taken by the ATSDR water modeling team to simulate the proper source disposal conditions at the ABC One-Hour Cleaners site by classifying: (i) **TechFlowMP** code as a research tool; and (ii) as a proprietary code that is not verified. Again, this is very puzzling and a misrepresentation of the scientific and public domain facts of this case by the NRC committee. These NRC statements that appear in several places in the NRC report ignore a scientifically sound attempt by the ATSDR water modeling team to properly evaluate a physical problem, above and beyond a traditional **MODFLOW** and **MT3DMS** application which the NRC review committee accepts (NRC 2009, p. 43). Further, the NRC committee failed to check current technical literature and scientific publications containing substantial evidence of publications involving the **TechFlowMP**. The evidence that the **TechFlowMP** code has been tested and verified against other applications (see section 5.1) exists in this technical literature. (web site: http://mesl.ce.gatech.edu/PUBLICATIONS/Publications.html). This lack of due diligence by the NRC committee is puzzling.

It is equally important to note that the use and application of specialized codes to address specific problems that codes, such as **MODFLOW** and **MT3DMS**, cannot address, is not shunned by government-based scientific organizations, but rather, it is recognized and encouraged. As stated in the U.S. Environmental Protection Agency report, "Guidance on the Development, Evaluation, and Application of Environmental Models" (USEPA 2009, p. 31): **"However, the Agency acknowledges there will be times when the use of proprietary models provides the most reliable and best-accepted characterization of a system."** The point being made in this statement is that the most appropriate model should be applied to characterize a system, not necessarily, the most popular or most often-used model; and this is the exact modeling philosophy and approach that ATSDR took when applying the **TechFlowMP** and **PSOpS** and other sub-models at ABC One-Hour Cleaners and Tarawa Terrace and vicinity (see discussion of this topic in section 5.1).

7.3 Comments on the NRC report associated with science-based tools, analysis and interpretation of study results.

Comment on p. 43: *For example, **MT3DMS** can predict the transport only of dissolved contaminants, so a key approximation was made to represent the mass dissolved from the DNAPL source. To apply **MT3DMS**, ATSDR replaced the highly complex DNAPL contaminated source zone with a hypothetical model node where PCE was injected directly into the saturated aquifer formation at a constant rate (1.2 kg/day).*

Response: This NRC report statement relies on their unsubstantiated and undocumented source characterization concept (see my review comment above and in section 6.4). Using this conceptualization as an undisputable fact, the NRC committee then attempts to discredit the groundwater-modeling study conducted by ATSDR at the ABC One-Hour Dry Cleansers site and Tarawa Terrace and vicinity. This statement is a hyperbole, wherein first an "assumption" is made which is wrong and then that "assumption" is considered to be a "fact" to critique the findings of a study. This approach in a scientific critique is puzzling.

Comment on p. 43: *Unlike the MODFLOW and MT3DMS codes, the PSOpS and TechFlowMP codes lack validation by a broad spectrum of practicing geoscientists in an open-source environment.*

Response: I have addressed the point the NRC committee chose in reference to the misrepresentation of **TechFlowMP** as an unverified code in my response above. I will not repeat that here. In reference to the **PSOpS** and other sub-model developed by the Georgia Tech research group (see section 5.1), the following needs a clear answer: Can a reference to a public domain code be provided by the NRC committee members that is available through the published literature that provides the analysis performed by **PSOpS** and other sub-models? Has such a public domain code been developed for, and applied to, any study that they are aware of to manage pumping-schedule operations in an optimal manner for a complex system such as the one at Tarawa Terrace? The answer to these questions is obvious and the answer is: "This type of public domain model does not exist in the literature and needed to be developed to complete the study in appropriate scientific confidence bounds."

PSOpS is an optimization application that was developed by the MESL-Georgia Tech research group participating in the ATSDR water modeling analysis to yield answers to specialized uncertainty-related questions pertinent to the current health study conducted at Camp Lejeune site. The analysis is based on the **MODFLOW** family of codes in the generation of the database used to solve an optimization problem. The development of this optimization model was necessary to respond to scientific questions raised by the ATSDR Expert Panel (March 2005) whose members guided our study and contributed significantly to its quality. The members of this ATSDR Expert Panel are well known and respected scientists in the field and their names are listed in the Expert Panel report (Maslia 2005) that is also available on the ATSDR website. The question ATSDR Expert Panel members raised in this case was related to the uncertainty of a pumping-schedule operation that may be implemented at the site and the characterization of its effects on the study outcome. The **PSOpS** model that was developed for the purposes of this analysis and used in the ATSDR water modeling analyses to address this question became part of the peer reviewed PhD thesis of a graduate student at Georgia Tech. In that sense, the theoretical background of the model is reviewed and accepted by independent PhD thesis committee members at Georgia Tech and the detailed documentation of this model can be found in the PhD thesis of Dr. J. Wang, which is public domain information (Wang, 2008).

In conclusion, the NRC committee is most likely aware of the following: (1) specialized models such as **PSOpS** are not available in the technical public-domain literature; and (2) codes such as **PSOpS** only are developed for the specialized purposes of the current study to find answers to specialized questions that are raised by the current water modeling analysis. The concept of using an optimization algorithm that is fed by a database through the **MODFLOW** family of models, which is a common and routine procedure, is both scientifically sound and scientifically necessary in a study such as the one ATSDR conducted at Camp Lejeune site. If a public domain model existed that can be used for this study, that would serve the same purpose, instead of the **PSOpS** model, we would have used that model instead of the **PSOpS** model. To my knowledge, such a model is not available. In my opinion, the NRC committee also should recognize that the ATSDR water modeling effort is not a run-of-the-mill work-product and the problem at hand is not a routine problem that can be or should be analyzed using routine models. In such cases it is expected that specialized methods can be developed and implemented; this should not be shunned by the NRC, but instead, it should be encouraged (see USEPA comment and reference above) (USEPA 2009, p. 31).

Comment on p. 44: *The DNAPL source zone was represented by using a model node where PCE was injected continuously into the unconfined model layer-1 of the saturated zone at a constant rate of 1.2 kg/day (Faye 2008).*

Response: Again, in this statement, the NRC committee is asserting that the DNAPL source zone was misrepresented in the current study. I refer to the reader to my previous comments in my response to the DNAPL source mischaracterization by the NRC committee also see section 6.4 of this expert report.

To reiterate, we have not represented a DNAPL source zone as an injection point in our models because there is no DNAPL source zone in the aquifer underlying the ABC One Hour Dry Cleaners site at Tarawa Terrace and vicinity. If the claim of the NRC committee can be substantiated by any field data, I stand corrected. Not only I would stand corrected, but also, I would strongly recommend that the U.S. Environmental Protection Agency (USEPA), their consultants, and the North Carolina Department of Environment and Natural Resources (NCDENR) should immediately abandon their remediation efforts at the ABC One-Hour Dry Cleaners site at Tarawa Terrace and vicinity and adopt remediation strategies that would yield more effective results for a DNAPL source contaminant. The U.S. Environmental Protection Agency (USEPA), their consultants, and the North Carolina Department of Environment and Natural Resources (NCDENR) conducted remediation efforts at the ABC One-Hour Dry Cleaners site at Tarawa Terrace and vicinity using remediation strategies directed toward a dissolved phase contaminant. The fact that USEPA and NCDENR field consultants did not implement DNAPL remediation technologies at the site is additional evidence that these agencies and their consultants also do not agree with the NRC committee as to the characterization of the contamination source as DNAPL phase PCE.

Comment on p. 48: *Because insufficient historical pumping data were available to constrain the model predictions from 1953 to 1980, the ability of the advanced optimization models to estimate the dates accurately is questionable.*

Response: There are obvious uncertainties in the physical problem being studied at ABC One-Hour Dry Cleaners and Tarawa Terrace and vicinity. The NRC committee would most likely agree with this statement. If we accept this statement, then the question becomes, should one completely ignore uncertainty in the analysis or should one try to develop techniques that would provide an estimate of the effects of uncertainty on the solution in a systematic way? In this study we have chosen the second route, which is the sound science alternative which documents the inherent level of uncertainty.

The NRC committee should accept the fact that answers to uncertainty questions cannot be answered "**accurately**" as the NRC report states in the above statement. Expecting that from an uncertainty analysis outcome would be scientifically irresponsible. Our uncertainty analyses are not provided to give "accurate" answers to the problem studied. Instead, our uncertainty analyses are used as estimates that would indicate the variability range of deterministic results provided earlier. The domain of uncertainty analysis is a scientific field which is not in the realm of the traditional groundwater fate and transport analysis expertise and should be viewed using a different microscope and expertise. ATSDR's uncertainty analysis is a reliable and accepted methodology in the field of environmental modeling.

Comment on p. 48: *(5) there is no spatial variation in the microbiologic or geochemical characteristics.*

Response: The NRC committee correctly identified that in the application of the TECHFLOWMP model to the aquifers underlying the ABC One-Hour Dry Cleaners site and Tarawa Terrace and vicinity, we assumed no spatial variation of microbiologic characteristics. If the NRC committee is familiar with the finite element procedures used in the **TechFlowMP** model, they would acknowledge that this is not a restriction of the model but a restriction on the available field data for the site. If the microbial distribution in an aquifer can be accurately characterized, which we doubt can be accomplished in this case or in any case, we can certainly include that heterogeneity in our modeling effort.

Having pointed out this fact, I would also like to question issues pertaining to levels of acceptable homogeneity considered in our modeling effort and compare it with levels of unacceptable homogeneity that are shunned in our modeling analysis based on the critique presented in the NRC report. For example, the assumption of uniform infiltration across the model domain when the MODFLOW family of model codes is utilized was not critiqued in the NRC report, but the assumption of uniform microbial distribution in the multilayer aquifer domain is critiqued. Between these two processes, which would be the easier process to characterize and implement? I think the answer to this question is obvious, the infiltration process would be easier. Thus, although both processes are characterized by heterogeneity in the aquifer, accepting the homogeneity assumption for the infiltration case but not accepting homogeneity assumption for the microbial distribution case would be setting the bar too high and would be scientifically irresponsible considering the levels of data that may be available to characterize either process. A scientific review committee should be able to make these distinctions easily and come up with appropriate conclusions in their review comments.

Comment on p. 49: *However, there are some important limitations in ATSDR's modeling efforts because of the sparse set of water quality measurements, the need to make unverifiable assumptions, and the complex nature of the PCE source contamination.*

Response: There are limitations of the modeling analyses conducted by ATSDR water modeling team. We would be the first to acknowledge these limitations. This is evident by the level of detail of the uncertainty analysis conducted as part of the water modeling analysis to envelope the effect of those uncertainties on the outcome presented. However, in my opinion, characterizing the uncertainty analysis outcome as not "**accurate**" as previously stated (see response above) or, that uncertainty analysis should only be conducted in "**verifiable**" cases as stated above is not a scientifically sound assessment or procedure. As we all agree, **an uncertainty that can be verified would be no longer uncertain**.

Regarding the lack of historically measured values of contamination, it was not required to measure these contaminants in the timeframe of interest, according to regulatory agencies. It was when trihalomethane (THM) measurements were first required, those analytical techniques were utilized that could detect the presence of other halogenated (e.g., chlorinated) compounds like PCE and TCE. The lack of such measured values points to the need for historical reconstruction efforts – the NRC report offers no better alternative.

I fully agree with the NRC observation that "ATSDR applied best practices and cutting-edge modeling approaches to predict the complex groundwater-contamination scenario" (NRC, 2009; p 65) necessary for establishing reconstructed exposure levels. ATSDR conducted sensitivity analyses in both the 2009 Tarawa Terrace study (ATSDR, 2009) and the later 2013 Hadnot Point / Holcomb Boulevard study (ATSDR, 2013) that generated a range of possible exposure levels at a given point in time. Thus, in my opinion ATSDR not only satisfied but also built upon input from the NRC report to produce the best-possible engineering and scientifically valid information for assessing historical exposure levels at Camp Lejeune.

Comment on p. 49 first bullet: *The effects of the DNAPL in both unsaturated and saturated zones have not been included in the studies.*

Response: The NRC report brings back the DNAPL issue here again. Please see my response in the comments above.

Comment on p. 49 second bullet: *Constant values of dispersivity (longitudinal dispersivity of 25 ft and transverse 2.5 ft) were used in the transport model.*

Response: Although dispersivity is constant, based on the definition of the hydrodynamic diffusion coefficient, the hydrodynamic diffusion coefficients are variable because they depend on the velocity field at the site. This is a common assumption in most studies where field data are not available to support spatially variable dispersion/diffusion coefficients. This comment again is related to my discussion of acceptable homogeneity and unacceptable homogeneity conditions at a site study above.

Comment on p. 49 bullet four: *The numerical codes **TechFLowMP** and **PSOpS** used in the modeling are research tools and are not widely accepted public-domain codes, such as **MODFLOW** and **MT3DMS**, so their validation is important.*

Response: This characterization is a misrepresentation of the models, as clearly identified in my response above. The availability of codes with the capabilities of these models is very limited. In my opinion the use of these models in complex analysis should not be shunned by NRC, but instead, it should be encouraged since these models provide supplemental information beyond **MODFLOW** family of code applications (USEPA 2009, p. 31).

Comment on p. 49 bullet five: *The **PSOpS** modeling study is based on the premise that an optimization model can be used to evaluate pumping stresses. Without site-specific pumping and water-quality data, the results will be nonunique and uncertain.*

Response: PSOpS modeling concept is based on the effort of estimating the effects of uncertainty on the modeling outcome. This analysis is approached in a systematic manner following accepted processes such as an optimization analysis based on some constraints to satisfy the demands. The **PSOpS** model uses the **MODFLOW** family of codes as its database engine. We are not claiming that the outcome provides the exact conditions representing the problem at the site. But the outcome of the analysis provides us with an envelope which bounds our deterministic analysis. This is a standard uncertainty analysis procedure like, for example, Monte Carlo analysis that is routinely used in uncertainty analysis. Monte Carlo analysis, according to a well-established procedure, systematically evaluates the effects of uncertainty on the problem solution based on random synthetic data generation. In such an application, it is not certain that the random numbers generated would exactly represent the actual conditions for the problem at the site. However, the bounding limits of the analysis are the goal of the analysis. The application of **PSOpS**, in essence, is very similar to that analogy.

As I have stated earlier, this goes back to the NRC report statement about the "**accuracy**" of the uncertainty analysis results that cannot be justified scientifically. Also, I must emphasize again what I stated earlier: The domain of uncertainty analysis is a scientific field which is not in the realm of the traditional groundwater fate and transport analysis expertise and should be viewed using a different microscope and expertise.

Comment on p. 49 bullet seven: *The **TechFlowMP** model predicted very high vapor concentrations. For example, **TechFlowMP** predicted that the PCE vapor concentration in the top 10 ft of soil beneath the Tarawa Terrace elementary school should be 1,418 μg/L. Studies of PCE vapor concentrations in buildings that house or are near a drycleaning facility have reported measured concentrations around 55 μg/L.*

Response: This reference to a vapor concentration at 1,418 μg/L is another example of misrepresentation of the results of the modeling analyses conducted by the ATSDR water modeling team. This aforementioned information was taken from Chapter A of the ATSDR Tarawa Terrace report series (Maslia et al. 2007, p. A44). The statement provided in the ATSDR report reads as follows: ***"b. the maximum simulated PCE concentration in groundwater (model layer 1) at the Tarawa Terrace elementary school was 1,418 μg/L (Figure A15b), whereas the maximum simulated vapor-phase PCE (in the top 10 ft of soil) was 137 μg/L (Figure A20a)"***

The above sentence, taken directly from the ATSDR report submitted to NRC, clearly states that the groundwater (not vapor) concentration of PCE in layer "1" is at 1,418 μg/L concentration. Vapor concentration is given separately in the paragraph towards the end of that sentence. For the NRC report to represent this number (1,418 μg/L) as the vapor concentration that is simulated at the site to discredit a study is not appropriate for a scientific review. I will provide a more detailed analysis of this case using simulation results to bring clarity to the concern raised in the NRC report.

In this case, the work product referred to are the **TechFlowMP** modeling results and the analysis mentioned was conducted by the MESL - Georgia Tech research group participating in the ATSDR water modeling analysis of the ABC One-Hour Cleaners site and Tarawa Terrace and vicinity (Jang and Aral 2007). To provide the reader with clear evidence of scientific misrepresentation of the facts, the actual data reported in our report is presented below in sufficient detail, unlike the other responses I have provided to other comments in this document. In the numerical study of the multispecies, multiphase groundwater contamination at ABC One-Hour Dry Cleaners and Tarawa Terrace and vicinity, **TechFlowMP** simulations used two boundary-conditions to characterize the ground surface under the original pumping schedule: (1) GSBC = 0.01 and (2) GSBC = 1.0 (Jang and Aral 2007, p. G15). Here the acronym "GSBC" stands for the Ground Surface Boundary Condition. For the in-/out-flux of gas between the atmosphere and the unsaturated zone, if the ground surface does not have low-permeable zones or hindrances due to pavement, lakes, or buildings, the GSBC value is set to be 1.0. This implies that soil gas can be freely released into the atmosphere from the unsaturated zone. However, when some objects, including roads, buildings, ponds, or highly water-saturated areas, are present at the ground surface, the soil gas cannot be released into the atmosphere freely. Under such a condition, GSBC is set to be 0.01 in the current study. In a typical application, any number between these two extremes can be considered in the analysis. However, just to show the bounds of the results, the discussion here will be confined to these two extreme cases.

To analyze the concentration distribution around the school area as it is referred to in the NRC report comment, the location of the school at Tarawa Terrace must be identified and is shown in Figure 1 (ATSDR, 2007; ATSDR 2013).

Figure 1. Location of the Tarawa Terrace Elementary School

In the school area, the groundwater table is near the ground surface (CH2MHILL 2007). In this study, the ground surface is at z = 7.6 meters (m, z = 25 ft), and the groundwater table is around z = 2.4 - 4 m (z = 8 - 13 ft) (Jang and Aral 2007, Figure G3, p. G10). Thus, the concentration distributions of the vaporized PCE at z = 6 m are presented below, where the unsaturated zone is at this location.

As shown in Figure 2 (ATSDR, 2007a), under GSBC = 0.01, which is more representative of an area where there are buildings and pavements, the predicted vaporized PCE concentrations in the pore space of the soil at the center of the school area (x = 2,580 m, y = 1,975 m) are about 15.5 μg/L during December 1984 (Figure 2a) and 3.7 μg/L during December 1994 (Figure 2b). Within the school area (marked with the circle in this figure), the PCE concentration ranges 0.1-100 μg/L during December 1984 (Figure 2a) and 0.1-50 μg/L during December 1994 (Figure 2b) (ATSDR, 2007a).

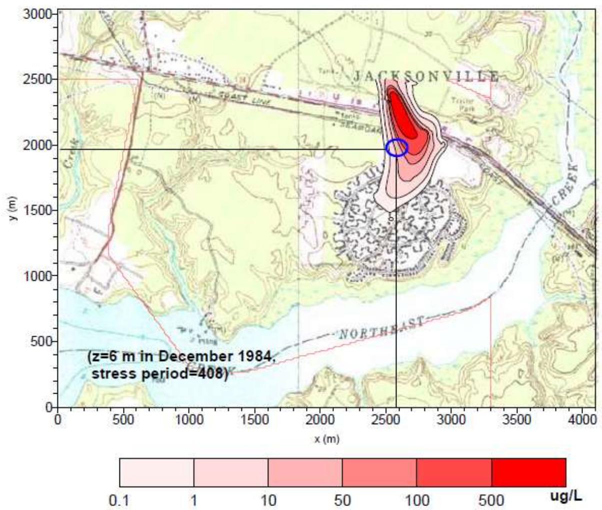

Figure 2a. Vaporized PCE concentrations in the gas phase under the original pumping schedule (PS-O) with GSBC=0.01, at z=6, December 1984.

In Figure 2, the vaporized PCE concentrations near the ABC One-Hour Cleaners site are very high where the contamination source is located. This is expected, but the vapor concentrations decrease sharply with the distance away from the ABC One-Hours Cleaners site. Furthermore, the simulated concentration of PCE in the gas phase, ranging from 0.1 to 100 μg/L, is not significantly different from the value of 55 μg/L, given in the NRC report.

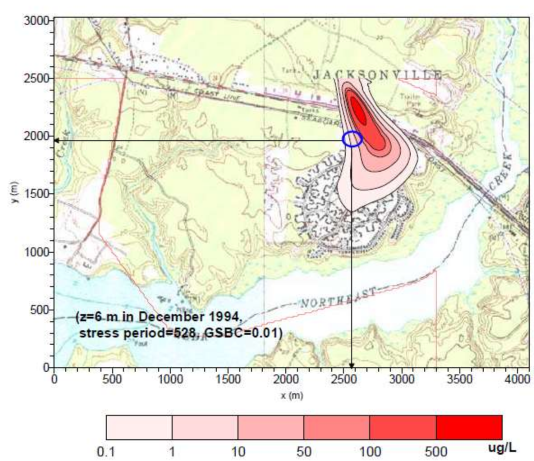

Figure 2b. Vaporized PCE concentrations in the gas phase under the original pumping schedule (PS-O) with GSBC=0.01, at z=6, December 1994.

Having provided this comparison, I also question the source of the reference number, 55 μg/L, that is used in the NRC report. The NRC report provides a reference for this case and this reference is McDermott et al. (2005). I was curious about this reference; therefore, I located and obtained a copy of the referenced paper. In the McDermott et al. (2005) study, the authors are analyzing and reporting data on the PCE vapor concentrations in a building where dry-cleaner operations are housed in New York City.

Does the NRC committee expect us to accept the concept that what is observed (measured) as vapor concentration in a building that houses a dry-cleaner facility in New York City should also apply to the subsurface pore space of the soil at the site of an elementary school area in Camp Lejeune, North Carolina? Or do they expect that what we have simulated in the pore space of the soils at a site in North Carolina should also confirm the observations made in New York City, 17-20 years beyond our final simulation date (2001-2003), in some dry-cleaner facility building? In my opinion, these types of comparisons, expectations, and assertions are scientifically not acceptable or credible.

In the groundwater contamination study that utilized TECHFLOWMP (Jang and Aral 2007), the local equilibrium of contaminant partitioning between the water and gas phases is implemented while calculating the contaminant distribution between the two phases (gas and liquid). Thus, we can use the Henry coefficient, H, in estimating PCE concentration in the gas phase from the concentration in the groundwater phase as follows:

$$C_{Vapor,PCE} = HC_{GroundWater,PCE}$$

For PCE, H is 0.35 (Jang and Aral 2007, Table G2). Using the dissolved PCE concentration in the groundwater shown in Figure G5 of Jang and Aral (2007) (in the unsaturated and saturated zones), the overall concentration distribution of the vaporized PCE within the gas phase in the unsaturated zone can also be estimated. This simple calculation could have been made by the NRC committee to confirm the vapor concentration numbers they are reporting in their statement. In Figure G5 of Jang and Aral (2007), the dissolved PCE concentration in the groundwater is 100-500 μg/L near the ground surface at the location of the elementary school (x = 2,580 m, y = 1,975 m). Therefore, the vaporized PCE concentration will be approximately 35-175 μg/L in the unsaturated zone near the school area. The cross-section line A-A, in Figure G5 is located at x = 2,606 m.

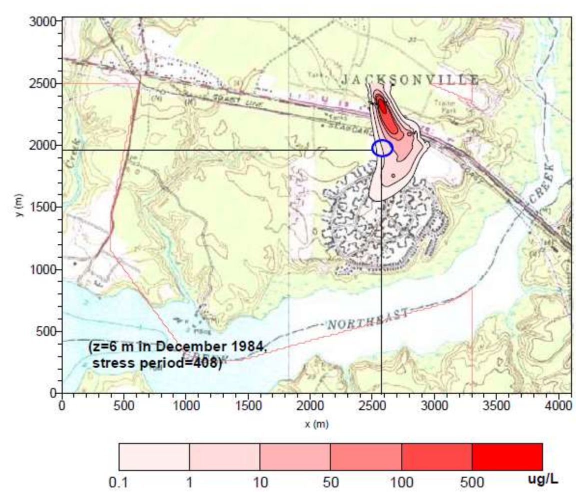

Figure 3a. Vaporized PCE concentrations in the gas phase under the original pumping schedule (PS-O) with GSBC=0.01, z=6, December 1984.

Let us also analyze the results of the other boundary condition that is used in the **TechFlowMP** model out of curiosity and see if the vapor concentration value of 1,418 μg/L reported in the NRC report was referring to that case. The results reported in (Jang and Aral 2007) under the condition GSBC = 1 are shown in Figure 3 (ATSDR, 2007; ATSDR 2013). The predicted vaporized PCE concentrations at the center of the school area (x = 2580 m, y = 1975m) are about 0.99 during December 1984 (Figure 3a) and 0.1 μg/L during December 1994 (Figure 3b) (ATSDR, 2007; ATSDR 2013) (i.e. more PCE vapor is released to the atmosphere and less is remaining in the pore space when compared to the previous results). Within the school area (marked with the circle in the figure), the concentration ranges 0.1-10 μg/L in December 1984 (Figure 3a) and less than 5 μg/L in December 1994 (Figure 3b) (ATSDR, 2007).

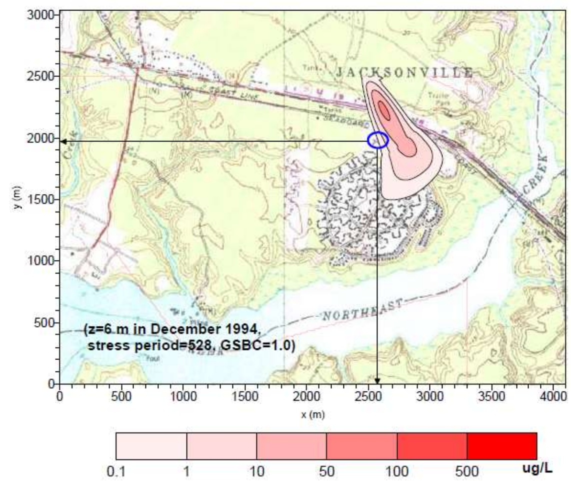

Figure 3b. Vaporized PCE concentrations in the gas phase under the original pumping schedule (PS-O) with GSBC=0.01, z=6, December 1994.

As can be seen from these results the number reported in the NRC report does not exist in the ATSDR water-modeling analysis as vapor concentration. This is a clear misrepresentation of the ATSDR water modeling results.

The field investigation during 2007 (CH2MHILL 2007) it was reported that the vaporized concentrations of PCE near the ground surface were below detection limits or very low, 3.9 ppbv (parts per billion volume), which is equivalent to 0.028 μg/L. Considering the time gap between the end of the historical simulation time (December 1994) and the field investigation time (July 2007), the simulation results that are provided in the Chapter G report of the ATSDR Tarawa Terrace report series (Jang and Aral 2007) provide reasonable modeling results and represent acceptable levels of expected vapor concentration near the Tarawa Terrace elementary school. Are we asserting that this is absolutely the case? The answer to that question is absolutely "No." This outcome is only an estimate based on the assumptions and limitations of the models considered and the boundary conditions used in the ATSDR water modeling analyses and the assumptions and limitations are based on our best judgment of the conditions that may exist at the ABC One-Hour Dry Cleaners site and Tarawa Terrace and vicinity.

The ATSDR water modeling reports do not report such high concentration of vaporized PCE concentration in the gas phase. The vaporized PCE concentration of 1,418 μg/L is equivalent to a dissolved PCE concentration of 4,051 μg/L, in the groundwater which does not exist in our results:

$$C_{Vapor,PCE} = HC_{GroundWater,PCE}$$
$$C_{GroundWater,PCE} = 1418 / 0.35 = 4051.4$$

I also note that the unsaturated zone is located at a very thin layer near the ground surface (z = 7.6 m (25 ft)) in Jang and Aral (2007, Figure G5) which is characterized in terms of several layers in water-modeling analysis. The maximum thickness of the unsaturated zone is about 7.6 m.

In conclusion the data, the associated discussion of the vapor levels near the Tarawa Terrace elementary school area, and the reference provided in the NRC report (McDermott et al. 2005) are far from the facts of the case and the results that are presented by the ATSDR water modeling team.

Comment on p. 49 bullet eight: *The biodegradation model used within the **TechFlowMP** code is based on an untested preliminary research model.*

and also,

Comment on p. 50: *The **TechFlowMP** simulations assumed that the biodegradation byproduct of TCE is trans-1,2-DCE. However, the scientific literature indicates that cis-1,2-DCE is the predominant product of TCE reduction under in situ groundwater conditions.*

Response: The detailed description of why trans-1,2-dichloroethylene is chosen as the representative byproduct of TCE bioreaction at the Tarawa Terrace area instead of cis-1,2-DCE is given in page G4 of the report, Chapter G (Jang and Aral, 2007). An additional explanation regarding this issue is given below.

As shown in Figure G2 of the report (Jang and Aral, 2007), the anaerobic biological degradation of trichloroethylene (TCE) generates three isomers, cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), and 1,1-dichloroethylene (1,1-DCE). As discussed in the report (Jang and Aral 2007), cis-1,2-DCE (1,2-cDCE) is the most common byproduct among the three DCE isomers produced theoretically (Wiedemeier 1998). Even though cis-1,2-DCE has been often used as a primary byproduct of TCE-biodegradation under the anaerobic conditions in contaminant transport modeling of chlorinated ethenes (Clement et al., 2000; Jang and Aral, 2008), but the primary byproduct of the TCE bioreaction highly depends on the chemical-biological conditions (especially, microorganisms and nutrients) at the contaminated sites (Bradley, 2003), implying that the biological reaction of TCE is highly site-specific. For example, Christiansen et al. (1997) and Miller et al. (2005) reported the anaerobic biological degradation of TCE produced more trans-1,2-DCE than cis-1,2-DCE. At the TCE contaminated site in Key West, Florida, the ratio of trans-1,2-DCE to cis-1,2-DCE was greater than 2 (SWMU9, 2002). Griffin (2004) reported that the ratio could reach up to 3.5, based on field data for several sites, including Tahquamenon River, MI; Red Cedar River, MI; Pine River, MI; and Perfume River, Vietnam.

In the modeling of contaminant transport at a contaminated site, the field measurement data at the site are very important in validating the numerical models and in obtaining more accurate simulation results. For the numerical study at the Tarawa Terrace area, we had limited field data regarding the concentrations of PCE, TCE, and trans-1,2-DCE. This is indicated in the following statement of the ATSDR report: Review of degradation byproduct data analyses, provided to ATSDR by the Department of the Navy, U.S. Marine Crops, the North Carolina Department of Environment and Natural Resources, and others indicated that the predominant degradation byproduct of TCE at Tarawa Terrace and vicinity was trans-1,2-DCE (Faye and Green 2007, Tables E2 and E7).

As mentioned above, since the primary byproduct of the biological degradation of TCE depends on site-specific conditions, it is more reasonable to select trans-1,2-DCE instead of cis-1,2-DCE as a primary TCE-bioreaction-byproduct in the study on the groundwater contamination at the Tarawa Terrace area.

The NRC critique, therefore, ignores site-specific TCE degradation by-product data pertinent to Tarawa Terrace and vicinity, listed in Chapter E of the Tarawa Terrace report series. This statement again clearly demonstrates the lack of due diligence by the NRC review committee in their review of the data that exists at the Tarawa Terrace, Camp Lejeune site and their lack of understanding of the facts of the site-specific case based on this data.

Comment on p. 50 next to last bullet: *In the absence of data, historical reconstruction efforts that use groundwater models can only provide a general conceptual framework for what happened at the site and why.*

Response: Historical reconstruction is a procedure that is accepted in literature. It uses models to predict the past in a conceptually similar manner to the models that are routinely used to predict the future in other engineering studies. The ATSDR response document provides references to such historical reconstruction applications.

Comment on p. 65: *Therefore, the committee recommends the use of simpler approaches (such as analytic models, average estimates based on monitoring data, mass-balance calculations, and conceptually simpler* ***MODFLOW/MT3DMS*** *models) that use available data to rapidly reconstruct and characterize the historical contamination of the Hadnot Point water-supply system. Simpler approaches may yield the same kind of uncertain results as complex models but are a better alternative because they can be performed more quickly and with relatively less resources, which would help to speed-up the decision-making process.*

Response: Use of simpler models may be easier to implement. We have also proceeded in that direction as well for the Hadnot point study. However, how the detailed questions that are raised in the NRC report could be answered using simpler models is not clear to me. Further, simpler models will not necessarily reduce the level of uncertainty. Instead, they may introduce conceptual misrepresentation of the physical system modeled. The ATSDR's approach, which in my opinion is the correct approach, is to use the most appropriate model that can provide the needed information, rather than the simplest or an off the shelf model.

CONCLUSIONS:

The scientific and engineering evidence presented in this response statement (submitted to EDRP/ATSDR as a memorandum in 2009) and the discussion of this evidence herein clearly indicate that the data and the analysis presented in the NRC report (NRC, 2009) are misrepresentations and mischaracterizations of the findings of the ATSDR water modeling analyses conducted at the ABC One-Hour Cleaners site, Tarawa Terrace area and vicinity. The conceptual characterization of the contaminant source made by the NRC committee also does not fit available field data or reported field conditions by the USEPA, their consultants, or the NCDENR which guided remediation efforts at ABC One-Hour Cleaners and Tarawa Terrace and vicinity.

Thus, I believe, due to the presence of numerous errors, misrepresentations and mischaracterization of the scientific facts of the ATSDR water modeling analyses, the NRC report cannot be used as a reliable rebuttal to ATSDR conclusions on water modeling or a guidance document in its entirety. I reserve the right to update this report should any additional evidence or deposition testimony be provided to me that calls into question the conclusions of the NRC report or that concerns any other topic in my report.

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22. The documents, information and data identified in Appendix A2 ("Information sources used to extract model-specific data for historical reconstruction analyses, U.S. Marine Corps Base Camp Lejeune, North Carolina") to Maslia et al., Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina—Chapter A: Summary and Findings, ATSDR 2013.
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27. April 29, 2009 Expert Peer Review Panel Meeting Transcript, available at https://www.atsdr.cdc.gov/sites/lejeune/expertpanels.html
28. April 30, 2009 Expert Peer Review Panel Meeting Transcript, available at https://www.atsdr.cdc.gov/sites/lejeune/expertpanels.html
29. February 8, 2012 Deposition of Elizabeth Ann Betz and any exhibits referenced therein
30. June 30, 2010 Deposition of Morris Maslia and exhibits referenced therein
31. May 28, 2024 Deposition of General Anthony Zinni; Zinni Deposition Exhibits 1-8
32. August 5, 2024 Deposition of Kim Henderson; Henderson Deposition Exhibits 1-18
33. August 6, 2024 Deposition of Dan Waddill; Waddill Deposition Exhibits 1-20
34. August 14, 2024 Deposition of Jason Barry Sautner; Sautner Deposition Exhibits 1-10
35. August 15, 2024 Deposition of Rene Suarez-Soto; Suarez-Soto Deposition Exhibits 1-5
36. August 22, 2024 Deposition of Dr. Chris Rennix; Rennix Deposition Exhibits 1-6
37. September 26, 2024 Deposition of Morris Maslia; Maslia Deposition Exhibits 1-22
38. ATSDR Camp Lejeune Project File: CLJA_ATSDRWM01-0000000001-CLJA_ATSDRWM01-0000189563; CLJA_WATERMODELING-0000000001-CLJA_WATERMODELING-0000209307; CLJA_WATERMODELING_01-0000000001-CLJA_WATERMODELING_01-0000854197; ATSDR_WATERMODELING_01-0000854198-ATSDR_WATERMODELING_01-0000936235; CLJA_WATERMODELING_01-0000936236-CLJA_WATERMODELING_01-0001118025; CLJA_WATERMODELING_04-0000000001-CLJA_WATERMODELING_04-0000117996; CLJA_WATERMODELING_05-0000000001-CLJA_WATERMODELING_05-0001394405; ATSDR_WATERMODELING_05-0001394406-ATSDR_WATERMODELING_05-0001394413; CLJA_WATERMODELING_07-0000000001-CLJA_WATERMODELING_07-0002316354; CLJA_WATERMODELING_08-0000000001-CLJA_WATERMODELING_08-0000193508; CLJA_WATERMODELING_09-0000000001-CLJA_WATERMODELING_09-0000547124; ATSDR_WATERMODELING_09-0000547125-ATSDR_WATERMODELING_09-0000568329;

CLJA_WATERMODELIING_09-0000568330-CLJA_WATERMODELIING_09-0000615612; CLJA_WATERMODELING_09-0000615613-CLJA_WATERMODELING_09-0000745917

39. Georgia Tech Camp LeJeune Water Modeling Working Files
40. 00897_PLG_0000067113-00897_PLG_0000067132
41. 00897_PLG_0000339484-00897_PLG_0000339588
42. 00897_PLG_0000063393-00897_PLG_0000063594
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The forthcoming depositions of Frank Bove, Susan Martel, and Scott Williams, including any accompanying deposition exhibits and any other materials later produced in this litigation for which I reserve the right to read, review and rely upon.

9. Glossary of Abbreviations, and Definitions

Definitions of terms and abbreviations used throughout this report are listed below in alphabetical order.

ATSDR: Agency for Toxic Substances and Disease Registry.

BTEX: Benzene, toluene, ethyl benzene, and xylenes. These compounds are some of the VOCs found in petroleum derivatives such as gasoline. BTEX compounds typically occur near petroleum and natural gas production sites, gasoline stations, and other areas with underground storage tanks (USTs) or above-ground storage tanks (ASTs) containing gasoline or other petroleum-related products

CDC: Centers for Disease Control and Prevention.

DCE Dichloroethylene; an industrial chemical that is not found naturally in the environment. The USEPA has determined that 1,1-dichloroethylene is a possible human carcinogen

1,1-DCE 1,1-dichloroethylene or 1,1-dichloroethene

1,2-DCE 1,2-dichloroethylene or 1,2-dichloroethene

1,2-cDCE *cis*-1,2-dichloroethylene or *cis*-1,2-dichloroethene

1,2-tDCE *trans*-1,2-dichloroethylene or *trans*-1,2-dichloroethene

total 1,2-DCE total 1,2-dichloroethylene or total 1,2-dichloroethene

DNAPL: Nonaqueous Phase Liquids that are denser than water.

DOD: Department of Defense.

DON: Department of the Navy.

DPL: Liquids that mix with water, as opposed to nonmixing phase liquids NAPL.

EPANET 2: A water-distribution system (or network) model developed by the USEPA (Rossman 2000)

GAO: Government Accountability Office.

GSBC: Ground Surface Boundary Condition.

HBWTP: Holcomb Boulevard Water Treatment Plant.

HPWTP: Hadnot Point Water Treatment Plant.

HSMM: A one-dimensional NAPL volume estimator model and software developed by USEPA (Weaver et al. 1996).

LCT: Linear Control Theory. A scientific methodology of the scientific field of control engineering and applied mathematics. The methodology deals with the control of dynamical systems in engineered processes. In the case of ATSDR study of the Camp Lejeune site, the methodology was applied to groundwater contaminant transport analysis as a simple application to predict concentration values at a specific point in space and time based on limited data available at the site. This study was requested by the expert panel which reviewed the ATSDR Camp Lejeune site study and provided scientific advice.

LNAPL: Nonaqueous Phase Liquids that are lighter than water.

Markov process: A process that analyzes the tendency of one event to be followed by another event based on the sequence of events. Using this analysis, one can generate a new sequence of random but related events, which will look similar to the original; a stream of events is called a Markov Chain.

MCL: Maximum contaminant level; a legal threshold limit set by the USEPA on the amount of a hazardous substance that is allowed in drinking water under the Safe Drinking Water Act; usually expressed as a concentration in milligrams or micrograms per liter (USEPA 2003, 2009).

MESL: Multimedia Environmental Simulations Laboratory, a research center at Georgia Institute of Technology.

MODFLOW: A U.S. Geological Survey modular finite-difference flow model, which is a computer code that solves the groundwater flow equations. Used worldwide in groundwater flow simulations in subsurface systems.

Monte Carlo analysis: Also referred to as Monte Carlo simulation; a computer-based method of analysis that uses statistical sampling techniques to obtain a probabilistic approximation to the solution of a mathematical equation or model (USEPA 1997).

MT3DMS: Three-dimensional mass transport, multispecies model developed on behalf of the U.S. Army Engineer Research and Development Center. MT3DMS-5.3 (Zheng and Wang 1999) is the specific version of MT3DMS code used for the Hadnot Point–Holcomb Boulevard study area analyses; references to MT3DMS in text, figures, tables, appendixes, and supplemental information refer to MT3DMS-5.3. It can be used linked to a **MODFLOW** model. Used worldwide in contaminant transport simulations in subsurface systems.

NAC: National Academy of Sciences.

NAPL: Nonaqueous phase liquids; hazardous organic liquids such as dry-cleaning fluids, fuel oil, and gasoline that do not readily dissolve in water. Dense NAPLs (DNAPLs), such as the chlorinated hydrocarbons (e.g., PCE, TCE) used in dry cleaning and industrial degreasing, are heavier than water and sink through the water column. Hydrocarbon fuels and aromatic solvents are described as light NAPLs (LNAPLs), which are less dense than water and float. These include lubricants and gasoline, pollutants often associated with leaking gasoline or oil storage tanks (e.g., benzene).

NRC: National Research Council.

PCE: Tetrachloroethylene, 1,1,2,2-tetrachloroethylene, or perchloroethylene; also known as PERC® or PERK®. PCE is a manufactured chemical used for dry cleaning and metal degreasing. In 2012, following its Guidelines for Carcinogen Risk Assessment (USEPA 2005), the USEPA characterized PCE as likely to be carcinogenic in humans by all routes of exposure (USEPA 2012).

PEST: Model independent, objective parameter estimation and uncertainty analysis code originally developed by Watermark Numerical Computing (Doherty 2003, 2010); the current version is PEST-12, available at *http://www.pesthomepage.org/Downloads.php.*

PSOpS: Pumping Schedule Optimization System application developed by MESL, Ga. Tech. The study included the development of a simulation and optimization procedure identified as PSOpS, which combines simulation models (MODFLOW, MT3DMS, TECHFLOWMP) and optimization techniques to optimize the pumping schedules to identify maximum or minimum contaminant concentrations in the WTP consistent with the reported pumping schedules and demanfs on finished water supply at Camp Lejeune site. Based on the optimized pumping schedules, variations of PCE concentration and the maximum contaminant level (MCL, PCE, TCE etc.) arrival times at water-supply wells and the WTP are evaluated (Wang and Aral, 2008, ATSDR, 2007; ATSDR, 2013).

Sensitivity Analysis: A method used to ascertain how a given model output (e.g., concentration) depends upon the input parameters (e.g., time-step size, pumping rate). Sensitivity analysis is an important method for assessing the quality of a given model and a powerful tool for analyzing the robustness and reliability model analyses.

TCE: 1,1,2-Trichloroethene; commonly referred to as 1,1,2-trichloroethylene or trichloroethylene. TCE is a colorless liquid which is used as a solvent for cleaning metal parts. In 2011, following its Guidelines for Carcinogen Risk Assessment (USEPA 2005), the USEPA characterized TCE as carcinogenic in humans by all routes of exposure (USEPA 2011).

TechControl: A linear control theory model and software developed by MESL, Ga Tech. It is used to address the question of application of simpler models to predicting contaminant concentrations at certain locations of Camp Lejeune site. The development of the software was based on a request that was initiated by the ATSDR Expert Panel of scientists.

TechFlowMP: Three-dimensional multispecies, multiphase mass transport model developed by the Multimedia Environmental Simulations Laboratory at the Georgia Institute of Technology, Atlanta, Georgia.

TechMarkovChain: A model and software developed by MESL, Ga. Tech. It is based on a scientific mathematical methodology called Markov stochastic sequential processes (Ross, 1997). It is used to estimate intermittent connections (1972–1985) of the Hadnot Point and Holcomb Boulevard water-distribution systems based on the analysis of available field data collected at the Camp Lejeune site. The development of the software was based on a discussion that was initiated by the ATSDR Expert Panel of scientists (see section 5.9 for more details).

TechNAPLVol: A subsurface NAPL volume estimation model developed by MESL, Ga. Tech. It is a NAPL volume estimation model based on USEPA HSMM analysis described above. In this case the USEPA HSSM procedures are extended to three-dimensional analysis and used to estimate the volume of spilled BTEX compounds at the Camp Lejeune site. This software is an integral part of TECHFLOWMP (see section 5.10 for more details).

TechWellOp: A subsurface pumping well estimation model and software developed by MESL, Ga. Tech. The methodology uses the daily data in the Training Period to determine the monthly operational behavior of the water supply wells at the Camp Lejeune site that would satisfy the total water volume delivered to the water treatment plants. Once the average monthly working days in the Training Period are estimated for each calendar month, they are utilized in the prediction stage which is based on the same principle of satisfying the total monthly flow delivered to the treatment plant. This methodology is an efficient and effective way of integrating the available data in recent years to the prediction process for the past years. The development of the software was based on a discussion that was initiated by the ATSDR Expert Panel of scientists (see section 5.8 for more details and ATSDR, 2007).

Uncertainty: Lack of knowledge about specific factors, parameters, or models (for example, one is uncertain about the mean value of the concentration of PCE at the source).

Uncertainty analysis: Determination of the uncertainty (e.g., standard deviation) of the output variables' expected value (e.g., mean) due to uncertainty in model parameters, inputs, or initial state by stochastic modeling techniques (Schnoor 1996).

Unsaturated zone: Zone or area below ground in which the interconnected openings within the geologic medium contain a mixture of water under pressure less than atmospheric and air under atmospheric pressure; sometimes referred to as the vadose zone or the zone above the water table. The capillary fringe is part of the unsaturated zone and sometimes occurs as completely saturated.

USEPA: United States Environmental Protection Agency.

USMC: United States Marine Corps.

VC: Vinyl chloride or chloroethene; a colorless gas that burns easily, is not stable at high temperatures, and has a mild, sweet odor. It is a manufactured substance that does not occur naturally. It can be formed when other substances such as TCA, TCE, or PCE undergo biochemical degradation. The USEPA has characterized VC as a known human carcinogen (USEPA 2000). The NTP Report on Carcinogens (NTP 2011) has recognized vinyl chloride as a known human carcinogen based on sufficient evidence of carcinogenicity in humans.

VOC: Volatile organic compound; one of a group of carbon-containing compounds that evaporate readily at room temperature and can readily be inhaled. Examples of VOCs include tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride (VC), and benzene. These contaminants typically are generated from metal degreasing, printed circuit board cleaning, dry cleaning, gasoline, and wood preserving processes. VOCs are environmental contaminants, and some are classified as known human carcinogens (e.g., TCE, VC, and benzene).

WTP: Water treatment plant.

Exhibit A

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EDUCATION:

Ph.D. in Environmental Fluid Mechanics with minor in Numerical Analysis and Applied Mathematics, Sept. 1971, School of Civil Eng., Georgia Institute of Technology, USA.

M.S. in Civil Engineering with major in Environmental and Water Resources Engineering, June 1969, School of Civil Eng., Georgia Institute of Technology, USA.

B.S. in Civil Engineering, June 1967, Department of Civil Engineering, Middle East Technical University, Turkey.

EMPLOYMENT:

2018-present	Emeritus Prof.	School of Civil and Environmental Engineering, Ga. Tech., USA.
2018-2020	Dean	College of Engineering, Architecture and Design, Bartın Univ., Turkey.
2018-2020	Vice President	International Programs and Research, Bartın University, Turkey.
2018-2020	Professor	Department of Civil Engineering, Bartın University, Turkey.
1993-2018	Prof. Director	Multimedia Environmental Simulations Laboratory, Ga. Tech. USA
1983-1993	Assoc. Prof.	School of Civil and Environmental Engineering, Ga. Tech., USA
1979-1983	Visiting Prof.	School of Civil and Env. Engineering Ga. Tech. (On sabbatical), USA
1974-1982	Adjunct Prof.	Marine Sciences Dept., Civil Eng. Dept., Eng. Science Dept., Middle East Tech. Univ., Turkey.
1977-1982	Assoc. Prof.	Mathematics Dept., Middle East Tech. Univ., Turkey.
1974-1979	Asist Chairman	Mathematics Dept., Middle East Tech. Univ., Turkey.
1971-1977	Assistant Prof.	Mathematics Dept., Middle East Tech. Univ., Turkey.

PROFESSIONAL REGISTRATION:

Professional Engineer (PE): GA.USA. 15254

HONORS:

1973, **NATO, Science Fellowship**, September 1973.
1976, **Best Teacher Award**, Middle East Technical Univ., Mathematics Department, May 1976.
1976, **NATO, Science Fellowship**, September 1976.
1980, **Who is Who in Science, Engineering and Education** series since 1980.

1984, **Award of Appreciation**, in acknowledgment of contributions to the organization of the ASCE International Conference held in Atlanta, American Society of Civil Engineers, June 1984.

1986, **Outstanding Faculty Member**, Georgia Institute of Technology, May 1986.

1986, **Sigma Xi Research Society**.

1986, **Best Teacher Award**, Georgia Institute of Technology, June 1986.

1995, **Award of Recognition**, for the Organization of the East-West Advanced Study Institute on Environmental Issues, NATO, Scientific and Environmental Affairs Division, August 1995.

1996, **Engineering Technical Excellence Award**, Public Health Serv., USDHHS 1996 for the technical paper: "Estimating Exposure to VOCs from Municipal Water System Pipelines: Use and Application of a Computational Model, *Archives of Environmental Health*, May 1996 (with co-authors).

1997, **Research Program Development Award**, in Recognition for Developing a Consistent and Comprehensive Research Program in Environmental Health, School of Civil and Environmental Engineering, Georgia Institute of Technology, May 1997.

1997, **Science Publication Award**, ATSDR, US DHHS, for the technical paper: "Use of Computational models to Reconstruct and Predict Trichloroethylene Exposure," *in Toxicology and Industrial Health*, April 1997 (with co-authors).

1997, **Award of Appreciation and Recognition**, in acknowledgment of contributions to the organization of the International Conference on Geology and Environment (GeoEnv'97), September 1997.

1998, **Engineering Literary Excellence Award**, Public Health Serv., USDHHS for the technical paper: "Exposure Assessment Using Analytical and Numerical Models: A Case Study," *in ASCE Practice Periodical of Hazardous, Toxic, and Radioactive waste Management*, April 1998 (with co-authors).

1998, **Honorary Professor of Environmental Sciences**, Huazong University of Science and Technology, Wuhan, Peoples Republic of China.

2000, **Cuming Medal Award 2000**, The Society of American Military Engineers award to Dover Township Water Distribution System Modeling Research Team.

2000, **Best Practice Oriented Paper Award**, ASCE Environmental & Water Resources Institute Planning and Management Council, for the technical paper "Using Water-Distribution System Modeling to Assist Epidemiologic Investigations," *ASCE Journal of Water Res. Plan. and Man., Vol. 126, No. 4, 2000*.

2003, **Excellence in Environmental Engineering Award in Research Category**, American Academy of Environmental Engineers (AAEE). *Research Topic: "Enhancing Environmental Engineering Science to Benefit Public Health: Integrating Hydraulic Network Modeling, Spatial Analysis, and Genetic Algorithms with Epidemiologic Studies,"* Awarded to **M. M. Aral** for the Leadership of the ATSDR – MESL/GT Research Group.

2005, **Engineering Technical Excellence Award**, Public Health Service, USDHHS for the technical paper: "ACTS - A Multimedia Environmental Fate and Transport Analysis System." *in ASCE Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management*, published in 2004 (with co-authors).

2006, **Excellence in Applied Environmental Health Research**, National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC), for our work in assisting NCEH/CDC in an epidemiological study of childhood leukemia and central nervous system cancers that occurred in the period 1979 through 1996 in Dover Township, New Jersey and Camp Lejeune (Air Force Army Base) at North Carolina.

2010, **Best Research Paper Award**, ASCE Water Resources Management Council, for the technical paper "Saltwater Intrusion Hydrodynamics in a Tidal Beach," *ASCE Journal of Hydrologic Engineering, Vol.* 13, No. 9: pp. 863-872*126* (with co-authors).

2010, **US Public Health Service Engineering Best Research Paper Award**, CDC, DHHS. "Reconstructing Historical Exposures to Volatile Organic Compound-Contaminated Drinking Water at a U.S. Military Ba

2010, **ASCE Outstanding Service Award**, ASCE EWRI, for Groundwater Hydrology Committee Chair activities under EWRI Groundwater Council.

2010, **Life Member**, ASCE EWRI.

2010. **Fellow ASCE**, ASCE, EWRI.

2011, **James R. Croes Medal**, ASCE EWRI, for the paper: "Optimal Design of Sensor Placement in Water Distribution Systems," ASCE Journal of Water Resources Planning and Management, Vol. 136, No. 1, pp.5-18, 2010.

2011, **Founders Award**, American Institute of Hydrology for dedicated contribution to the profession.

2011, **USPHS Engineering Literary Award**, for an outstanding Engineering Management Paper entitled "Stochastic Analysis of Pesticide Transport in the Shallow Groundwater of Oatland Island, Georgia." Published in the International Journal on Water Quality, Exp. and Health, Vol. 2, No. 1, pp. 47-64.

2013, **Sustained Interdisciplinary Research Award**, in Recognition for Developing a Consistent, Comprehensive and Integrated Research Program within CEE, Georgia Institute of Technology.

2015, **Panel Leadership and Organization Recognition, 68. Turkish Geology Conference.** "Groundwater Supplies and Drought" Panel, 68. Turkish Geology Conference, Organized by Turkish Maden Tetkik Arama Kurumu and Turkish Geology Engineers, 6 April 2015, Ankara, Turkey.

2015, **Invited Speaker in the opening session of the 68. Turkish Geology Conference.** "Evolution of Environmental and Geological Engineering Systems Analysis in Modern Day," 68. Turkish Geology Conference, Organized by Turkish Maden Tetkik Arama Kurumu and Turkish Geology Engineers, 6 April 2015, Ankara, Turkey.

2015, **Grand Prize in Environmental Engineering Award in Research Category by Am. Acad. of Env. Engineers (AAEE)**. *Research Topic: "Using Environmental Engineering Tools, Scientific Analyses, and Epidemiological Studies to Quantify Human Exposure to Contaminated Drinking Water and to Benefit Public Health,"* Awarded to **M. M. Aral** for the Leadership of the ATSDR – MESL/GT Research Group.

2018, **Best Teacher Award**, Center for Teaching and Learning, Ga. Institute of Tech., January 09, 2018.

2018, **Invited Speaker, HIDRODER.** "Climate Change and its Effects on Water Quality and Quantity" Organized by HIDRODER-2018 National Hydrology and Water Resources Symposium, 27-29 September 2018, Ankara, Turkey.

2022, **Invited Speaker, IWA DIPCON, Istanbul, Turkey.** "The Institute of Environmental Sciences co-organized the International Water Association (IWA) 4th Regional Diffusion Pollution and Eutrophication conference held in Istanbul 24-28 October, 2022" Istanbul, Turkey.

BOOKS:

Aral, M. M., Ground Water Modeling in Multilayer Aquifers - Steady Flow, *Lewis Publ. Inc.*, 1990.

Aral, M. M., Ground Water Modeling in Multilayer Aquifers - Unsteady Flow, *Lewis Publ. Inc.*, 1990.

Aral, M. M. (2011) "Environmental Modeling and Health Risk Analysis," Springer Publishers, Berlin, 487p., ISBN 978-90-481-8607-5.

EDITED BOOKS:

Aral, M. M. (Editor), Recent Advances in Ground-Water Pollution Control and Remediation, NATO Adv. Study Inst., *Kluwer Acad. Publ*., 609p, January 1996.

Aral, M. M., Brebbia, C, Maslia M and Sinks, T. (Editors) (2005) "Environmental Exposure and Health," Proceedings of the 1st International Conference on Environmental Exposure and Health, Atlanta Ga. USA, WIT Press, 502p.

Aral, M. M. and Taylor S. (Editors) (2011) "Groundwater Quality and Quantity Management," ASCE, 573p., ISBN-978-0-7844-1176-6.

CHAPTERS IN BOOKS:

Aral, M. M., C. Shea and F. Al-Khayyal, "Optimization Methods in Ground Water Management," Review Paper in Volume 8, "Applications of Management Science: Network Optimization Applications," *JAI Press Inc*., pp. 213-246, 1995.

Aral, M. M. C. Shea and F. Al-Khayyal, "Optimal Design of Pump-and Treat Well Networks," NATO Adv. Study Inst. on Ground Water Pollution Control and Remediation, *Kluwer Acad. Publ*., pp. 307-333, January 1996.

Aral, M. M., and Guan, J, "Genetic Algorithms in Search of Groundwater Pollution Sources," NATO Adv. Study Inst. on Ground Water Pollution Control and Remediation, *Kluwer Acad. Publ*., pp. 347-369, January 1996.

Aral, M. M. and Maslia, M. L., Application of Monte Carlo Simulations in Analytical Contaminant Transport Modeling, Chapter 13, pp. 305-315, in ASCE book on "Groundwater Quality Modeling and Management Under Uncertainty," Ed. by Srikan Tamishra, 2003.

Aral, M. M., and Gunduz, O., Scale Effects in Large Scale Watershed Modeling. Chapter 11 in "ADVANCES IN HYDROLOGY" Ed. by V. Singh and R. N. Yadava, 2003.

Aral, M. M. and Gunduz, O. Large-Scale Hybrid Watershed Modeling, Section 2 in "WATERSHED MODELS," CRC Press, 2005, Ed. Dr. Vijay Singh, 75-95pp.

Aral, M. M. (2010) "Saltwater Intrusion Management in Urban Area Aquifers - A Case Study for Savannah, Georgia," The Effects of Urbanization on Groundwater: An Engineering Case-based Approach for Sustainable Development, Editor, Ni-Bin Chang, ASCE/EWRI publication, pp. 51-89.

Jang, W. and **Aral, M. M.** (2011) "In-Situ Air Sparging and Thermal Venting in Ground Water Remediation," Chapter 11 in Groundwater Quality and Quantity Management, Editors Aral, M. M. and Taylor, S., ASCE, pp. 530-575, ISBN-978-0-7844-1176-6.

Aral, M. M. (2011) "Groundwater Management," Chapter 14 in Groundwater Quality and Quantity Management, Editors Aral, M. M. and Taylor, S., ASCE, pp. 560-568, ISBN-978-0-7844-1176-6.

Gunduz, O. and **Aral, M. M.** (2015) "Integrated Watershed Modeling," Handbook of Applied Hydrology, Edited by Vijay Singh. Chapter 56.

PATENTS:

Aral, M. M. Atlanta, USA and Demirel. E. Eskisehir, Turkey.

TITLE: "Baffle Design to Improve Mixing and Reduce the Flow Through Energy Requirements in Chlorine and Ozone Contact Tanks," USA Patent and Trademark Office, USA Patent # 62/498,260, USA and EUROPEAN Union and Turkey.

JOURNAL ARTICLES (Google Scholar h-index 33):

1. Martin, C.S. and Aral, M.M. (1971). "Seepage Force on Interfacial Bed Particles." Journal of the Hydraulics Division-ASCE 97(HY7): 1081-1101.
2. Aral, M.M. and Isilgan, N. (1973). "Seepage Through Earth Dams: A Finite Element Solution." Journal of Pure and Applied Sciences 6(2): 185-194.
3. Aral, M.M. and Gulcat, U. (1977). "Finite-Element Laplace Transform Solution Technique for Wave-Equation." International Journal for Numerical Methods in Engineering 11(11): 1719-1732.
4. Aral, M.M. (1980). "Steady Jet Impingement on Straight and Curved Surfaces." Journal of Pure and Applied Sciences 13(3): 349-368.
5. Aral, M.M. (1981). "A One-Dimensional Mass-Transport Model for Natural Rivers." Journal of Environmental Systems 11(2): 139-154.
6. Aral, M.M. and Sturm, T.W. (1982). "Groundwater Pumping from Shallow Axisymmetric Ponds." Journal of the Hydraulics Division-ASCE 108(12): 1469-1485.
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8. Ozsoy, E., Aral M.M., et al. (1982). "Coastal Amplification of Tsunami Waves in the Eastern Mediterranean." Journal of Physical Oceanography 12: 117-126.
9. Aral, M. M. and Maslia, M.L. (1983). "Unsteady Seepage Analysis of Wallace Dam." Journal of Hydraulic Engineering-ASCE 109(6): 809-826.
10. Aral, M.M. and Maslia, M.L. (1984). "Unsteady Seepage Analysis of Wallace Dam - Closure." Journal of Hydraulic Engineering-ASCE 110(5): 671-673.
11. Aral, M.M. (1985). "Aquifer Parameter Prediction in Leaky Aquifers." Journal of Hydrology 80(1-2): 19-44.
12. Aral, M.M. (1986). "A Regional Multilayered Aquifer Model for Microcomputers." International Journal for Microcomputers in Civil Engineering 1(1): 69-78.
13. Aral, M.M. (1987). "An Unsteady Regional Multilayered Aquifer Model for Microcomputers." International Journal for Microcomputers in Civil Engineering 2(3): 197-206.
14. Aral, M.M. and Tang, Y. (1988). "A Boundary Only Procedure for Time-Dependent Diffusion-Equations." Applied Mathematical Modeling 12(6): 610-618.
15. Aral, M.M. and Tang, Y. (1988). "A New Boundary Element Formulation for Time-Dependent Confined and Unconfined Aquifer Problems." Water Resources Research 24(6): 831-842.
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32. Aral, M.M., Zhang, Y. et al. (1998). "Application of relaxation scheme to wave-propagation simulation in open-channel networks." Journal of Hydraulic Engineering-ASCE 124(11): 1125-1133.
33. Guan, J. and Aral, M.M. (1999). "Optimal remediation with well locations and pumping rates selected as continuous decision variables." Journal of Hydrology 221(1-2): 20-42.
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35. Liao, B. and Aral, M.M. (1999). "Interpretation of LNAPL Thickness Measurements under Fluctuating Groundwater Table Conditions." Journal of Hydrologic Engineering 4(2): 125-134.
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38. Liao, B.S. and Aral, M.M. (2000). "Semi-analytical solution of two-dimensional sharp interface LNAPL transport models." Journal of Contaminant Hydrology 44(3-4): 203-221.
39. Maslia, M.L., Sautner, J.B., Aral, M.M., et al. (2000). "Using water-distribution system modeling to assist epidemiologic investigations." Journal of Water Resources Planning and Management-ASCE 126(4): 180-198.
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41. Aral, M.M., Guan, J. et al. (2002). "Closure to "Identification of contaminant source location and release history in aquifers" by Mustafa M. Aral, Jiabao Guan, and Morris L. Maslia." Journal of Hydrologic Engineering 7(5): 400-401.
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44. Maslia, M.L., Sautner, J.B. and Aral, M.M. (2002). "Using water-distribution system modeling to assist epidemiologic investigations." Epidemiology 13(4): S86-S86.
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64. Ayvaz, T., Karahan, H. and Aral, MM. (2007). "Determination of Aquifer Parameters and Parameter Structures with Genetic Algorithm," *National Hydrology Congress*, Middle East Technical University, September 5-7, [CD-ROM].
65. Suarez-Soto, R., Wang, J., Faye, RE, Maslia, LM, Aral, MM and Bove, F. J., "Historical Reconstruction of PCE-Contaminated Drinking Water Using Probabilistic Analysis at U.S. Marine Corps Base Camp Lejeune, North Carolina," *Proceedings of the World Water and Environmental Resources Congress, ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
66. Telci, IT, Nam, K., Guan, J. and Aral, MM, "Real Time Optimal Monitoring Network Design in River Networks," *Proceedings of the World Water and Environmental Resources Congress, ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
67. Guan, J. and Aral, MM, "Identification of Contaminant Sources in Aquifers under Uncertainty," *Proceedings of the World Water and Environmental Resources Congress, ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
68. Aral, MM, Guan, J. and Maslia, ML, "A Multi-objective Optimization Algorithm for the Solution of Water Sensor Placement Problem in Water Distribution Systems," *Proceedings of the World Water and Environmental Resources Congress, ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
69. Jang, W. and Aral, MM, "The Effect of Oxygen Transport on Biotransformation of Trichloroethylene in the Subsurface," *Proceedings of the World Water and Environmental Resources Congress, ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
70. Maslia, ML, RE Faye, MM Aral, FJ Bove, and W. Jang. (2008) "Historical reconstruction of single-specie and multispecies PCE-contaminated drinking water, U.S. Marine Corps Base Camp Lejeune, North Carolina," *World Environmental & Water Resources Congress 2008*, American Society of Civil Engineers, Honolulu, HI, May 13-16.
71. Suarez-Soto, RJ, Anderson, BA, Maslia, ML. and Aral, MM, "A Comparison Between Biochlor and the Analytical Contaminant Transport System (ACTS) for a Case Study in Coastal Georgia," *Proceedings of the World Water and Environmental Res. Cong., ASCE/EWRI*, Honolulu, Hawaii, May 12-16, 2008.
72. Jang, W. and MM. Aral. (2009) "Modeling of chlorinated VOCs transport under dual bioreactions," *World Environmental & Water Resources Congress 2009*, American Society of Civil Engineers, Kansas City, Missouri, May 17-21.
73. Guan, J., Maslia, ML and MM. Aral. (2009) "A Novel Methodology to Reconstruct Groundwater Contamination History with Limited Field Data," *World Environmental & Water Resources Congress 2009*, American Society of Civil Engineers, Kansas City, Missouri, May 17-21.
74. Aral, MM, Guan, J., and Maslia, ML. (2009). "Reconstructing Groundwater Contamination History: A Control Theory Based Approach," Water and Public health, *American Public Health Association Conference,* Philadelphia, PA, November 7-11.
75. Jang, W. Maslia, ML and Aral, MM. (2010). "The Effect of Atmos. Chemical Release on the Reduction in Groundwater Pollution by CVOCs," ASCE, EWRI Water Res. Cong., Rhode Island. May 25-30.
76. Guan, J. Jang, W., Maslia, ML and Aral, MM. (2010). "Historical Reconstruction of Groundwater Contamination at Contaminated Sites and Uncertainty Analysis," ASCE, EWRI Water Resources Congress, Rhode Island. May 25-30.
77. Aral, MM. (2010) "Resilience Analysis of Climate Change Effects on Water Quality," NATO Advanced Research Workshop on Climate Change and Health, Izmir, Turkey.

78. Park. C., S.-H. Kim, I. Telci and MM. Aral. (2010). "Designing Optimal Water Quality Monitoring Networks for River Systems and Application to a Hypothetical case, Proceedings of the 2010 Winter Simulation Conference, Austin, TX. (Invited).
79. Guan, J., Maslia, ML and Aral, MM. (2011). "Reconstruction of Groundwater Contamination History in Hadnot Point Area of Camp Lejeune, North Carolina Using Linear Stochastic Model," ASCE, EWRI Water Resources Congress, Palm Springs California, May 25-30.
80. Maslia, ML, Aral, MM. and Faye R. (2011). "Impact of Historical Contaminant Source Uncertainty Analysis and Variability on Human Health Risk," ASCE, EWRI Water Resources Congress, Palm Springs California, May 25-30.
81. Aral, MM, Guan, J. and Chang, B. (2011). "Climate Change and Sea Level Rise," ASCE, EWRI Water Resources Congress, Palm Springs California, May 55-68.
82. Biao, C, Guan, J. and Aral, MM, (2012). "Semi-Empirical Modeling of Spatial Variations in Sea Level Rise," ASCE, EWRI Water Resources Congress, Albequerque, NM, May.
83. Guan, J., Biao, C. and Aral, MM, (2012). "Exploration for Impact of Radiative Forcing on Global Warming and Sea-Level Rise," ASCE, EWRI Water Resources Congress, Albequerque, NM.
84. Telci, IT and Aral MM (2012). "Renewable Energy Production from Water Distribution Systems." Hydro Research Foundation Conference.
85. Dede, OT, Telci, IT and Aral MM (2013). "Water Quality Index Assessment of Surface Waters near Ankara, Turkey," ASCE, EWRI, IPWE 2013 Congress, Izmir, Turkey, January 2013.
86. Chang, B, Guan, J and Aral MM (2013). "Spatial Analysis of Climate Change and Sea Level Rise," ASCE, EWRI, IPWE 2013 Congress, Izmir, Turkey, January 2013.
87. Aral, MM. (2014). Application of Water-Modeling Tools to Reconstruct Historical Drinking Water Concentrations in Epidemiological Studies, Exposure Science Integration to Protect Ecological Systems, Human Well-Being, and Occupational Health 24th Annual Conference of The International Society of Exposure Science, Cincinnati, Ohio.
88. Morgan, W. and Aral, MM. (2015). "Modeling Hydraulic Fracturing in Pre-Fractured Rock Using the Discontinuous Deformation Analysis." 49th U.S. Rock Mechanics/Geomechanics Symposium, June 28 – July 1, 2015, San Francisco, USA.
89. Aral, M. M. (2015) "Concepts and development of modeling principles in environmental analysis," 68th National Geological Eng. Conf., 6 – 10 April 2015, MTA Kultur Sitesi, Ankara, Turkey (Keynote speech.)
90. Aral, M. M. (2015) "Integrated modeling of coupled watershed processes," 68th National Geological Engineers Conference, 6 – 10 April 2015, MTA Kultur Sitesi, Ankara, Turkey (invited).
91. Kentel, E., Gunduz, O. and Aral, M. M. (2015). "Critical Infrastructure Management: Risk, Resilience, Extent Concepts," The International Emergency Management Society 2015 Annual Conference, 30th September - 2nd October 2015, Rome, Italy.
92. Aral, M. M. (2016) "Transition from simple, complicated to complex systems," YTSAM, Yeni Türkiye Bilim ve Araştırma Merkezi International Conference, Ankara, Turkey, September 14, 2016.
93. Kentel, E., Gunduz, O., Bayar, M. and Aral, M. M. (2017). "Critical Infrastructure Management: Risk, Resilience, Extent Concepts," 12th Conference on Sustainable Development of Energy, Water and Environment Systems. Dubrovnic, Croatia.
94. Kizilaslan, M. A., Demirel, E., Aral, M. M. (2020). "Pathogen Inactivation and By-Product Formation in a Full-Scale Contact Tank," 2020 11th international Conference on Environmental Science and Development (ICESD 2020), Barcelona, Spain, February 10-12, 2020.
95. Aral, M.M. and Demirel, E. (2020). "İçme Sularının Arıtılmasında Kullanılan Temas Tanklarının Verimlerinin Arttırılması için Tasarım Önerileri ve Elde Edilen Verimler," HİDRO 2020: Hidrojeoloji and Water Resources Sempozium, June 18-20, Bartın, Turkey.

96. Demirel, E. and Aral, M.M. (2020). “Batmış Kapağın Mansabındaki Vorteksleri̇n İncelenmesi ve Sönümlenmesi,” HİDRO 2020: Hidrojeoloji and Water Resources Sempozium, June 18-20, Bartın, Turkey.
97. Kizilaslan, M.A., Demirel, E., Aral, M.M., (2020). “Pathogen inactivation and by-product formation in a full-scale contact tank,” 11th International Conference on Environmental Science and Development (ICESD 2020), E3S Conf., 167 (2020) 01011, https://doi.org/10.1051/e3sconf/202016701011.
98. Aral M. M., (2022). “Optimal Water Treatment Tank Design and Analysis” IWA DIPCON, Istanbul, Turkey. The International Water Association (IWA) 4th Regional Diffusion Pollution and Eutrophication conference held in Istanbul 24-28 October, 2022” Istanbul, Turkey.

RESEARCH PROJECTS:

1. Principal investigator of the project titled, *Finite Element Analysis in Continuum Mechanics: FEMAC Computer Program*, (Funded by Middle East Technical Univ. Research funds - $18,000), 1972-73.
2. Principal investigator of the project titled, *An Analysis of Convective Diffusion Equation and Its Finite Element Solution*, (Funded by Turkish Sci. and Tech. Research Inst.- $ 12,000), 1976-77.
3. Principal investigator of the project titled, *Analytical and Numerical Study of Jet Deflection from Curved Boundaries*, (Funded by Middle East Technical Univ. Research funds - $ 19,000), 1976-77.
4. Principal investigator of the project titled, *Tsunami Study: Akkuyu Nuclear Power Plant*, (Funded by Turkish Electric Authority, Nuclear Energy Division - $ 75,000), 1977-79.
5. Principal investigator of the project titled, *Analysis of the Development of Shallow Ground Water Supplies by Pumping from Ponds*, (Funded by the Department of the Interior, Office of Water Resources Research and Technology - $ 48,000), 1979-80.
6. Principal investigator of the project titled, *Mathematical Modeling of Aquatic Dispersion of Effluents in Natural Rivers*, (Funded by the Health and Safety Division of the Oak Ridge National Laboratories, Oak Ridge Tennessee - $ 52,000), 1979-80.
7. Principal investigator of the project titled, *Aquifer Parameter Prediction by Numerical Modeling*, (Funded by the Department of the Interior, Office of Water Research and Tech. - $ 56,000), 1981-82.
8. Principal investigator of the proposal titled, *An Analysis of Rimming Condensate Flow*, (Funded by Beloit corporation, Beloit, Wisconsin - $ 68,000), 1981-83.
9. Principal investigator of the project titled, *Parameter Identification in Layered Aquifer Systems*, (Funded by the Department of the Interior, Office of Water Policy - $ 44,000), 1983-84.
10. Principal investigator of the project titled, *A Simplified Approach to Regional Multilayered Aquifer Analysis*, (Funded by the Department of the Interior, U.S. Geological Survey - $25,000), 1986-88.
11. Principal investigator of the project titled, *Modeling Transient Ground Water Flow in Multilayered Aquifer Systems*, (Funded by the Department of the Interior, USGS - $ 29,000), 1988-89.
12. Principal investigator of the project titled, *Multilayered Aquifer Modeling in a Landfill Site*, (Funded by the Waste Management, Inc., Geosyntec, Inc. - $ 42.000), 1990-91.
13. Principal investigator of the Research Program titled, *Exposure-Dose Reconstruction at Graton Massachusetts*, (Funded by: U.S. DHHS - $ 44,000), 1992.
14. Director, NATO Advanced Study Institute, *Recent Advances in Groundwater Pollution Control and Remediation*, (NATO - Directorate of Environmental Programs $ 111,000), 1994.
15. National Science Foundation, *Water, Sustaining A Critical Resource*, Joint Proposal with Dr. A. Zoporozec, University of Wisconsin, $ 30,000 1995.
16. Principal investigator of the Research Program titled, *Research Program on Exposure-Dose Reconstruction*, (Funded by: ATSDR/CDC- $ 2,500,000), 2000-2005.

17. Principal investigator of the Research Program titled, *Analysis of Coastal Georgia Ecosystem Stressors Using GIS Integrated Remotely Sensed Imagery and Modeling: A Pilot Study for the Lower Altamaha River Basin*, (Funded by: Sea Grant Program - $ 288,000), 2000-2003.
18. Principal investigator of the Research Program titled, *GIS Integrated Environmental Systems Modeling*, (Funded by: CDC - GT Bioengineering Center $ 30,000), 2000-2001.
19. Principal investigator of the Research Program titled, *Research Program on Exposure-Dose Reconstruction*, (Funded by: ATSDR/CDC- $ 2,500,000), 2005-2010.
20. Principal investigator of the research Program titled "*Potential n-Nitrosodimethylamine (NDMA) Formation at Water and Wastewater Treatment Plants and Exposure Pathway Analysis*," (Funded by: SNF FLOERGER, France, program period: 2004-2006. $ 550,432).
21. Principal investigator (co-investigator Prof. Ching-Hua Huang) of the research Program titled "*Potential n-Nitrosodimethylamine (NDMA) Formation at Water and Waste water Treatment Plants and Exposure Pathway Analysis*," (Funded by: SNF FLOERGER, France, program period: 2007-2009. $ 308, 821).
22. Principal investigator of the Research Program titled, *Research Program on Exposure-Dose Reconstruction*, (Funded by: ATSDR/CDC- $ 2,500,000), 2010-2015.
23. Principal investigator of the Research Program titled, Chinese Drywall Emission and Exposure through Inhalation, (Funded by: ATSDR/CDC- $ 500,000), 2012-2014.
24. Co-Principal investigator of the research program, "Combining Statistical Process Control and Optimization via Simulation for Robust Sensor Network Design in the Presence of Sensor Measurement Error," Funded by National Science Foundation, $ 350,000), 2016 – 2018.
25. Co-Principal investigator of the research program, "EU-Horizon 2020 Energy Efficiency Program-Eco-QUBE," Funded by EU Horizon 2020 program, €4.5 million, 2020-2023.

PROFFESIONAL ACTIVITIES:

National (USA):

1. **Member**, American Society of Civil Engineers, (ASCE). (1969 – present)
2. **Member**, Sigma Xi Research Society, (U.S.A.). (1971- present)
3. **Member**, American Geophysical Union, (U.S.A.) (1978-2010).
4. **Member**, National Water Well Association, (U.S.A.) (1978 – 2010).
5. **Member**, American Water Resources Association, (U.S.A.) (1978 – 1989).
6. **Member**, **Task Committee on Ground Water Strategy**, ASCE Hydraulics Division, 1983-85.
7. Listed in the directory of experts in Ground Water and Ground Water Contamination, Prepared by Edison Electric Institute and by Dames & Moore Consultants, Co.,1984
8. Listed in the directory in Who is Who in Science and Engineering.
9. **Member** of the organizing committee of the conference, *The Water Resources of Georgia and Adjacent Areas*, Sponsored by Ga. TECH and Georgia Geologic Survey, October 1983.
10. **Session Chairman**, ASCE. Spring Convention, Atlanta, 1984.
11. **Session Co-Chairman**, Engineering Mechanics Society, Blacksburg, 1984.
12. **Member**, American Water Resources Association, Publications Committee and Conference Organization Committee, 1987 – 1989.
13. **Member** of the Organizing Committee of the conference and Session Chairman, *Key Problems in Hydrology, Hazardous Waste*, Sponsored by American Institute of Hydrology, 1987.
14. **Member**, American Institute of Hydrology (1978-present).
15. **Session Chairman**, Int. Conference on Computational Eng. Sci., Atlanta, April 10-14, 1988.

16. **Chairman**, **Multidisciplinary Geohydrology Program**, Georgia Institute of Technology, College of Engineering, 1988-present (founding member).
17. **Invited Speaker - Board of Scientific Counselors**, Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services, 1990 - 1992.
18. **Member, Sci. Review Board**, Waste Policy Institute, U.S. Department of Energy, 1991 – present
19. **Director, Multimedia Environmental Simulations Lab.**, CEE, Ga. Tech., 1994-present.
20. **Member, Scientific Review Panel on program Analytical and Monitoring Methods in Subsurface Remediation**, USEPA, 1995 – 2001.
21. **Member, Scientific Review Panel on program STAR Program**, USEPA, 1995-present.
22. **Member, Scientific Review Panel on Eastern Research Group**, 1997-present.
23. **Member, International Society of Exposure Analysis,** 2002 – present.
24. **Member, International Association of Hydrogeology,** 2002 – present.
25. **Organizing Committee Member,** Achieving Sustainable Water Resources in Areas Experiencing Rapid Population Growth, 2003 AIH International Conf., Atlanta, GA.
26. **Vice President for International Affairs, American Institute of Hydrology,** 2004 – 2006.
27. **Elected to the Board of Dir. of the Buried Asset Man. Inst.– International**, (2004 – 2007).
28. **Chair** of the ASCE Groundwater Hydrology Technical Committee (2007 – 2009).
29. **Member** of the ASCE Groundwater Hydrology Technical Committee (2007 – present).
30. **Vice-Chair** of the ASCE, GWH Tech. Report Com. on Exp.-Dose Reconstruction (2007 – 2009).
31. **Member** of the ASCE, EWRI Ground Water Council (2007 – 2009).
32. **Vice President for Int. Affairs, American Institute of Hydrology, (**2009 – 2011).
33. **Member** of the ASCE, EWRI World Water Council, (2010 – present).
34. **Member of the ASCE EWRI International Council (2010 – Present).**
35. **Control Group Member, ASCE EWRI World Water Council (2012 – Present).**
36. **Member** of the ASCE, EWRI Env. Health and Water Quality Committee, (2008–present).
37. **FELLOW ASCE/EWRI**, elected by the ASCE Board of Directors to the rank of ASCE Fellow, 2010.
38. **Co-Chair of the organizing committee,** ASCE EWRI IPWE 2013 Conference Izmir, Turkey.
39. Short Course on **"Environmental Modeling and Health Risk Analysis,"** ATSDR/CDC Atlanta, GA (2010, 2011, 2012) and Izmir, Turkey (2012).
40. Invited Speaker ORLOB INTERNATIONAL SYMPOSIUM ON THEORETICAL HYDROLOGY. Presentation Title: "Climate Change and Spatial Variability of Sea Level Rise," University of California (Davis), August 4, 2013.
41. **PRESIDENT ELECT, 2013-2015 and PRESIDENT 2015 - 2017. American Institute of Hydrology (AIH).** Elected by the AIH membership.

International:

1. **Member**, Association for the Advancement of Mathematical Sciences. (1971 – 1978)
2. **Member**, Marine Sciences Research Institute, (Turkey, founding member). (1971 – 1978)
3. **Member**, Computer Sciences Research Institute, (Turkey, founding member). (1971 – 1978)
4. **Member**, International Engineering Analysts, Southampton, England.
5. **Member**, International Association for Computational Mechanics (1987 – 1990).
6. **Director, NATO Advanced Study Institute**, "Recent Advances in Ground Water Pollution Control and Remediation." June 1995.
7. **Session Chairman and Member** of the Organizing Committee of the conference, *International Conference on Geology and Environment*, Sponsored by Academy of Sciences of Turkey and other International Organizations, 1997.
8. **European Community FP6 – FP7 – FP8 proposal review panel member.** (2005 – present)

9. **Fulbright Senior Scientist.** (2005 – 2011).
10. **Short Course on ACTS/RISK** (Dec., 2011) Dokuz Eylul University, Izmir Turkey.
11. **Organization Committee Member,** ASCE/EWRI IPWE International Conference on Perspectives on Water Resources and Environment, Izmir, Turkey, 2013.
12. **Organizing Committee member, HydroEnv. Ist-2017.** International Association for Hydro-Environment Engineering and Research (IAHR).
13. **European Community Horizon 2020 panel member.** (2013 – Present).
14. **Austrian Science Fund review committee member.** (2015 – Present).

EDITORIAL AND REVIEWER WORK

Reviewer:

Journal of Pure and Applied Sciences, 1976 – 1985.
Environmental Protection Agency (review of proposals), 1980 – present.
U.S. Dept. of Int., Geological Survey (review of reports and proposals), 1980 – present.
TUBITAK Research Council, Turkey (review of reports and proposals), 1980 – present.
ASCE Committee on Computational Hydraulics, 1981 – 1995.
ASCE Journal of Engineering Mechanics Division, 1982 – 1995.
Journal of American Water Works Association, 1985 – 1995.
Water Resources Bulletin, American Water Resources Association, 1985 – 1995.
Journal of Hydrology, 1986 – present.
Journal of Computational Mechanics, 1986 – 1995.
Water Resources Research**,** 1985 – present.
ASCE, Water Resources Planning and Management Journal, 1998 – present.
Saudi Geologic Survey *for Scientific Research*, 2000 – present.
Turkish Scientific Research Council, 2000 – present.
Netherlands *Organization for Scientific Research*, 1999 – present.
Danish *Organization for Scientific Research*, 2000 – present.
NSF/NIH*, Engineering Centers of Excellence review committee member*. 2003 – 2004.
Advances in Water Resources, 2005 – present.
Water Resources Research, 1990 – present.
Journal of Contaminant Hydrology, 2004 – present.
European Community, *F6, F7, F8, Horizon 2020 committee member*. 2005 – present.
Journal of Transport in Porous Media, 2005 – present.
NSF, SBIR *review committee member*. 2005 – present.
USEPA**,** ***SBIR*** *review committee member*. 2005 – present.
Journal of Environmental Management**,** 2007 – present.
Journal of Water Quality, Exposure and Health, 2009 – 2016.
Journal of Environmental Monitoring and Assessment, 2007 – present.
Journal of Water Resources Management, 2007 – present.
Journal of Neural Networks**,** 2007 – present.
Environmental Science and Technology**,** 2008 – present.
Journal of Risk Assessment, 2008 – present.
Journal on Neural Networks, 2008 – present.
Journal on Water, Air and Soil Pollution, 2009 – present.
Journal of Environmental Modeling and Software**,** 2009 – present.
Journal of Environmental Engineering, 2010 – present.

***USEPA*, STAR Fellowship** *review committee member*. 2013 – 2014.
Water Journal, 2015 – present.
Processes Journal, 2015 – present.

Associate Editor:
***Journal of Environmental Science and Health**, Am. Chem. Society*, 1989 – 99.
ASCE, Journal of Hydrologic Engineering, Associate Editor, 1985 – 1995.
ASCE, Journal of Hydrologic Engineering, International Associate Editor, 1995 – present.
International Journal of Hydroelectric Energy, International Editor, 1998 – present.
***ISI Journal of Hydraulic Engineering**, Taylor & Francis,* 2011 – present.
***Journal of Engineering Sciences**, (Turkey),* 2011 – present.
***Journal of Engineering and Environmental Sciences**, (Turkey)*, 2013 – present.

Special Issue Editor:
Population Dynamics, Climate Change and Technology Nexus on Human Health (2019)
International Journal of Environmental Research and Public Health (Impact Factor: 2.47)
https://www.mdpi.com/journal/ijerph/special_issues/pdcctnhh

Water Quality Modeling (2019)
PROCESSES Journal (Impact Factor: 1.97)
https://www.mdpi.com/journal/processes/special_issues/Water_Model

Computational Methods in Water Resources (2020)
WATER Journal (Impact Factor: 2.53)
https://www.mdpi.com/journal/water/special_issues/computainal_methods

Chemical and Non-Chemical Water Treatment (2020)
WATER Journal. (Impact Factor: 2.53)
https://www.mdpi.com/journal/water/special_issues/ozone_treatment

Editor-in-Chief:
International Journal on Water Quality, Exposure and Health, Springer Publishers. 2008 – 2014.

ENGINEERING CONSULTING:

1. Allied Gulf Nuclear Services, (1978-80).
2. NATO, United Nations Development Program, (1979-present).
3. The Coca Cola Company, Corporate Engineering Department, (1983).
4. Georgia Geologic Survey, Department of Natural Resources, State of Georgia, (1983-85).
5. Dames and Moore (1987), Numerical study of flow through earth embankments, Sarasota reservoir.
6. Atlantic Richfield Co. (ARCO) (1990-92), Performance analysis of a cleanup operation in a vadose zone, numerical modeling of saturated-unsaturated flow pump-and-treat operation, Opa Locka, Florida and Numerical modeling of ground water flow and contaminant transport control in a multilayer aquifer with a slurry wall design at a Super Fund Site.
7. CHEVRON Products Co. USA (1992-2002), Numerical modeling of transport of NAPL

contamination, Cleves, Ohio and CHEVRON Chemical Products Co., USA (1996-1997), Investigation of Agricultural Pesticides pollution, Ortho-CHEM plant, Missouri.

8. Expert Testimony: Atlanta Gas Light -vs.- various Environmental Insurance Underwriters (1993), Numerical modeling of transport of petroleum products in aquifers, Georgia.
9. L&L Landfill Co. (1994), Transport of leachate through L&L landfill, Chicago, Illinois.
10. DOD, Mass. Military Reservation, EDB plume modeling and exp. risk analysis, (1997-1998).
11. GeoSyntec Consultants, Consultant (1994 - 2001) (subsurface resources and contaminant transport modeling support and expert testimony).
12. Globex Engineering & Development, Consultant (1998 - 1999) (subsurface resources and contaminant transport modeling support, risk analysis and expert testimony).
13. DOE, Waste Isolation Pilot Plant Project (WIPP), New Mexico (1998 - 1999) (Technical support for expert testimony).
14. Texas Education Board, State Proposal Reviews, (1999-2000).
15. Eastern Research Group, Subsurface Resources and Environmental Health related analysis and exposure assessment, (1998-2013).
16. Hydraulic Fracturing and shale gas extraction, Washington Law Group, (2010 – 2017).
17. Camp Lejeune Exposure Litigation, Bell Law Group, Atlanta, GA, USA. (2022 – Present).

SPECIALIZATION AREAS:

Research, teaching and engineering experience in the following specific areas:

- Groundwater flow and contaminant transport modeling in aquifers, aquifer remediation.
- Groundwater resources evaluation and management.
- Aerodynamic Analysis.
- Multimedia (air-surface water- groundwater) environmental simulations, risk based env. modeling.
- Exposure analysis, exposure-dose reconstruction.
- Environmental health.
- Renewable Energy.
- Climate Change, Water Resources and Environmental Health.
- Analytical and numerical analysis in aerodynamics, surface water, groundwater and air pollution.
- Evaluation of groundwater and surface water monitoring data, site assessment.
- Site characterization and surface water groundwater interaction.
- Saturated and unsaturated groundwater flow analysis.
- Miscible and immiscible groundwater flow analysis.
- Computational methods in environmental fluid mechanics.
- GIS applications in environmental systems.
- Optimization methods in environmental systems.
- Hydraulics and water resources engineering.
- Hydraulic Fracturing and shale gas extraction.
- Population Dynamics and Climate Effects.

PhD/MS Students:

Graduated 25 PhD students at Georgia Institute of Technology.
Graduated 68 M.S. students at Georgia Institute of Technology.

Exhibit B

MEMORANDUM

To:	Morris Maslia, PE Project Manager Exposure-Dose Reconstruction Program ATSDR, CDC
From:	Prof. Mustafa M. Aral Director, Multimedia Environmental Simulations Laboratory School of Civil and Environmental Engineering Georgia Institute of Technology Atlanta, Georgia 30332-0355 Phone: 404 · 894 · 2243 Fax: 404 · 894 · 5111 E-mail: maral@ce.gatech.edu WWW: http://mesl.ce.gatech.edu/
Date:	June 27, 2009
Subject:	**Response to Comments of the NRC Report on ATSDR Water Modeling Study.**

This memorandum was submitted to EDRP/ATSDR on June 27, 2009, and became an internal document for the Camp Lejeune study at ATSDR/CDC. Contents of this memorandum are now included in Section 7 of this expert report.

EXHIBIT 12

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION
No. 7:23-CV-00897

IN RE:
CAMP LEJEUNE WATER LITIGATION

This Document Relates to:
ALL CASES

EXPERT VIDEO-RECORDED DEPOSITION OF
LEONARD KONIKOW, PHD

Tuesday, February 25, 2025
9:38 AM EST

Reported by: Denise Dobner Vickery, CRR, RMR
Job No. MDLG7172979

Tuesday, February 25, 2025
9:38 AM EST

Video-Recorded Expert Deposition of LEONARD KONIKOW, PHD, held in the conference room of:

WASHINGTON DULLES MARRIOTT SUITES
13101 Worldgate Drive
Herndon, VA 20170

Pursuant to notice, before Denise Dobner Vickery, Certified Realtime Reporter, Registered Merit Reporter, and Notary Public in and for the Commonwealth of Virginia.

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CIVIL DIVISION
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ALSO PRESENT:
Gene Aronov, Videographer

PRESENT BY ZOOM:
Deanna Havai
Dennis Reich
Tim Thompson
Jeffrey Davis
Morris Maslia
Devin Botlon
Bill Williams
Alex Spiliotopoulos

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KONIKOW DEPOSITION EXHIBITS

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P R O C E E D I N G S

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THE VIDEOGRAPHER: Good morning. We are now on the record.

My name is Gene Aronov. I'm videographer for Golkow Veritext division. Today's date is February 25th and the time is 9:38 AM.

This video deposition is being held at the Washington Dulles Marriott Suites, 13101 Worldgate Drive, Herndon, Virginia in the matter of Camp Lejeune Water Litigation versus United States of America for the Eastern District of North Carolina. The deponent is Leonard Konikow.

Would counsel please introduce themselves for the record.

MR. DEAN: Good morning. Kevin Dean on behalf of the Plaintiffs Leadership Group and the witness.

MS. BAUGHMAN: Laura Baughman on behalf of Plaintiffs Leadership Group and the witness.

MR. ANWAR: Haroon Anwar Department of Justice for the United States.

MR. ANTONUCCI: Giovanni Antonucci for the United States.

MS. SILVERSTEIN: Kailey Silverstein for the United States.

THE VIDEOGRAPHER: The remote participants will be noted on the stenographic record.

The court reporter is Denise Vickery will now swear in the witness.

- - -

LEONARD KONIKOW, PHD

called for examination, and, after having been duly sworn, was examined and testified as follows:

- - -

EXAMINATION

- - -

BY MR. ANWAR:

Q. Good morning, Dr. Konikow.

A. Good morning.

Q. My name is Haroon Anwar. I am a

lawyer for the Department of Justice here to take your deposition today in the Camp Lejeune Justice Act Litigation.

A. Okay.

Q. Do you understand that?

A. Yes.

Q. Okay. Have you ever sat for a deposition before?

A. One time.

Q. Okay. Well, you may recall that experience, but I just wanted to go over some ground rules to help the deposition today go as smoothly as possible.

A. Good.

Q. First, you're -- you're under the oath to tell the truth as if you were in an actual court of law.

A. Okay.

Q. Do you understand that?

A. Yes, I do.

Q. And is there any reason, sitting here today, that you would be unable to testify truthfully?

A. No.

Q. Okay. We have a court reporter sitting right next to you taking down everything, typing down everything for the record.
A. (Nods head).
Q. To make life easier for her, if we could avoid speaking over each other --
A. Okay.
Q. -- it will -- it will make for a cleaner record and a happier court reporter. She can't get everything down when we're speaking over each other.
A. (Nods head).
Q. Fair enough?
A. Fair enough.
Q. Okay. And sort of corollary to that is, to help with that, if you could pause or after I ask my question, maybe pause for a second and then respond.
Fair enough?
A. Okay.
Q. Okay. If I ask a bad question or a question that you need clarification on -- and it's very possible I would do that today -- could you let me know, please?

A. I will.

Q. Okay. If you don't let me know, I will assume that you understood the question. Fair?

A. Yes.

Q. Okay. Now, we'll be going for a few hours today. If at any point you need a break, just let me know. This isn't intended to be punishment. The only -- the only stipulation I would put on that is if there's a pending question, I'd ask that you answer that question, and then we can take a break.

Fair enough?

A. Yes.

Q. Okay. And I'll try to take a break every hour or so anyway.

A. Good. Okay.

Q. Now, I want to start by asking you what you did to prepare for today's deposition.

A. Well, a number of things. Over the past several weeks, I reviewed all of the reports from ATSDR for the Tarawa Terrace model and Hadnot Point/Holcomb Boulevard.

Last week I flew down to South

Carolina to meet with these lawyers, a few other lawyers, and Morris Maslia were there for basically two days of meetings. And then yesterday I met with Kevin and Laura just to discuss general questions, such as the things you just pointed out to me and had to respond.

Q. Sure.

A. Yeah.

Q. For the meeting last week, the two-day meeting in South Carolina with the lawyers and Mr. Maslia, was there anyone else present besides lawyers and Mr. Maslia?

A. Besides the lawyer -- there were several lawyers and myself and that's -- that's all I recall being there.

Q. Okay. No -- no non-lawyers other than Mr. Maslia?

A. No what?

Q. No non-lawyers other than Mr. Maslia?

A. I don't believe so.

Q. Did you review any documents during that meeting?

A. What do you mean by "reveal"?

Q. Did you review documents?
A. Oh, review?
Q. Correct.
A. During the meeting?
Q. During the meeting last -- last week, the two-day meeting with the lawyers and Mr. Maslia.
A. We may have looked things up for to check some facts, but I don't think there was anything that was a review of a document necessarily. I mean, we looked at some documents to answer some questions, but, you know, in terms of reviewing, if you mean like a technical review, that was not done.
Q. Okay.
A. But for specific points, there may have been discussions.
Q. Understood.
Did you -- I guess understanding I'm not asking about technical review sort of from a scientific perspective. Understanding that you are a scientist.
Did the documents that you reviewed with the lawyers and Mr. Maslia, did they help

refresh kind of your recollection about points that you were discussing?

A. It did. Occasionally, you know, something would come up, and we would look at one of the reports that ASDR -- ATSDR published.

Q. Okay. Do you recall what documents you reviewed during the two-day meeting last week?

A. I believe we looked at the chapter of the Tarawa Terrace that described the summary and findings and probably the groundwater flow model and maybe even the transport model.

Q. That was for Tarawa Terrace?

A. Tarawa Terrace and similar, you know, I don't remember exactly which ones we looked at, but I suspect we did the same types of documents for Hadnot Point when we talked about that.

Q. Understood.

Do you recall during last week's two-day meeting reviewing any other documents?

A. I do not.

Q. How about during yesterday's meeting? Was that -- did that meeting take place with Kevin and Laura?

A. It was in this room yesterday.
Q. Okay. And with the attorneys -- with your attorneys here present today; correct?
A. The two attorneys that are here today, yes.
Q. Understood.
Did you review any documents during yesterday's meeting?
A. I don't -- I don't recall that we did. I mean, maybe I don't remember, but I don't remember us reviewing any documents yesterday.
Q. Understood.
About how long -- how long did the meeting yesterday last?
A. It was probably about six hours, not counting lunchtime.
Q. All right. Did you do anything else besides the two separate meetings that we've discussed to prepare for your deposition today?
A. To prepare for the deposition? No, not that I can think of.
Q. Okay. But -- and I should say, besides the two meetings last week and this week with your -- the lawyers and Mr. Maslia and then

you had testified, I believe, that you had went through and reviewed the ATSDR modeling reports; correct?

A. Yes.

Q. Okay. Besides that, did you do anything else to prepare for your deposition today?

A. No.

Q. Okay.

(Document marked for identification as Konikow Exhibit 1.)

BY MR. ANWAR:

Q. I am handing you what is being marked as Konikow Exhibit 1.

Have you seen this document before?

A. (Reviews document.)

Yes, this looks familiar.

Q. Okay. I'll represent to you it's the notice for deposition and the subpoena scheduling your deposition --

A. Yeah.

Q. -- today.

A. Okay.

Q. I wanted to direct your attention to

Attachment A. There are three document requests there.

The first one is for e-mails, letters, correspondence, text messages, conversations, chats, voicemails, and communications pertaining to Camp Lejeune prior to your retention as an expert in this litigation.

Do you see that there?

A. Yes.

Q. And we received a document production from your counsel last night.

A. Yeah.

Q. Did that document production contain all of the responsive documents or communications you have in response to request number 1?

A. Well --

MR. DEAN: Object to form, except, you know, we've served an objection.

MR. ANWAR: Understood.

MR. DEAN: So subject to that.

THE WITNESS: I had responded I believe, several weeks ago with e-mails and then yesterday with other documents that I realized were covered up. But I wasn't intentionally not, you know, I wasn't intentionally not sending those forward.

I just -- I was focused on the e-mails, letters, correspondence part of this, and I had some files from my service on the expert panels in 2005 and 2009. And until Sunday, this past Sunday, it just didn't pop into my head that those were covered by this. It was just an oversight on my part.

BY MR. ANWAR:

Q. Understandable and, you know, I'm not suggesting you did anything --

A. Yeah.

Q. -- anything wrong.

I'm just trying to confirm --

A. Yeah.

Q. -- whether -- what was produced in response to this subpoena.

And so request number 2 is essentially the same thing. E-mails, letters, correspondence, communications with any of --

anyone that has filed a claim in this litigation.

And then request number 3 asks for bills, invoices, and other documents reflecting compensation paid.

In response to these three requests, did you give your lawyers everything that you have?

A. At this time, I would say I gave everything that I have, yes.

Q. Okay. Is there anything that you can think of related to Camp Lejeune prior to your retention as an expert in -- in this current litigation, communications, documents that you have in your possession currently?

A. That I have not turned over?

Q. Correct.

A. No. As far as I know, I've turned over everything.

MR. ANWAR: Okay. Thank you. You can set that aside.

(Document marked for identification as Konikow Exhibit 2.)

BY MR. ANWAR:

Q. I'm going to hand you now what is

being marked as Exhibit 2. There you go.
Dr. Konikow, is this a true and correct copy of the rebuttal report -- expert report that you submitted in this case?
A. It appears to be.
Q. Okay. Is there anything in your rebuttal report -- well, let me back up for a second.
This rebuttal report on page 33 is dated January 13; correct?
A. Yes.
Q. That's when you signed the report; correct?
A. And sent it probably to Kevin, yes.
Q. Sure.
And is that your electronic signature there on page 33?
A. It is.
Q. Okay. Since submitting the report and giving it to the lawyers on January 13, 2025, is there anything in your rebuttal report that you now believe is incorrect?
A. Yes.
Q. What -- what is that?

A. On page 10 -- let me look at my copy. Page 11 line 10 it says "equivalent to a fraction or 0.001," the word or should be "of" o-f. So just a typographical error.
Q. Understood.
And this is the sentence starting with "OCC is equivalent to TOC?
A. Yes.
Q. "And 0.1% is equivalent to a fraction of .001"?
A. Yes.
Q. Is there anything else, as you sit here today, that you believe is incorrect in your report?
A. No.
Q. Is there anything in your rebuttal report that needs to be updated, as you sit here today?
A. Not that I'm aware of, no.
Q. Is there any portion of your rebuttal report that you believe is incomplete?
A. Not -- no, not that I can think of.
Q. And does your rebuttal report contain all of the opinions that you intend to

offer in this case?

MR. DEAN: Object to the form. Subject to anything that you might ask him in the deposition not covered by the notice -- I mean, the report.

THE WITNESS: I may have other opinions. I'm not, you know, I mean, from my review of those two expert reports, these are the comments that I felt were significant criticisms that I thought were worth making.

If something else comes up, I probably have another opinion. So I don't think I could say that these are the only opinions I would give. You ask me a question, I'll give you my opinion.

BY MR. ANWAR:

Q. Sure.

So aside for any conversation we have in the deposition today, does this report contain all of the opinions that you intend to offer in the litigation?

A. Well, you, again, if I, you know, if I'm asked questions about something other than

this, I would offer an opinion on it.
So I'm really not sure about the question what -- what it is encompassing but...
Q. Sure. I understand that.
I guess with the caveat that we may discuss things both contained in your report and not directly referenced in your report in today's deposition.
Putting that aside, is there anything -- are there any other opinions that you're currently aware of that you intend to offer in this case that aren't reflected in your report?
A. Not that I can think of.
Q. Okay.
(Document marked for identification as Konikow Exhibit 3.)
BY MR. ANWAR:
Q. I'm going to hand you what I'm marking as Konikow Exhibit 3.
A. (Reviews document.)
Q. Dr. Konikow, is this a complete list of the materials you considered in forming the opinions in your rebuttal report?
A. I believe so.

Q. Okay.
A. I'll look. There's a number of documents listed at the end, and I'm not sure exactly what those refer to.
Q. Okay. This document, Exhibit 3, that I handed you, it's titled "January 2025 Rebuttal Expert Report of Leonard Konikow, PhD, National Academy of Engineering" and then underneath it says "Materials Considered List" and it's dated January 21, 2025; is that right?
A. Yes.
Q. Okay. And as you sit here currently, you're not aware of anything else that should have been included on this Materials Considered List that's not included?
A. Not that I'm aware of.
Q. Okay. Did you review the rebuttal reports of or the rebuttal report of Morris Maslia?
A. I believe I did.
Q. Okay.
A. I don't recall it specifically, though.
Q. But you may have?

A. Yes.
Q. Did you review a rebuttal report from David Sabatini?
A. I believe I saw it. I saw something from Sabatini.
Q. Okay. Did you review the rebuttal report from Norman Jones and Jeffrey Davis?
A. Yes.
Q. And did you review the rebuttal report from Kyle Longley?
A. I -- I don't -- I -- yeah, I'm not sure which report that was. Is that the one related to the history or something?
Q. Yeah. Correct.
A. I think it was sent to me and I just glanced at the first page or so, and I did not review that whole report.
Q. Understood.
Do you have any opinions about the -- any of those rebuttal reports that aren't reflected in your -- in your own report?
A. Well, my report really focused on Alex and Remy's report, and I don't think there's any comments in here on the other rebuttal

reports.

Q. Okay. And as you sit here today, you don't intend to offer comments on the other rebuttal reports outside of any discussion we may have today in the deposition?

A. Correct.

Q. Okay. Did you listen to or review the transcripts for the deposition of Mustafa Aral?

A. I did. Yes, I looked at it. I read it.

Q. Okay. Did you either listen to or review the transcripts for the depositions of Norman Jones and Jeffrey Davis?

A. I believe I did.

Q. Do you have any opinions about anything that was said in those depositions that aren't reflected in your -- your own expert report, your rebuttal report?

MR. DEAN: Object to the form. Subject to whatever you may ask in this deposition or I do as a follow-up.

BY MR. ANWAR:

Q. You can answer.

A. Well, there's nothing in my expert report about the testimony or deposition of Jones and Davis. I read it. I may have some opinions on it, but it was nothing that belonged in my rebuttal report.

Q. Okay. Outside of any discussion we have today in the deposition, do you intend to offer any opinions related to anything that was said in -- well, strike that.

Outside of any discussion we have today during our -- the deposition, as you sit here, do you intend to offer any opinions based on the depositions of Mustafa Aral, Norman Jones, and Jeffrey Davis?

A. That's not my intent, but if I'm asked, I would try to answer the question to the best of my ability.

Q. Understood. Thank you.

Do you know Norman Jones?

A. I've met him once or twice. I do not know him personally very well, just, you know, other than an introduction at a professional meeting or something like that.

Q. Where did you meet him?

A. I've attended so many professional meetings in the last 40 years, I really -- I don't remember. It may have been a National Ground Water Association meeting. It may have been a Geological Society of America meeting. I go to, you know, many of these and occasionally our paths him across. It was probably one or two sessions where we were both speakers in a symposium, and I'm sure I shook hands with him, said hello, but nothing more than that.

Q. Understood.

Aside from crossing paths in professional settings once or twice, it sounds like you haven't -- you don't know Norman Jones otherwise; correct?

A. When I was -- well, basically the answer is no, I don't know him, but I believe I had another interaction with him in the last five years related to a man- -- I was editor-in-chief of Groundwater Journal for four years. And during that time, I believe he had submitted one manuscript not related to Camp Lejeune, and so we had some correspondence related to that, but had nothing to do with Camp Lejeune.

Q. Do you have any recollection what that manuscript was about?
A. I believe it was about an area called Spring Valley in Nevada or an adjacent area in Utah. I know it focused on the City of Las Vegas, trying to develop well fields in an area maybe a couple hundred miles north of Las Vegas, but in a valley in Nevada that extended into Utah. And they wanted to develop water supplies on the Nevada side, pump a lot of wells, and it would have had impacts on the Utah side. So he was -- the manuscript focused on that situation.
Q. Well, did that manuscript involve groundwater or transport modeling? Do you recall?
A. My recollection it probably, but I can't -- I don't have total recollection. It probably involved groundwater flow modeling.
Q. Okay.
A. Probably did not involve transport modeling.
Q. Understood.
In that instance, it sounds like it may have involved groundwater modeling for the purposes of developing supply wells outside of Las

Vegas; is that right?
A. It was related to that, but I think his focus was on assessing the impacts of that pumpage on water supplies on the aquifers in Utah.
Q. Okay. Aside from that manuscript, have you worked with Norman Jones on any other projects?
A. No.
Q. Do you know Mustafa Aral?
A. I've met him.
Q. Okay. In what context have you met Dr. Aral?
A. Serving on expert peer review panels for ATSDR in 2005 and 2009. I believe he was at both of those meetings, to the best of my recollection, and I met him there and we may have talked. You know, I don't remember. I believe he gave some presentations to the expert panel committees, but I don't remember the details.
I don't recall ever meeting him outside of those two meetings.
Q. Have you ever worked with Dr. Aral before outside of those two meetings, the ATSDR meetings?

A. No, not to recollection.
Q. Do you know Jeffrey Davis?
A. I believe I met him somewhere along the line, but I can't recall the occasion. I saw he said he was involved with the board of directors of National Ground Water Association, and while I was an editor for their journal, we probably attended meetings together at their annual meetings. And we probably talked there, but I have no direct recollection of that.
Q. Okay. So outside of those professional meetings, you don't know Jeffrey Davis; is that right?
A. That's correct.
Q. Have you ever -- and you haven't worked with Mr. Davis before?
A. Not that I could recall.
Q. Do you -- do you know David Sabatini?
A. No.
Q. Never met?
A. Well, again, I may have met. If he was at the 2005 or 2009 meetings, I probably met him, but I do not recall meeting him.

Q. Understood.
Earlier you mentioned reviewing all of the ATSDR reports.
It sounds like the modeling reports for Tarawa Terrace as well as the model -- modeling reports related to Hadnot Point and Holcomb Boulevard; is that right?
A. That's correct.
Q. Did you do anything further than review the reports?
A. I'm not sure what that would -- could include, but no, I mean, I read the reports. I didn't do anything else with them.
Q. Did you attempt to reconstruct ATSDR's models for Tarawa Terrace or Hadnot Point and Holcomb Boulevard?
A. I did not.
Q. Did you attempt to reevaluate the input parameters or assumptions upon which the Tarawa Terrace model or the Hadnot Point/Holcomb Boulevard model were based?
A. Well, I mean, part of my review was looking at their discussions of the parameter values, and I certainly, you know, considered them

and looked at, you know, what, you know, that they looked reasonable, you know.

Q. Outside of what's contained in your report and what we -- we discuss today, do you have any -- any opinions about ATSDR's parameter of values or input values?

A. Can you repeat that, please?

Q. I guess -- well, let's -- we'll come back to that. Let's that was maybe a bad question.

I'm going to hand the court reporter to hand you what is being marked as Konikow Exhibit 4.

(Document marked for identification as Konikow Exhibit 4.)

THE WITNESS: (Reviews document.)

BY MR. ANWAR:

Q. The first page of Exhibit 4 states "Attachment A" which was attached to your expert report, and Attachment A is a copy of your curriculum vitae; correct?

A. Yes.

Q. Okay. Is this a true and accurate

copy of your curriculum vitae?
A. Yes.
Q. Is it current?
A. Pretty current. I think I updated it a couple months ago.
Q. To the best of your knowledge, as you sit here today, is there anything that you need to update on this curriculum vitae?
A. No. Again, this -- this includes -- it's not a complete detailed list of everything I've ever done professionally --
Q. Okay.
A. -- but it's, you know, what I could get in two pages.
Q. Okay. How did you decide what to include on your curriculum vitae versus what not to include in terms of, you know, everything that you've done professionally?
A. Well, I included the points that I think people would expect to see in a curriculum vitae, my education, so on, and highlights of publications and professional side activities. A few awards that I received that I thought were of particularly high recognition, but I did not

include every award I've ever received or every publication I've ever had published.

Q. Understood.

As part of Exhibit 4, there's also an Attachment B, which is Attachment B to your -- your rebuttal report, and it's titled "Publications During Past 10 Years."

Is that right?

A. Yes.

Q. Is this a complete list of your publications during the past 10 years?

A. To the best of my knowledge, it is.

Q. I wanted to ask you a few questions about items on your CV.

I wanted to start by asking you whether you would describe yourself as a hydrogeologist; is that right?

A. That's how I usually describe myself, yeah.

Q. Is there any other title that you describe yourself with?

A. Occasionally, you know, my official job position with -- during my career with the U.S. Geological Survey, most of the time I was called, in fact probably all the time, I was called a research hydrologist.

Q. Okay. Do you consider yourself an expert in groundwater transport and water distribution modeling?

A. I am not an expert in water distribution modeling, but I do consider myself an expert in groundwater flow and transport processes in modeling.

Q. Is there any other subject area that you consider yourself an expert in?

A. I think hydrogeology, groundwater flow, and transport processes probably encompasses all of it.

Q. Okay. Now, you spent the bulk of your career at the U.S. Geological Survey; right?

A. Yes, sir.

Q. And then it looks like from your CV your most recent role was editor-in-chief of Groundwater Journal from 2020 to 2023; is that right?

A. Yeah, four years.

Q. Four years from 2020 to 2023?

A. Yeah, inclusive. All those years,

you know, from January 1st of 2020 to December 31st of 2023.
Q. Understood.
Are you currently retired?
A. Yes. Well, except for this. (Laugh).
Q. Except for the serving as a Camp Lejeune expert; correct?
A. Yes.
Q. Okay. Under -- I wanted to talk to you a little bit about some of your selected professional activity on your CV.
It looks like that throughout your career you've served on committees or panels for the National Research Council; is that right?
A. That's correct.
Q. Okay. From -- and I'm looking at your CV.
From 1981 to 1982, you served on an NRC panel on groundwater contamination; is that right?
A. That is correct.
Q. What did you do in this role?
A. Well, to the best of my

recollection, again, that one is, you know, more than 40 years ago, but as a panel member, we discussed the -- the problem of groundwater contamination, which was just in the late '70s becoming much more widely recognized as an important problem.

And the National Research Council had asked me to serve on this panel, and I thought it was a worthwhile activity. We would typically have discussions among the whole committee, as well as listen to presentations from experts that they brought in. I had no role in selecting who they brought in but, you know, and then we would have discussions.

And then somewhere after, you know, the first or second meeting, we started working on writing a report and, to the best of my recollection, a book came out from that activity.

Q. What book came out of that activity?

A. I believe it was just a National Research Council report published by National Academy Press. Something in the title about groundwater contamination. There may have been some other words there, but I don't recall. I haven't looked at that report in a while.

Q. Okay. Did you take part in writing any part -- any portion of that book?

A. Most likely, yeah.

Q. So either on the book itself or in the chapters, you likely would be listed as an author?

A. I don't know that they listed authors. I think they listed it in terms of who was members of the committee that wrote the report.

Q. Understood.

Do you know how you were selected to serve on that NRC committee on groundwater contamination?

A. No, I do not.

Q. You mentioned, I guess, other experts served on that committee; correct?

A. Yeah. Yes.

Q. Would it be fair to say you were selected to serve on that committee because of your expertise as a hydrogeologist?

A. I presume so.

Q. Do you know how other experts were

selected to serve on that committee?

A. I do not.

Q. Do you remember any of the experts that you -- you served on that committee with?

A. On that committee, I do not remember. I did not look at that report probably in the last year or two years or five years. I just -- I don't remember who else was on that committee. If I looked at the report, it would refresh my memory.

Q. Understood.

Now, looking further on your CV, it looks like from 1987 to 1989 you served on an NRC Committee on Ground-Water Modeling Assessment; is that right?

A. From '87 to '89, yeah. Committee on Ground-Water Modeling Assessment, yes.

Q. What was the committee or what is the Committee on Ground-Water Modeling Assessment?

A. Again, this is done at a time when groundwater modeling was becoming much more widespread and -- and, you know, particularly in the public there wasn't a widespread appreciation among the public or probably politicians and others, senior level government officials, about what groundwater models could do, how reliable they were and so on. And so this -- this committee was, I believe, was charged to review the state of the art of groundwater modeling.

It's not shown here, but like a subtitle of this committee, or at least of the book that was produced, was something to the effect of groundwater models in a regulatory and environmental framework or assessment, something like that. There was, you know, some additional subtitle that is not listed here. I was trying to keep everything on one line here.

Q. Understood.

What do you -- what did you do in this role on the -- the NRC Panel on Ground-Water Modeling Assessment?

A. We discussed the philosophy of modeling. We discussed the mathematical basis underlying the model. We discussed parameter estimation for the models, how reliable the results are, you know, things on that order, yeah.

Q. Do you know how it came to be that you were selected to be on that committee?

A. No, I do not.
Q. Did you apply to be on that committee?
A. No. I usually don't volunteer for things. (Laugh).
Q. Understood.
It sounds like you were selected to serve on that committee then?
A. Somebody asked me, I don't remember who, and I thought it was a worthwhile activity at the time and so I said sure.
Q. Okay. Do you recall any of the members of -- the other members that served on the Groundwater Modeling Assessment Committee?
A. I do.
Q. Who? Who were they?
A. Frank Schwartz was the chairman of the committee. He is a professor at Ohio State University. You know, I've known him off and on for many years. Jim Mercer was on that committee. Jim was one of the founders of a company called GeoTrans. I was more or less personal friends with Jim Mercer. He -- his company -- he used to work for the USGS. Formed his own company around

1980. That company was later bought by Tetra Tech, a larger consulting company.

I believe Charlie Andrews from Papadopulos & Associates was on this committee. I've known Charlie off and on, you know, over the years, at least since this time.

Just off the top of my head I can't think. I know there were other people on the committee, but I can't recall who.

Q. Sure.

Now, you mentioned some of the work you did on that Committee about Ground-Water Modeling Assessment.

Do you recall sort of more specifically the nature of that work? Were you -- were you evaluating sites? Were you -- or were you discussing sort of modeling as a -- as a science of itself?

A. I would say both. I think the report focused mostly on the state of the art of modeling. I do recall there were two or three case histories, site-specific studies that were included in the book of examples to illustrate examples of the application of models to real world complex problems.

Q. Do you recall what any of those sites -- three sites were?

A. I think one of them was a contaminated site in Ohio. Maybe Dyncam, D-y-n. I'm not positive, but that just sort of just popped in my mind.

The other one or two examples I just -- I can't recall at the moment but, you know, if I looked at the book, I would see it but, you know.

Q. Do you recall how groundwater modeling was involved for that site in Ohio?

A. Since it was a contamination problem, I assume there was a groundwater flow model and a related groundwater transport model, a solute transport model.

Q. Do you recall whether you were -- what the purpose of the model was for that Ohio site?

A. I do not.

Q. Do you recall whether it was sort of forward-looking or forecasting or whether it was backwards looking and hindcasting?

A. I don't recall.
Q. Okay. Do you recall what the models for the other two sites were used for?
A. I do not recall.
Q. Okay. Fair enough.
And then on your CV, from 1989 to 1997, it looks like you served on an NRC Committee on Waste Isolation Pilot Plant?
A. Yes.
Q. Could you tell me about that?
A. Sure. The Department of Energy had proposed a site near Carlsbad, New Mexico in thick bedded salt deposits for the disposal of radioactive waste, particularly plutonium waste related to weapons production and, you know, typically these were not high-level wastes in the sense of fuel rods from power plants, which would generate a lot of heat, even in a waste form.
These wastes although in a sense were high level -- they were very toxic -- they were not generating heat. It was basically plutonium garbage waste products.
Q. Understood.
A. Yeah.

Q. And was there a component on that committee -- committee that involved groundwater flow or transport modeling?

A. Yes, that was one of the big concerns, you know, in assessing the safety of the site, the big concern, could anything escape from the site and what's the likely pathway. And it was deemed that, you know, one of the likely pathways, particularly if the site operated to completion in the future and was sealed and closed, the most likely risk would come from water breaching the repository area and then leaking upwards into an overlying permeable aquifer.

And then what would happen to that liquid waste in that aquifer. How fast would it move through the aquifer? How would it spread? What kind of risk did it pose to future humans living downgradient of that?

So, you know, one of the focus of the committee was to assess the Department of Energy's safety assessment and so we were, you know, we looked very critically at everything they did in terms of trying to demonstrate safety.

This was -- and, again, the Waste

Isolation Pilot Plant, to my recollection, it was originally proposed as a pilot plant, which implies that this would be somewhat experimental and, you know, not quite a full operational.

But at some point they changed the name to the WIPP site, just the initials, and it was pretty clear this was going to be an operation. It wasn't an experiment. It was -- it was planned to be an operational waste -- radioactive waste disposal site for what they call transuranic wastes.

Q. Understood.

And it sounds like you were using groundwater modeling, and you may have mentioned transport modeling, but in this context, you were using it for sort of management or planning purposes, for purposes of?

A. Safety I'd say the overriding purpose. There was groundwater flow modeling involved. There was solute transport modeling involved and the overall framework for that and, again, this was just one aspect of many for this committee.

Q. Sure.

A. The groundwater was just one aspect. There were many things and many other experts involved from other disciplines, but the groundwater flow and transport was really based on a safety assessment. And they were expected to demonstrate safety of the site for 10,000 years into the future.

Q. Understood.

On this Waste Isolation Pilot Plant Committee, was there -- did you do any modeling work that you would describe as hindcasting or historical reconstruction?

A. No.

Q. On any of the three NRC committees or panels that you served on, the ones that we've just discussed, have you -- did you do any work model -- modeling work attempting to estimate exposure concentrations for purposes of -- excuse me -- let me -- strike that. Let me -- let me ask that again.

On any of these three NRC committees that we've just discussed, did you do any modeling work that was aimed at aiming -- aimed at estimating contaminant concentrations to be used

for making exposure determinations on individuals?
A. Yes.
Q. Which one?
A. The WIPP site. The WIPP committee. I didn't personally do those, but one of the things that was done by DOE and evaluated by our committee was potential doses to future humans, farmers, living somewhere downgradient from the site that might be exposed. You know, they might have a well, and what if they or their cows drank water from an aquifer after contaminants passed by.
So -- so the answer is yes, that kind of, the dose and the exposure and the consequences had been considered and assessed, but I was not personally involved in any of those calculations, estimations, or assessments.
Q. Okay. And that was looking into the future; correct?
A. It was looking into, I guess we could say, a hypothetical future.
Q. Got you.
And I apologize if I asked you this.
What was your role specifically on

that committee, the WIPP committee?
A. Well, I mean, everyone on the committee had, in a sense, an equal role to contribute towards the goals of the committee and assess presentations made to the committee by DOE and their contractors related to the site. So we were, you know, free and open to question anything on any topic if we had questions about it.
But, you know, I focused on groundwater flow and transport modeling, but I also looked at their human intrusion scenarios and the risk assessments that they made and, you know, basically anything related to the WIPP site, particularly anything that would have a geological or hydrological connection was a primary interest, but I looked at other things also.
Q. Sure.
Were you selected to serve on the WIPP committee -- the WIPP site committee?
A. I must have been.
Q. Okay. In other words, did you volunteer to join that committee, or did someone ask you to join that committee?
A. Someone asked.

Q. Okay.

A. Yeah.

Q. Do you recall any of the other members of that committee, the Waste Isolation Pilot Plant, which we've been referring to as WIPP?

A. Yeah. When I started on it, there was a professor from Stanford named Konrad Krauskopf, I think it is, who is a geochemist. He was the chairman of the committee when I first came on.

John Bredehoeft, a hydrogeologist also worked with the USGS, at least I think at the early part of that time. He retired somewhere around 1990 or so from the Survey. He was on the committee when I first entered, but he had stepped off by the time, you know, before I ended my participation.

A geochemist geologist named Rod Ewing was on the committee. An engineer named Chris Whipple was on the committee. You know, I'd have to take another look.

Oh, John Garrick, who was an expert in risk assessment was on the committee. There were, you know, five or six other people on the committee that I can't recall their names at the moment.

Q. Fair enough.

You mentioned undertaking a review of DOE's waste disposal plan on that committee; right?

A. Of the Waste Isolation Pilot Plant, yes.

Q. Oh, I'm sorry. Of the Waste Isolation Pilot Plant?

A. Yes, that was the focus of the committee.

Q. How thorough was that review?

MR. DEAN: Object to the form.

THE WITNESS: Well, you know, I think it was a pretty detailed, in-depth review. You know, I would say always questioning what was presented to the committee, looking to delve a little deeper but, you know, the committee did not, you know, reproduce or test or look at every detail of what was presented to us.

It just didn't have the time to do that, but we had, you know, 10 to 12 experts in topics ranging from nuclear physics to materials science, risk assessment, probabilistic analyses, hydrogeology, and so on, and so each person tended to ask some pretty thoughtful questions about areas within their expertise.

I think there was one expert -- I can't remember his name -- on trains, railroads because it had been proposed that the radioactive waste would be transported by rail to the site.

So they got a committee member who was an expert on safety of railroad transportation, and so after a short while they decided they were not going to transport it by rail. So, you know, that was -- but that's an example of the type of expertise that was on the committee.

BY MR. ANWAR:

Q. Understood. Thank you.

Now, these were all NRC committees;

correct?
A. That was the National Research Council. Sometimes NRC is confused with the Nuclear Regulatory Commission --
Q. Okay.
A. -- which is also called the NRC.
Q. (Laugh).
A. But no, this was all National Research Council, which, as best as I understand it, is an arm of the National Academy of Sciences.
Q. Okay. And you anticipated my question.
I was going to ask you: What is the National Research Council?
A. Okay. I'm not sure exactly, but my impression is it is somehow under the realm of the National Academy of Sciences.
Q. Do you have any understanding about the national research's -- National Research Council's reputation?
A. Well, you know, I think their reports are generally well-respected. It probably varies from report to report, and that probably varies from who the particular experts are on the

particular committee were. But if -- if, you know, you want a general report, I think the reports are considered -- for what they do, they're considered to be, you know, reasonable, reliable and, you know, frequently cited.

Q. Generally speaking, would you agree that the NRC is considered a reputable and a prestigious organization?

MR. DEAN: Object to the form of the question.

THE WITNESS: I, you know, I would say it depends on the particular committee but, you know, in general, I think their -- their reports or the books they produce are, you know, considered to be well thought out and reproduced, you know.

You know, there's always particular issues that many people might disagree with but, you know, a broad perspective, yes, they are respected.

BY MR. ANWAR:

Q. Okay. And you mentioned that the National Research Council is part of the national -- or an arm of the National Academy of Sciences; correct?

A. Yes. I don't understand perfectly what the relation is, but all I know is they somehow fall under the National Academy of Sciences.

Q. What is the National Academy of Science?

A. Basically, there are three organizations under that umbrella. One is the National Academy of Sciences, one is the National Academy of Engineering, and one is the National Academy of Medicine and some other word, which I can't remember.

So there's like three subspecialty areas and three actually they're considered separate institutes or academies that fall under the national -- it's called the National Academies of Science, Engineering, and Medicine Sciences, something like that.

So it, you know, encompasses those three areas and it's a -- my understanding is a nongovernmental organization. Although a lot of their funding comes from government agencies, but

I think -- and I may not have this completely accurate, but my impression is they're independent, standalone. They don't fall under any federal agency.

Q. The National Academy of Science, isn't it made up of scholars elected by their peers?

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. You can answer.

A. In terms of members, they are elected by existing members is my understanding.

Q. Is being elected as a member to the National Academy of Science generally considered to be an honor?

MR. DEAN: Object to the form of the question.

THE WITNESS: I think so, yes.

BY MR. ANWAR:

Q. And what is your understanding of the National Academy of Science's reputation?

A. My impression is that it has a good

reputation. You know, I personally am -- I was elected to membership in the National Academy of Engineering in 2015, and I considered that a high honor.

Q. I was going to ask. I was going to -- you've been anticipating my question.

A. Sorry.

Q. I've heard membership in the National Academy of Science to be considered one of the highest honors a scientist can receive a U.S. scientist.

It sounds like you agree with that?

A. Basically, yeah. Yes. Yeah.

Q. Now, on page 1 of your CV, under Honors and Awards, you have there in bullet points -- in bullet point sort of the last item bolded among all of the items, "Elected to National Academy of Engineering (2015)" --

A. Yes.

Q. -- correct?

A. Correct.

Q. Okay. What -- what is the National Academy of Engineering?

A. It's one of the three divisions of

the National Academy. It's really the National Academies.

Q. And why did you list it in bold under a section of your CV entitled "Honors and Awards"?

A. I wanted to make sure that it was noticed. (Laugh).

Q. Sure.

A. I consider it an honor. All the other things listed are honors, but I felt that this was probably, among all of those, the highest honor that I had.

Q. Okay. And you list NAE next to the PhD in your name; correct?

A. Yeah. Yes. That indicates I'm a member of the National Academy of Engineering.

Q. And reflecting the fact that you consider it to be one of the highest honors that you've received; correct?

A. Correct.

Q. Okay. Now, I wanted to talk to you a little bit more about sort of the scope of your expertise.

Earlier we discussed that you would

consider yourself a hydrogeologist with expertise in groundwater flow modeling and solute, I think, transport modeling; correct?
A. Yes.
Q. Okay. And if I understood you correctly, there were -- there were no other areas that you consider yourself an expert in; correct?
A. Yeah, I mean, I have some skills in other areas and certainly understandings, but that what you just said is, you know, where I consider my main skills and interests.
Q. Okay. And so this is perhaps a bit obvious, so forgive me, but you're not an epidemiologist; correct?
A. Correct.
Q. You're not a toxicologist?
A. Correct.
Q. The findings of epidemiology, those aren't within your area of expertise; correct?
A. Correct.
Q. And that includes the epidemiologic studies or epidemiological studies performed related to Camp Lejeune; correct?
A. Correct.

Q. You're not an expert on whether a contaminant can cause a disease; correct?
A. I'm not an expert on that, no.
Q. And you're not an expert on the amount of exposure to a contaminant that can cause a disease; correct?
A. That's correct.
Q. Okay. Your report sort of in passing or it references MC -- MCL in a few places.
What is your understanding of an MCL?
A. My understanding is that it stands for maximum contaminant level, and I believe it's a level set by the U.S. Environmental Protection Agency, and it reflects their consideration that any level higher than the MCL creates an undue risk to anyone drinking water with concentrations exceeding that. So it's a level that should not be exceeded in any public water supply.
Q. Understood.
Have you ever been involved in setting an MCL?
A. No.

Q. Okay. You're not aware of the methodology that the EPA uses to establish an MCL, are you?
A. No.
Q. Okay. And you're not aware of how MCLs are set related to health risks; correct?
A. No, I'm not.
Q. You're not aware; correct?
A. Correct, not aware.
Q. Okay. Are you aware of whether an exposure above an MCL presents a health risk?
A. My general impression is that it's -- the MCL is set to distinguish between what is reasonably safe and what poses a health risk. So anything above it, I would assume, reflects some undue risk.
Q. What is that based on? I guess what is your -- that assumption based on?
A. It's based on my understanding of why an MCL would be set for particular chemicals by the EPA.
Q. Okay. But you haven't ever been involved in setting an MCL yourself and you're not aware of the methodology they use; correct?

A. Correct.
Q. Okay. Are you aware that for certain chemicals MCLs are set as close to zero as technically feasible?
A. No, I'm not aware.
Q. Okay. Now, your -- your rebuttal report indicates that you're being paid $400 an hour for your opinion for your work in this case; correct?
A. That's as of January 1st. In 2024 I was charging a lower rate.
Q. Okay. What were you charging in 2024?
A. $275 an hour.
MR. ANWAR: Okay. I'm going to hand you two documents. I'm going to hand to the court reporter to hand you.
(Document marked for identification as Konikow Exhibit 5.)
(Document marked for identification as Konikow Exhibit 6.)
BY MR. ANWAR:
Q. I will represent to you that -- well, so I've handed you documents that I've

marked as Exhibits 5 and 6. These are copies of bills that -- billing records that were produced to us by your counsel last night.

Are these true and accurate copies of invoices that you've submitted to the lawyers for time that you've worked on this case?

A. Yes.

Q. Okay. And so on Exhibit 5, it says on the first page dates of service October 9, 2024 to October 21, 2024, that your hourly rate was 275, that you worked 19.75 hours, and that the total amount that you charged was $5,431.25; correct?

A. Yes.

Q. Okay. And then the next invoice is dated -- Exhibit 6 is dated, dates of service December 12, 2020 -- excuse me -- December 11, 2024 to December 31, 2024 with an hour -- hourly rate of 275 per hour, total hours 63.58 for a total amount due of $17,484.50; correct?

A. Correct.

Q. Okay. Have you issued any bills for work performed in January yet?

A. Not yet. I hope to get to that

soon.

Q. Okay. Do you have any idea of the total number of hours or the amount of the invoice that you intend to submit for January?

A. Let's see. I would guess it's on the order of 100 hours. I have a record of it at home, but I -- I never added it up because I haven't produced the, you know, I haven't gotten a chance to prepare an invoice for January yet. I hope to do that later this week.

Q. Okay. When you complete that invoice and issue it to your lawyers, we would request that a copy of that invoice be produced.

Is that okay with you?

MR. DEAN: No objection.

BY MR. ANWAR:

Q. And then you mentioned in 2025 your hourly rate has increased to $400 an hour --

A. Yes.

Q. -- correct?

A. Correct.

Q. Have you received any compensation related to Camp Lejeune outside of your paid work as -- currently as a -- as an expert in this litigation?

A. No.

Q. And I understand that you served on the two ATSDR expert panels on the water modeling; correct?

A. Correct.

Q. And based on the documents that were produced last night, at that time it looks like you were -- you were with the U.S. Geological Service; correct?

A. Survey. Yes.

Q. Survey. Excuse me.

A. Yeah.

Q. And based on the documents that were produced to us last night, it looks like for your participation on the ATSDR expert panels, the U.S. Geological Survey entered into a contract with ATSDR; is that right?

A. Yes.

Q. Okay. Did you receive any compensation individually for your participation in the expert panels?

A. No.

Q. Just your salary as a government

employee?

A. Just I -- yeah, my only compensation was as an employee of the U.S. Geological Survey and, you know, that -- that was it. The contract was between the USGS and ATSDR and I presume to compensate the Survey for my time.

Q. Okay. And based on the information we received or the documents that were produced last night, it looks like you were retained as an expert witness in -- for this litigation in October of 2024; is that right?

A. That's correct.

Q. Okay. And same, based -- based on the e-mails that were produced to us last night, it looks like it was Morris Maslia that put you in touch with Mr. Dean; is that right?

A. That is right.

Q. Okay. How did you come to the decision to serve as an expert witness for the plaintiffs in this litigation?

A. Well, Mr. Dean had contacted me, explained the -- what he was seeking, that he wanted me to serve, you know, to review some documents. I was hesitant because I'm retired, but he explained the problem, and I had certainly some familiarity with Camp Lejeune and the problem because of my service on those two expert panels.

So I maintained an interest in it. I thought it was an important issue, an interesting problem from many perspectives, but it was, you know, an interesting use of groundwater modeling and transport modeling. And in spite of being retired, I decided, okay, since this would not be a full-time activity for me, I could take this on.

Q. Understood.

A. You know, plus I would be compensated at a, you know, what I thought was a reasonable rate.

Q. Understood.

Now, it was Morris Maslia that introduced you to Mr. Dean; correct?

A. He had contacted me and asked if it was okay for him to give my contact information to a lawyer.

Q. Okay.

A. I don't recall that he mentioned Mr. Dean's name at the time, but he may have. I don't know.

Q. Okay. How do you know Morris Maslia?

A. I've known him for many years. He used to work for the U.S. Geological Survey. I believe he was an attendee at a training class for which I was an instructor.

The USGS had a fairly extensive training program. We have a National Training Center in Lakewood, Colorado just outside Denver, and I used to be involved as one of the instructors and for a couple of years as the coordinator for a class on solute transport modeling. And I believe Morris sometime way back was a student in that class, and that's probably the first time I met him.

Q. Okay. Around what time frame would that have been when you first met him?

A. It -- it was either the late '70s or early '80s is what I gather or what I would guess or estimate, but I don't recall specifically. I would have to look up attendee lists and things like that, which I may or may not even have. But -- so it was probably in the late '70s to early '80s, and then I knew at some point he resigned from the Survey and went to work with ATSDR.

Q. Okay. Have you worked with Mr. Maslia on any projects other than the ones at ATSDR related to Camp Lejeune?

A. Not that I could recall.

Q. Do you think of Mr. Maslia as a professional colleague?

A. Yes.

Q. Do you consider him a friend?

A. In a general sort of way, yes. I mean, we -- we've never socialized, but yeah, I consider him a professional friend.

Q. And earlier we discussed the meeting held last week in South Carolina, the two-day meeting, and Mr. Maslia was in attendance; correct?

A. Correct.

Q. Prior to your involvement in this litigation, prior to your retention in October of 2024, when was the last time you had spoken with Mr. Maslia?

A. It was several years before that. I

can't remember exactly when. We had some e-mail communications. Actually speaking with him, I don't recall the last time we actually spoke in a phone call or anything like that. That's probably quite a while, but we did occasionally have e-mail communications.

Q. Understood.

Have you ever served as an expert witness in any other litigation?

A. No.

Q. You mentioned at the beginning of your deposition that you've -- you've been deposed one other time.

A. Yeah.

Q. Can you describe for me the circumstance of, how did that deposition come about?

A. I had done early in my career a lot of work on the Rocky Mountain Arsenal in Colorado where there was pervasive groundwater contamination. Some of the contaminants had migrated beyond the boundaries and affected agricultural lands and farmers north of the arsenal.

I had worked on a project to develop a groundwater flow and solute transport model of that area of the whole problem. I probably worked at least two years full time on that project.

Can you remind me what the question was again?

Q. Sure.

A. (Laugh). I strayed off.

Q. Why were you deposed in the context of that work?

A. Right. So several years after I had completed my work on the Rocky Mountain -- excuse me.

Several years later there, the Superfund law was passed and -- and, you know, things happened. During the time that I was working on the, Shell Chemical Company had been a -- had leased facilities on the Rocky Mountain Arsenal and operated those facilities. I believe their primary activity was manufacturing pesticides and herbicides, as I recall.

Somewhere years, you know, after I had finished my work, EPA or the government was, I believe, suing Shell Chemical for having generated the waste.

The Department of Justice and some lawyers, I mean, they knew I had done work there. So the DOJ sent people to my office to review everything that I had, I mean, everything in my files, related to the Rocky Mountain Arsenal. And sometime after that, they asked me -- well, either asked or told me -- that they wanted to depose me to give a deposition.

Q. So you were deposed in that instance as what we -- I guess the lawyers would describe as a fact witness; right? You weren't -- you weren't hired as an expert in?

A. I was not hired in any way and to the best of my -- I don't remember the term a "fact witness," but that seems to be a good description of what I was.

Q. You were deposed about your knowledge of the events that had taken place; correct?

A. Correct.

Q. Okay. Now, you submitted your -- your expert rebuttal report in this case in response to the reports of DOJ's -- Department of

Justice's experts; correct?
A. Two experts, correct.
Q. And one of those experts is Dr. Alex Spiliotopoulos; correct?
A. Yes.
Q. And the other expert is Dr. Remy Hennet; correct?
A. Correct.
Q. Okay. Do you know Dr. Alex Spiliotopoulos?
A. Casually. Yes, I do.
Q. How do you know him?
A. Well, he works for Papadopulos & Associates. I believe he attended some of the meetings for the expert peer review panels for ATSDR. I've probably seen him occasionally when I've interacted with Papadopulos & Associates.
Q. Sure.
Do you know Remy Hennet?
A. Yes.
Q. How do you know Remy?
A. I've met him at a -- probably at least twice at social events, dinner parties that we were both invited to.

Q. Okay. Have you ever worked with either Dr. Hennet or Dr. Spiliotopoulos?
A. No.
Q. Do you know a Gordon Bennett?
A. Yes.
Q. Okay. And Gordon Bennett, my understanding is he worked at USGS for many years, and is that right?
A. Yes.
Q. Okay. And then my understanding is then he went on to become a principal at Papadopulos.
Is that consistent with your understanding?
A. After he retired from the USGS, he went to work for one consulting company, I believe in Alexandria, but was not there very long, maybe a year or less than a year. And then after that, my understanding is he went to work for Papadopulos & Associates and worked for them at least 10 years before fully retiring. I don't know if he was a principal or what, but he was an employee certainly.
Q. Sure. Okay.

And is it right, my understanding is Gordon Bennett is considered the father of MODFLOW?

A. Ooh. He played an administrative role in getting it going. I would not have called him the father of MODFLOW.

Q. Okay.

A. He played a role in getting that done in terms of -- I believe he had a big role in hiring the two people or designating the two people, Harbaugh and McDonald, to work on this, and I think administratively he pushed for this to be a project to get this done. So.

Q. So he --

A. But I don't believe he actually worked on the development of the code.

Q. Understood.

Are you generally familiar with SS Papadopulos & Associates?

A. In general, yeah.

Q. Okay. Do you have any opinion about S.S. -- S.S. Papadopulos & Associates?

MR. DEAN: Object to the form.

THE WITNESS: Well, I know

several individuals there, including Stavros Papadopulos. Most of the people working there I do not know. I don't. So I can't have any opinion about them or their work.

Stavros used to work for the Survey -- USGS for quite a while. He left, I believe, in '79 or '80 to form his own company as a consultant.

BY MR. ANWAR:

Q. Within the environmental, you know, based on your experience, within the environmental sort of consulting and, I guess, modeling consulting community, is S.S. Papadopulos from your understanding generally considered a good firm?

MR. DEAN: Object to the form of the question. Asked and answered.

THE WITNESS: Well, again, I think, you know, some of the people there have good reputations and some of the people there I don't know their reputation. Most of the people there I don't know anything about them.

BY MR. ANWAR:
Q. Okay.
A. So it's difficult to -- to say.
Q. Are you familiar with John Doherty?
A. Oh, John Doherty from Australia?
Q. Correct.
A. Yeah, I know the name. I've met him certainly at professional meetings. I remember at least one case at a National Ground Water Association meeting where he was a guest speaker. So, you know, said hello, interacted socially. I know who he is, and I know, you know, kind of what he's done in terms of developing the parameter estimation code called PEST.
Q. Can you talk a little bit about that, what he's done in terms of developing PEST?
MR. DEAN: Object to the form of the question.
THE WITNESS: Well, I know he's the principal author of the software and a book that describes it. How he did it I have no idea or, you know, what he did specifically I have no understanding. I don't know.

The PEST code, I know what it
does and I know it's -- it's generally
considered a state of the art software
tool --
BY MR. ANWAR:
Q. Understood.
A. -- that could be applied for ground
-- excuse me -- could be applied to groundwater
modeling problems. It's a general code that can
probably be applied to any modeling problem, not
just groundwater.
Q. Were you aware that John Doherty
also now works with S.S. Papadopulos?
A. That he what?
Q. That he's also at S.S. Papadopulos?
A. I'm not sure what you -- could you
repeat the question? That he was at?
Q. That John Doherty is now at S.S.
Papadopulos?
A. I did not know that.
Q. Okay.
A. That he was. I knew there was some
linkage there and I know he had been at their
offices, but being -- I had no idea he worked for

the firm as an employee.
Q. Okay. And I think I might have misspoke. I think you're perhaps right.
He used to be at S.S. Papadopulos; correct?
A. I don't know that.
MR. DEAN: Object to the form.
BY MR. ANWAR:
Q. You don't know.
You said --
A. I know he was at the -- in their office.
Q. Okay.
A. I don't know what you mean by "at" Papadopulos & Associates.
Q. Okay. You said he used to be linked to it.
What do you --
A. I know he visited there and, you know, I know he -- it's my understanding or recollection that he taught a short course for them on the use of that, and I think he collaborates or has collaborated with Matt Tonkin, who is an employee of Papadopulos & Associates,

but I have no direct knowledge of what they did or how they did it.

Q. Okay. Aside from responding to their opinions in this case, do you have any opinion about Dr. Spiliotopoulos or Dr. Hennet?

A. No.

Q. Why don't we take a break. I think this is a good place --

A. Good idea.

Q. -- to take a break. We've been going over an hour.

THE VIDEOGRAPHER: We're going off the record. The time is 11:06 AM.

(A recess was taken.)

THE VIDEOGRAPHER: Back on the record the time is 11:15 AM.

BY MR. ANWAR:

Q. We are back on the record from a short break.

Dr. Konikow, are you okay to continue?

A. Yes.

Q. Okay. During the break, did you speak with your -- your lawyers about the

substance of your testimony at all?
A. No.
Q. Okay. Before the break, we had just wrapped up a conversation about John Doherty.
Do you recall that?
A. Yes.
Q. One other question occurred to me that I wanted to ask.
I noticed in the documents that were produced last night in response to the subpoena, there was a document where you passed along Doherty's -- John Doherty's contact information to Mr. Dean.
Do you recall that?
A. Yes.
Q. Do you know, what is your understanding about why you passed that contact information along?
A. Well, I believe he asked me if I had contact information --
Q. Okay.
A. -- for John Doherty, and I had some information and so, you know, I sent it to him.
Q. Okay. Do you know what came of

that?

A. No.

Q. Okay. Have you -- when is the last time you've spoken with Mr. Doherty?

A. Several years ago. Probably four or five years ago.

Q. Okay. Understood.

A. Yeah.

Q. Now, we discussed earlier you served on ATSDR's expert panel on the Camp Lejeune water modeling; correct?

A. Correct.

Q. Okay. And there was an expert panel in 2005; correct?

A. Correct.

Q. How did you come to serve on the 2005 expert panel?

A. Somebody asked me, and I would -- I would guess that it was probably Morris asked if I'd be interested in doing that. I don't recall exactly who or when I was asked or how I was asked, but I would guess it was probably Morris.

THE VIDEOGRAPHER: Counsel, could you please put on your mic?

BY MR. ANWAR:
Q. What do you remember about the 2005 expert panel?
A. I remember they -- I think they had asked us some questions in advance before meeting, maybe four to six questions to get our preliminary opinions. I think they had sent us some documents or draft reports to review to prepare for it.
I remember, you know, going to Atlanta. There were two days of meetings. There were, you know, a fair number of people in the audience, maybe -- I don't know -- 10 to 20 at different times, maybe a few more.
I think there were probably something on the order of 10 people on the expert panel. May have been 12. I don't recall exactly. We had meetings. We had presentations made to us about what was expected of the committee.
And then we had technical presentations from people such as Morris, Bob Faye and others about the background of the situation, the hydrogeologic framework, the groundwater flow systems, the contaminant sources, and basically everything related to that.

So there were technical presentations. The committee members asked questions. I think towards the end we met in a closed session, and I believe we came to a consensus of our assessments.

I can't recall specifically what follow-up, if any, was done after the second day of the meeting.

Q. Thank you. That's helpful.

Do you recall what draft documents you were provided to review in advance?

A. I do not recall which ones, but I -- I'm -- I would guess it was preliminary versions of some of the reports that were eventually published, but I don't recall.

Q. What did you understand about the purpose of the ATSDR water modeling for Camp Lejeune heading into the 2005 expert panel?

A. Well, my understanding I believe then was similar to my understanding now that the purpose of the modeling was to estimate what the concentrations were coming out of the Water Treatment Plant and going into the distribution system.

Q. And that was in support of a population level epidemiology study; right?

A. I knew there were epidemiological studies that would be done and that, I presume, would use the information from the -- from the models. I have no knowledge of any of the epidemiological studies, how they were done or what the results were. I don't have that information.

Q. Sure.

And that 2005 expert panel, that took place over two days in March 2005; right?

A. I presume so. That sounds about right.

And, again, the other thing I believe is that it focused on the Tarawa Terrace situation.

Q. Okay. And you said it took place in Atlanta.

Did it take place at ATSDR's facilities?

A. That's my recollection. That we went into a CDC campus, and they brought us over to an ATSDR facility, I think, but I don't recall.

I remember there was a gate, and we had to go in and get, you know, approved to go into the facility and then were directed somewhere, but I don't remember those, any more details than that.

Q. Sure.

You mentioned Morris Maslia and then Robert Faye, or Bob Faye.

Who is Bob Faye?

A. Bob Faye? He's a person who, when I first met him, he worked for the U.S. Geological Survey. I believe his position was as a regional groundwater specialist, and at the time the Water Resources Division of the U.S. Geological Survey was divided into four regional offices.

The Southeast Region was headquartered in Atlanta, and my recollection is that for that regional office, Bob Faye was considered the -- or had the position of being the regional groundwater specialist.

So reports or any other issues dealing with groundwater that came up in any of the district offices in the Southeast Region, if there was some issues, Bob Faye would be the regional groundwater specialist is the one who would assess, comment on, evaluate any problems or issues.

Q. Understood.

Do you remember who any of the other members of the expert panel were? The 2005.

A. The 2005 panel.

I, you know, I looked at the list of members probably a week or two ago, but I just -- I can't remember who was on the 2005 panel.

Q. That's okay. Fair enough. Thank you.

You were an expert on the 2005 expert panel; correct?

A. Correct.

Q. Now, you mentioned it was focused on ATSDR's water modeling efforts -- the 2005 panel was focused on ATSDR's water modeling efforts related to Tarawa Terrace; correct?

A. That's my understanding, yes.

Q. Do you recall whether there was any discussion about the Hadnot Point/Holcomb Boulevard modeling at that time?

A. Of the modeling? I doubt it, but of

the existence of Hadnot Point/Holcomb Boulevard, I'm sure that was mentioned.

Q. Did you provide feedback or input about the -- about ATSDR's water modeling efforts related to Tarawa Terrace in 2005?

A. I'm sure I did.

Q. Do you recall what that feedback or input was?

A. Well, specific explicit comments I can't recall. I recall, you know, the -- you know, I'm sure I had questions about parameter values and how they did this or why they did it this way. I'm sure there was a lot of questions, comments and, you know, issues.

I know the bottom line at the end, the expert peer review panel felt very positive about what they were doing in the sense that I think the consensus of the expert peer review panel was that the work being done by ATSDR for groundwater modeling flow and transport was state of the art and excellent work, reliable work.

Q. Okay. Were there any concerns expressed at the 2005 expert panel?

A. I'm sure there were.

Q. Why do you say you're sure there were?
A. Well, our job was to critique and review everything they done -- did and we would, you know, question, why did you do this? Or where did you get that value from? Or what's the basis of this? Again, I can't recall specific questions. If I thought about it, maybe I could.
But I know I had some concerns about numerical dispersion in the transport model, about the representation of model layer 1. You know, I remember these were some of the specific issues that concerned me before I could get any response back from them, but I felt overall that they addressed all of the concerns that I had.
Q. Do you recall if any of the other members of the expert panel expressed concerns or critiques about the Tarawa Terrace efforts?
A. I can't recall.
Q. Okay. Now, you also served on the expert panel held by ATSDR on Camp Lejeune water modeling in 2009; right?
A. Correct.
Q. Okay. And how did you come to serve

on the 2009 expert panel?
A. I assume someone asked me to serve on it. I, you know, again, I -- I assume Morris had some role in inviting me, but I don't know that. You know, I just don't recall.
Q. Okay. What do you remember about the 2009 expert panel?
A. It focused on the Hadnot Point/Holcomb Boulevard areas and the models developed for that area. There probably was some discussion of Tarawa Terrace, but the main focus was on Hadnot Point/Holcomb Boulevard.
I remember Mary Hill was on that panel. Dave Dougherty was on that panel. But, again, I looked at the names the other day and I just can't remember right now who else was on it, but, you know, again there were probably 10 to 12 experts on the panel.
Q. Sure.
And that panel took place over two days in 2009?
A. Exactly, yes. Correct.
Q. Was there a Mr. Jerry Ensminger on -- that participated in that expert panel?

A. My recollection that's the name of a Marine who was -- I remember there was one Marine in the audience, and he was given a chance to speak. I believe that's the name that you gave, but I can't -- I'm not absolutely certain.
Q. You said he was in the audience and he was given an opportunity to speak?
A. That's my recollection.
Q. Okay. Mr. Ensminger is not a modeling expert or an epidemiologist, to the best of your knowledge?
A. Correct.
Q. Was there a Mr. Mike Partain that attended the expert panel as well?
A. I don't recall that name.
Q. Okay. Did you provide feedback about the Hadnot Point/Holcomb Boulevard modeling efforts at the 2009 expert panel?
A. I'm sure I did. That's why I was there.
Q. Do you recall the feedback that you provided?
A. I know initially I came in with some skepticism, which is, you know, normal in any

technical review, and I had some concerns about how well they could define the source terms and the timing. Specific comments I don't recall.

Q. Do you recall any comments from other members on the expert panel?

A. Not that I -- I do not recall specific comments.

THE VIDEOGRAPHER: Counsel, do you need help with your mic?

MR. ANWAR: Excuse me?

THE VIDEOGRAPHER: Do you need help with your mic?

MR. ANWAR: Yeah, I'm fixing it.

THE WITNESS: I don't recall specific comments of the other participants off the top of my head.

BY MR. ANWAR:

Q. Okay. Were there -- do you recall any critiques or concerns about performing the Hadnot Point/Holcomb Boulevard water modeling?

A. Well, yeah. I mean, I know I had some concerns but, you know, again I think they addressed my concerns.

Q. What were your concerns?
A. Well, one of the concerns was compared to Tarawa Terrace where there was believed to be one single source of contamination and its location was pretty well known and the contaminant was pretty well known and the timing of it was pretty well known, looking at the Hadnot Point/Holcomb Boulevard, there seemed to be multiple sources just spread out over the industrial areas and the landfill areas and that they could not be defined with the same precision that the source term on the Tarawa Terrace area could be defined. So this was a concern.
Q. Okay. Did you --
A. For --
Q. Go ahead.
A. I was going to add that, you know, for both of them, there was, you know, no observations of concentration for a period of years before the problem became recognized, you know, that's an issue that has to be addressed.
Q. Sure.
There -- there were observed contamination levels or samples taken in 1982 and

1985 at Camp Lejeune; right?

A. I believe so, and maybe, you know, in between. There may have been some '83, '84 I believe, but I don't recall the exact dates. But that sounds about right.

Q. Okay. And the ATSDR modeling efforts related to Tarawa Terrace and Hadnot Point and Holcomb Boulevard, they were attempting to reconstruct historical contamination levels, monthly contamination levels dating back to 1953; correct?

MR. DEAN: Object to the form.

THE WITNESS: 1953 for Tarawa Terrace, but I believe earlier for Hadnot Point and Holcomb Boulevard.

BY MR. ANWAR:

Q. And the earliest available data during that period was 19 -- and when I say "available data" what I'm specifically referring to is observed contaminant concentration levels of sampling data.

The earliest data available during that time was 1982; correct?

A. Yes, that's the observed, but I also

view the assumption at the start of the simulation before there was any as equivalent to an observed level of no contaminant in the aquifer as a known condition. Even though there were no samples that showed it was zero before 1953, that seemed like a pretty reliable and accurate assumption.
Q. What is the assumption that you're referring to?
A. That you have to -- in developing the model -- and they started with Tarawa Terrace in 1953. To solve any governing partial differential equation, which is what the numerical models do, you have to define boundary conditions and initial conditions.
Definition of the initial conditions for the solute transport model are the concentration distribution of the solute of concern at times zero, which would be 1953.
And inherently there's an assumption that it was zero before any contaminant was introduced, and that is a very reasonable, logical assessment of the initial condition in terms of what the concentration distribution was at that time, which is zero.

Q. Understood.
But for the period prior to 1982, there were no historical observed concentration level data; correct?
MR. DEAN: Object to the form.
THE WITNESS: Not that I'm aware of.
BY MR. ANWAR:
Q. Besides serving on these two expert panels, the one in 2005 focused on Tarawa Terrace and the one in 2009 more focused on Hadnot Point/Holcomb Boulevard, did you contribute or do any work related to ATSDR's water modeling efforts for Camp Lejeune?
A. No.
Q. I saw that you're not listed as an author on any of the reports; right?
A. Correct.
Q. You weren't involved in writing the reports?
A. Not at all.
Q. And you didn't perform any of the data collection or the field testing; right?
A. No, I did not.

Q. Okay. Have you ever visited Camp Lejeune?
A. No, I have not.
Q. And earlier in your deposition I think we discussed that at that time you were -- that you served on the -- the two expert panels, you were employed by the U.S. Geological Survey; correct?
A. Yes.
Q. And so other than your salary as an employee of the U.S. Geological Survey, you were not compensated at all to participate in the -- the 2005 or 2009 panels; correct?
A. That's correct.
MR. ANWAR: Okay. I'm going to mark an exhibit. I'm handing to the court reporter what is being marked as Exhibit 7.
(Document marked for identification as Konikow Exhibit 7.)
MR. DEAN: Can we agree that this is not the entire book? Just select to.
MR. ANWAR: We can agree this

is not the entire book.

BY MR. ANWAR:

Q. I've handed you an exhibit that I've marked as Exhibit 7. This is -- this is an excerpt from a book entitled "The Handbook of Groundwater Engineering"; correct?

A. Yes.

Q. And you're familiar with this book; right?

A. I haven't looked at it in years, but I was a coauthor of that chapter. So yes.

Q. Okay. The book itself was published in 1999; right?

A. (Reviews document.)

It says 19 -- yeah, it says copyright 1999.

Q. Okay. And you just mentioned you coauthored that chapter.

You coauthored Chapter 20 on "Groundwater Modeling"; right?

A. Yes.

Q. Okay. And you coauthored it with a gentleman named Thomas E. Reilly?

A. Correct.

Q. Who is Thomas E. Reilly?

A. Tom was a groundwater scientist or engineer that worked with the U.S. Geological Survey. I knew him as a colleague from the USGS. We were in the -- we overlapped in the same office for a while in the -- I think it's called the Office of Groundwater, which was kind of a headquarters quality assurance type of group.

Tom moved -- he had worked on Long Island, New York in the Long Island office for many years. Then he moved to Reston to join us headquarters group. Then I left that to join the research program, and several years later Tom did the same thing and was in the research program. We were colleagues there. Then he moved back into the Office of Groundwater after a year or two in the research program.

So, you know, we were colleagues, you know, knew each other, and I had invited him to help me prepare this chapter on "Groundwater Modeling." He had more expertise on finite element methods than I did and I thought he was, you know, well-known and well-rounded in groundwater modeling technique. I thought it would be very beneficial to have him as a coauthor.

Q. Understood.

And the words in this chapter in Chapter 20 are yours and his; right?

A. Yes.

Q. Okay. I wanted to ask you a few questions about Section 20.1 in Chapter 20, which is the Introduction.

The opening line in the chapter reads:

"Effective management of groundwater requires the ability to predict subsurface flow and transport of solutes, and the response of fluid and solute flux to changes in natural or human-induced stresses."

Did I -- did I read that correctly?

A. Yeah. Yeah.

Q. What do you mean by "effective management of groundwater"?

A. Well, I mean, groundwater is a resource. It's, you know, used to the benefit of society, also to the benefit of individuals and benefit of cities, benefit of factories, benefit of agricultural. You know, there's just multiple uses.

It's a resource that should be managed and it's a resource that in many cases throughout the U.S. and the rest of the world is not managed at all. Because people -- a landowner could drill a well and pump out as much water as they want, in some cases without anyone overseeing their use of the resource.

In the U.S. that varies greatly by state to state. In some areas, particularly if there have been some problems or limitations on the use, it's been overdeveloped, then they form management districts or laws are implemented in a state or in a county to try to, well, in effect, manage the resource and try to assure that it lasts longer as a resource, as a usable resource than it would if there was no limitations on development.

So by "effective management," we're really implying that there is some management structure governing the use of groundwater that's there for basically the benefit of society and the common good. And, you know, I guess in our opinion, the effective management, management that is efficient and effective in trying to assure the sustainability of a groundwater resource in an area is just a necessary and valuable imposition of some controls on the use of the resource, but it's not done everywhere.

Q. Understood.

Does management entail planning?

A. Management should involve planning, thinking ahead, yeah. If they're not thinking ahead, then they're not doing a good job managing it.

Q. And that I think you mentioned -- I can't recall if it was scarcity or conservation of water.

Is it management of?

A. Well, I think I put it in the terms of sustainability.

Q. Sustainability, correct.

A. And, you know, that's easier to do in some areas than in others.

Q. Sure.

If you turn the page to Chapter 20.2 on page 20-2, it's a subsection entitled "Models";

right?

A. Okay.

Q. And the first couple sentences there:

"The word 'model' has so many definitions and so overused that it's sometimes difficult to discern its meaning."

And then there's a citation to you and I think Fred Bredehoeft?

A. Bredehoeft. Bredehoeft.

Q. Bredehoeft.

And then the next line:

"A model is perhaps most simply defined as a representation of a real system or process. A conceptual model is a hypothesis for how a system or process operates."

Did I read that correctly?

A. Yes.

Q. Okay. And so a model is a simplified representation of a real world system or process; that's what you're saying there?

A. That's what we said.

Q. Okay. And a conceptual model is a hypothesis for how a system or process operates;

right?

A. In effect. It's a -- it's a verbal description of your understanding.

Q. And the --

MS. BAUGHMAN: Were you finished, Dr. Konikow?

THE WITNESS: Well, I was just going to add: As a verbal description, it could be either qualitative or quantitative.

BY MR. ANWAR:

Q. Okay. And the start of the next paragraph there it says:

"Most groundwater models in use today are deterministic mathematical models."

Right?

A. That's what it says, yes.

Q. Okay. What -- what is a deterministic model?

A. A deterministic model is one in which the solution, the result is, in effect, predetermined by the solution to a governing equation. You have a mathematical equation that describes quantitatively your understanding of the processes that govern, let's say, groundwater flow, and to solve the differential equation, you need to define boundary conditions and initial conditions and the solution to that, the results.

It's not random. It's predetermined by the parameters you put in and the nature of the equation and your definition of initial and boundary conditions and, you know, if one person does it here and another person does it there, if they have all the same parameters and the same equation, they should get the same results.

Q. Got it.

The next line in that second paragraph says:

"Deterministic models are based on conservation of mass, momentum, and energy and describe cause and effect relationships."

Right?

A. Yes.

Q. Okay. And what does "conservation of mass, momentum, and energy" mean?

A. Okay. These are basic thermodynamic principles that, you know, if you have a certain volume of water coming into a box, or an aquifer or some kind of element, masses can serve that's neither created nor disturbed, destroyed, except for radioactive constituents and, you know, what goes in has to be balanced by what comes out or what the mass and storage in that unit changes.

Q. Does that mean that in a deterministic model, the mass, momentum, and energy remain constant throughout time?

A. No.

Q. Okay.

A. It just means that, you know, if you add mass to the system at some later time, then it all has to be balanced.

Q. I got you.

A. Yeah.

Q. So if we turn to -- well, it's on the same printed page, but the next page of the book is subsection 20.3 Flow and Transport Processes.

A. Yes.

Q. I wanted to ask you about the -- that first line says or the first line of the second paragraph -- paragraph:

"The purpose of a model that

simulates solute transport in groundwater is to compute the concentration of a dissolved chemical species in an aquifer at any specified time and place."

Is that right?

A. I believe so.

Q. Okay. And then if we jump ahead a little bit to the paragraph at the end of that section starting with "The subsurface," it says:

"The subsurface environment constitutes a complex, three-dimensional herogeneous hydrogeologic setting. This variability strongly influences groundwater flow and transport, and such a reality can be described accurately only through careful hydrogeologic practice in the field."

Did I read that correctly?

A. Yeah. The word "heterogenous" was on the first line.

Q. Oh, hetero. Yeah, heterogenous.

A. Yes, you read it correctly.

Q. Okay. These are your words, so you'll agree with that; right?

A. Yes.

Q. Okay. And then "However" the next sentence in that same paragraph.

"However, regardless of how much data are collected, uncertainty always remains about the properties and boundaries of the groundwater system of interest."

Why -- why does uncertainty always remain?

A. Well, the subsurface environment, basically the geologic framework of an aquifer due to geologic processes, its properties and characteristics of permeability, porosity and so on just vary in space because of the geologic processes that led to the deposition of material and its geologic modification subsequent to its deposition, its burial by under sediments and so on.

And these are complex patterns and they're underground. You can't look at them directly. So there you could use geophysical methods to try to find out different characteristics, change in space, but there's limitations to how accurate that is.

You use wells to observe at a point,

but whatever you define at that point, the properties could be a little different 10 feet away or maybe even more than a little different.

In other words, it's out of sight out of the ability of us to see underground to completely characterize all the properties of the system. It's, you know, it just can't be done with present -- certainly not with present technology.

Q. Understood.

A. And so we do the best we could, interpolate between points where we have more data, and then build that into a model.

Q. And there's no way to create a model that perfectly recreates reality; right?

A. That's my belief.

Q. Okay. And you just explained it, but a large part of that is because there are aspects of the subsurface that we don't know about; correct?

MR. DEAN: Object to form.

THE WITNESS: We --

MR. DEAN: You can continue.

THE WITNESS: Yeah.

That we can't observe directly within any kind of feasible economic framework. I mean, if you drill more and more wells to observe more and more spaces, pretty soon the wells themselves are increasing the porosity of the aquifer.

So there's a limit to how much we could do, and certainly it's expensive to drill one well. So you never have a budget to drill an infinite number of observation wells.

BY MR. ANWAR:

Q. And are subsurface conditions -- I guess for lack of a better way of saying this, are subsurface conditions changing based on sort of the environmental conditions surrounding them?

A. The hydraulic properties very rarely would change in time on a human time frame. That just doesn't happen. The hydraulic conditions in terms of pressure distributions and water levels, those certainly can change quickly.

Q. Okay. How groundwater modeling and transport is typically used for planning and management purposes; right?

MR. DEAN: Object to form.

THE WITNESS: Can you repeat that?

BY MR. ANWAR:

Q. Groundwater -- groundwater modeling is typically used for planning and management purposes; right?

MR. DEAN: Same objection.

THE WITNESS: Well, typical uses of groundwater models? I wouldn't say it's typical for that. Models are used for management purposes, but they're used for many other purposes, and I don't know which purpose is more typical.

BY MR. ANWAR:

Q. What are some of the management purposes that models are used for?

A. I think the first highest level use is to understand the system to help. Good management of the system requires that you understand the system and understand which way groundwater is flowing, what the head distribution is, and how the whole system operates. How to predict the effects of drilling a new well and pumping it at a specified rate might impact other users. It might impact the water table and the sustainability of the resource. The model allows you to do that in a quantitative way.

Q. And to understand the system, that could be one of the purposes of sort of a model or uses of a model would be to project water needs in the future for -- for agriculture; right?

A. Well, not to project water needs, but to project the impacts of water use. You wouldn't use the model -- a groundwater model to predict water use. You would use it -- you would predict water use some other way based on economic, climate, whatever.

There you would estimate water use, and then you could say, what would happen to the system if this water use is implemented in the future? And the model could then help you assess what the impacts of a proposed water use would be.

Q. Okay. That's really helpful.

And then a model can also be used to estimate the movement of contaminants for remediation efforts; right?

A. Certainly.

Q. Now, I'd like you to take a look at your rebuttal report. It's Exhibit 2.

Okay. So looking at the first paragraph under Introduction on page 1, it says there that:

"ATSDR prepared reports describing models developed to stimulate groundwater flow and contaminant transport at two areas of Camp Lejeune, North Carolina: Tarawa Terrace and then Hadnot Point/Holcomb Boulevard area."

Correct?

A. Yes.

Q. And when we're talking about ATSDR's Camp Lejeune water modeling efforts -- I think this has been clear already, but I just want to confirm.

When we're talking about ATSDR's Camp Lejeune water modeling efforts, we're really talking about two separate water models; correct?

A. Correct.

Q. ATSDR completed a water model related to Tarawa Terrace; right?

A. Yes.

Q. And my understanding, at least of the last report, it was completed around 2009.
Is that consistent with your understanding?
A. I believe so. I don't remember the dates on the reports, but that sounds about right.
Q. Okay. And for Tarawa Terrace, ATSDR performed a groundwater model using MODFLOW; right?
A. Correct.
Q. And then they performed a fate and transport model using MT3DMS; right?
A. Yes.
Q. Is there -- the general uncertainty that we just discussed in terms of flow and transport processes, does that exist for groundwater models as well?
MR. DEAN: Objection.
BY MR. ANWAR:
Q. For -- for flow models?
MR. DEAN: Object to the form.
THE WITNESS: Well, groundwater flow models such as MODFLOW --

BY MR. ANWAR:
Q. Yeah.
A. -- assume that the changes can be described by a governing equation that is fairly standard, well accepted by scientists and engineers. You know, it's pretty common.
Parameters values, in other words, the equation has coefficients in it, and those coefficients need to be described in order to solve the equation. Those coefficients include hydraulic properties such as hydraulic conductivity, the saturated thickness, how you discretize the system, storage coefficients or specific yields. If it's a transient flow problem.
But, you know, one of the primary is hydraulic conductivity, but you could also sometimes refer to as transmissivity if you account for the saturated thickness of the layer.
So you need to describe these and, again, as with any other geologically based parameter or property, yes, there is uncertainty.
Q. And I guess I was wondering.
When you -- so for the Tarawa

Terrace model, MODFLOW was used for the groundwater flow model and MT3DMS were used -- was used for the fate and transport model and then they were linked together; correct?

A. Well, yeah, there's a linkage between the two, but it's not necessarily, you know, one integrated model.

Generally what is done, at least for those codes, for MT3D, is you run the flow model first and you generate a very large file that has all the heads and specific discharges, all the fluxes, and then you run -- afterwards you run MT3D and the MT3D reads the file. There's some linkage file that connects MT3D with the data that was produced by the flow model.

Q. I guess my -- my question is that if you use MODFLOW, a MODFLOW-based flow model and with an MT3D-based flow and transport model, with both models having some level of uncertainty, when you use them -- when you use them together, does that uncertainty sort of -- does it become cumulative?

A. No, I wouldn't say that, but I would correct you. MT3D is not a flow model.

Q. Oh, I'm sorry.
A. So it's just a solute transport model. It uses the flows or fluxes that are output or calculated by MODFLOW.
Q. Okay. I think that's what I meant was it's a transport model; correct?
A. It's a transport model, and I would not say that the, you know, uncertainty is cumulative in any way.
Q. Okay. And for the Hadnot Point/Holcomb Boulevard water modeling effort, that was separate from Tarawa Terrace; right?
A. That's my understanding.
Q. Okay. And that was completed around 2013; right?
A. That's my understanding.
Q. And for that -- for Hadnot Point/Holcomb Boulevard, ATSDR again used MODFLOW for the groundwater flow model; correct?
A. I believe they used a newer version of MODFLOW than was used in the Tarawa Tara list -- Terra -- Tarawa Terrace model.
Q. Okay. And for the transport model, they used MT3DMS --

A. Yes.
Q. -- again; right?
A. Yes.
Q. And then this time they also used a water distribution model EPANET to simulate intermittent connections between Hadnot Point and Holcomb Boulevard; right?
A. Yes.
Q. Okay. To the best of your knowledge, did ATSDR perform water models for any other water distribution systems at Camp Lejeune?
A. At Camp Lejeune? Not that I'm aware of.
Q. Okay. Now, looking at your report, going back to your report, the next line after that first sentence we -- we just discussed is:
"Their use of the models was innovative in the sense that instead of a typical use of a groundwater model to predict future behavior, they used the model to 'predict' how the system evolved in the past (before concentration observations were made) from a known state (an initial condition), in which no contaminants were present, to a contaminated aquifer with a mapped

distribution in the early to mid-1980s when contamination was observed at a number of locations (wells, soils samples, and water treatment plants)."

Did I read that correctly?

A. Yes.

Q. My question was about -- I guess my question was a moment ago I asked you whether models are typically used -- I guess groundwater flow and transport models are typically used for planning or groundwater -- groundwater management purposes, and I think you said you weren't sure whether they were used typically or not typically for that purpose.

Is that a fair assessment?

A. Yeah, it's --

MR. DEAN: Hold on.

Object to form of the question. Misstates his prior testimony.

BY MR. ANWAR:

Q. Was that a fair characteristic -- characterization of your testimony?

A. Yes.

Q. Okay. And so here you say that the

ATSDR models were "innovative in the sense that instead of a typical use of a groundwater model to predict future behavior."

Groundwater and transport models are typically used to predict future behavior; right?

A. Very often or to help understand present behavior.

Q. And the ATSDR model, you know, here in your report is innovative in the sense that it was being used to predict past concentration levels for which real world observed concentration level data wasn't available; correct?

MR. DEAN: Object to the form.

THE WITNESS: Well, the objective -- primary objective seemed to be that historical reconstruction. That's, I'd say, typically not the main objective, but I didn't mean to imply that -- that what you call historical is never done. It's actually commonly done, but not as the main purpose of the model.

BY MR. ANWAR:

Q. Can you elaborate on that a little bit? When you say you didn't mean to imply that it's not commonly done but not the main purpose of the model, what do you mean by that?

A. What I mean is, for the Tarawa Terrace, it seemed like a main objective in terms of computing the concentrations over time. A main focus was on reconstructing that concentration distribution in that period in which there were no data prior to 1982.

That the solution of the governing equation for a period in which there's no observation is actually very common in transport models -- in contaminant transport models because it's very common that there's a period of record in which there is no observations.

For groundwater contamination problems, people generally are not aware it's a problem until it shows up someplace where it doesn't belong.

A well is contaminated. Someone is, you know, drinking. Then all of a sudden people recognize a problem. Then they start making measurements and observations, but groundwater moves slowly. So that could be 10, 20, or 30 years before the problem is recognized and observations are made.

If you're going to model that system, you have to start back at time zero before any contaminants are introduced, and so it's very common that, you know, you would be doing essentially the same thing, but it's very often not called historical reconstruction.

Q. Understood.

The -- I think earlier in your deposition we discussed that the ATSDR models were attempting to reconstruct population level monthly contaminant concentrations for use in an EPI study; right?

MR. DEAN: Object to the form of the question.

THE WITNESS: Well, I mean, I don't know about population level studies. I'm not even sure what that means.

But we were aware that the groundwater modeling would be used for epidemiological studies.

BY MR. ANWAR:

Q. Okay. And I think I misspoke.

What I meant to say was the ATSDR models were used to reconstruct or estimate past monthly concentration levels to support a population level epidemiological study; right?

MR. DEAN: Object to the form of the question.

THE WITNESS: Yeah. Well, everything you said after "support" I'm not sure about, but yes, the models were used to reconstruct the concentrations distributions throughout the aquifer prior to 1982.

BY MR. ANWAR:

Q. Okay. Are you aware of any other models besides AT -- or strike that.

Are you aware of any models attempting to reconstruct historical contaminant concentration levels for the purpose of determining exposure in individuals?

MR. DEAN: Object to the form.

Are you talking about Camp Lejeune or just in general?

MR. ANWAR: I asked about any models.

MR. DEAN: Okay.

BY MR. ANWAR:

Q. Are you aware of any modeling attempting to reconstruct historical contaminant concentration levels for the purpose of determining exposure in human individuals in real life?

A. For that purpose in real life? No. I mean, I would say modeling at the WIPP site was used to predict future exposure, and then they were health studies or assessments made on that, but that was all hypothetical a thousand years in the future. But that's what the modeling was done. It was related to exposure of a future farmer living downstream. So yes, that was done there.

I'm aware of many studies where that historical reconstruction was done but not for the purpose of exposure.

Q. Okay. And during that WIPP study, did that model into the future actually simulate estimated concentration levels?

A. Yes.

Q. It did?

A. Yes, but not -- the model itself did not get into the health and exposure issue. It just computed the concentrations how they would spread under a hypothetical breach of the repository.

Q. And then what was that information used for?

A. As part of a safety assessment for the proposed radioactive repository, and all of those analyses were included in the safety assessment that was submitted to EPA to get an operational license for the site, and that approval was granted somewhere in the mid-1990s or late 1990s.

Q. Okay. Now, jumping back to Exhibit 7, which is Chapter 20 of your book. Yeah, Chapter 20. Your Chapter 20 of the book that we looked at.

I'd like to ask you a few questions about section 20.6.

A. Okay.

Q. That subsection is titled "Model Design, Development, and Application"; right?

A. Yes.

Q. And the first sentence there in your book -- excuse me -- in your chapter that you coauthored states:
"The first step in model design and application is to define the nature of the problem and the purpose of the model."
Right?
A. Yes.
Q. Okay. And those are your words; right?
A. Well, mine and Tom Reilly's.
Q. Okay. But you don't disagree with those words; right?
A. Nope.
Q. Okay. Why is defining the nature of the problem and the purpose of the model the first step?
A. Well, you have to know the nature of problems to know before you decide what the best form of a model is to simulate it. Knowing the purpose of the model, what it would be used for, helps you assess what factors should be included and what could be safely ignored.
Q. Understood.

And so if we go on, it says:
"Although this may seem obvious, it is important -- it is an important first step that is sometimes overlooked in a hasty effort to take action. This step is closely linked with the formulation of a conceptual model, which again is required prior to development of a mathematical model."
Did I read that correctly?
A. Yes.
Q. Okay. And those are words that you coauthored; right?
A. Excuse me?
Q. Those are words that you coauthored; right? Those are your words; right?
A. Yes.
Q. Okay. And you still agree with what's said there; correct?
A. I believe so. Yes.
Q. And then if we jump to the end there or if we go a little further down in the paragraph, starting with the sentence that says "Good judgment."
"Good" -- do you see where I'm at?

A. Yeah, I could see it.
Q. Okay.
"Good judgment is required to evaluate and balance the trade-offs between accuracy and cost, with respect to model development, model use, and data requirements. The key to efficiency and accuracy in modeling a system probably is more affected by the formulation of a proper and appropriate conceptual model than by the choice of a particular numerical method or code."
Did I read that correctly?
A. You did.
Q. Okay. And do you agree with that statement?
A. Yes.
Q. Okay. And in particular, the key -- what it says there is that the key to efficiency and accuracy in a modeling system is more affected by the formulation of a proper and appropriate conceptual model; right?
A. Yes.
MR. ANWAR: Okay. I'm going to hand -- I'm going to hand you what I

am marking as Exhibit 8.
(Document marked for identification as Konikow Exhibit 8.)
BY MR. ANWAR:
Q. Exhibit 8 is the "Chapter A: Summary of Findings" for ATSDR's Tarawa Terrace water model; correct?
A. Yes.
Q. Okay. If you turn to -- it's page Roman numeral III. Just a couple pages in. Under the Foreword.
A. Yes.
Q. You see that?
A. Yes.
Q. It says:
"ATSDR, an agency of HHS, is conducting an epidemiological study to evaluate whether in utero and infant (up to 1 year of age) exposures to volatile organic compounds in contaminated drinking water at U.S. Marine Corps Base Camp Lejeune, North Carolina, were associated with specific birth defects and childhood cancers. The study includes births occurring during the 19 -- during the period 1968 to 1985 to women who

were pregnant while they resided in family housing at the base."

Did I read that correctly?

A. Yes.

Q. And as we discussed before, the ATSDR's water model for Tarawa Terrace was developed to obtain estimates of historical exposure for the EPI study that they were performing --

MR. DEAN: Object.

BY MR. ANWAR:

Q. -- correct?

MR. DEAN: Object to the form of the question.

THE WITNESS: Well, I don't know that it was developed that the models would calculate exposures. The models would calculate the concentration distribution in time and space.

BY MR. ANWAR:

Q. The -- if we go to the next paragraph just underneath, it says:

"Historical exposure data needed for the epidemiological case-control study are limited. To obtain estimates of historical exposure, ATSDR is using water-modeling techniques and the process of historical reconstruction."

Did I read that correctly?

A. You did.

Q. And that was the purpose of ATSDR's model for Tarawa Terrace; correct?

A. Well, yeah. I think the next sentence that you didn't read is critical also.

These -- these methods, the water modeling techniques, "are used to quantify concentrations of particular contaminants in finished water and to compute the level and duration of human exposure to contaminated drinking water."

So I think that's a key part of it.

Q. Sure.

But that -- that was the purpose?

A. Yeah.

Q. What we both read; correct?

A. Yes. Yes.

Q. Okay. Now, if you turn to page -- well, let me -- let me -- one question before we turn the page.

Per the first paragraph, the EPI study that was being performed was for the period between 1968 and 1985; correct?

A. Apparently, yes.

Q. Okay. And if we turn the page to A98.

A. To which page?

Q. A98.

A. A98.

Q. This is a -- this is part of a Q&A about the Tarawa Terrace model and there's a question there. The last question on A98 says:

"ATSDR's historical reconstruction analysis documents that Tarawa Terrace drinking water was contaminated with PCE that exceeded the current maximum contaminant level (MCL) of 5 milligrams per liter during 1957 and reached a maximum value of 183 micrograms per liter. What does this mean in terms of my family's health?

Did I read that correctly?

A. Yes.

Q. Okay. And the answer is:

"ATSDR's exposure assessment cannot be used to determine whether you, or your family, suffered any health effects as a result of past exposure to PCE-contaminated drinking water at Camp Lejeune."

Did I read that correctly?

A. Yes.

Q. And it goes on to say:

"The study will help determine if there is an association between certain birth defects and childhood cancers among children whose mothers used this water during pregnancy. Epidemiological studies such as this help improve scientific knowledge of the health effects of these chemicals."

Did I read that correctly?

A. Yes.

Q. And, again, per this information here, the model -- the -- the estimated monthly concentration -- contaminant concentration levels were for the purpose of epidemiological studies; correct?

MR. DEAN: Object to the form of the question.

And also note you didn't read the entire answer to the question into the record. You only chose a few select sentences.

MR. ANWAR: You can the -- correct.

THE WITNESS: Could you repeat the question?

BY MR. ANWAR:

Q. Sure.

The -- it's what we -- what we've been talking about, that the purpose of the simulated monthly estimated contaminant concentrations produced by the Tarawa Terrace model, those were intended to be used for an EPI study, right, that ATSDR was performing?

MR. DEAN: Object to the form of the question.

You've asked this same question 50,000 times already. I'm not going to instruct the witness not to answer it but --

MR. ANWAR: Kevin, I'm going to ask you to limit.

MS. HURT: -- you keep asking the same question 40 different times, and you're looking for a specific response you're not getting. So I would --

BY MR. ANWAR:

Q. The answer is correct. It was used for an EPI study; right?

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. It was intended for use for an EPI study; right?

MR. DEAN: Object to the form of the question.

THE WITNESS: I believe so.

BY MR. ANWAR:

Q. Okay. As you sit here today, as someone that has reviewed all of the reports for Tarawa Terrace, the Tarawa Terrace model, can you point me to anywhere in the ATSDR report stating that the TT model, the Tarawa Terrace model was intended to be used for exposure -- exposure determinations in individuals in the real world?

MR. DEAN: Object to the form of the question.

This witness is not qualified,

and he's told you that, as an epidemiologist.

THE WITNESS: The answer would be no.

BY MR. ANWAR:

Q. Okay. And can you point me to anywhere in the ATSDR reports stating that the Tarawa Terrace model was intended to be used in litigation as part of a causation analysis for individual plaintiffs?

MR. DEAN: Object to the form of the question.

THE WITNESS: I do not recall seeing any mention of litigation in there.

BY MR. ANWAR:

Q. Okay.

MR. DEAN: It was an independent study performed by the United States government.

MR. ANWAR: I am going to hand you what I'm marking as Exhibit 9.

(Document marked for identification as Konikow Exhibit 9.)

BY MR. ANWAR:

Q. And if you turn to page Roman numeral III again, the Foreword. The almost identical language is included as in the Tarawa Terrace report, and I'll read it. It says:

ATSDR "is conducting epidemiological studies to evaluate the potential for health effects from exposures to volatile organic compounds (such as PCE, TCE, and benzene) in drinking (finished) water at U.S. Marine Corps Base Camp Lejeune, North Carolina. Historical exposure data needed for the epidemiological studies are limited. To obtain estimates of historical exposures, ATSDR is using water-modeling techniques and the process of historical reconstruction to quantify concentrations of particular contaminants in finished water and to compute the level and duration of human exposure to contaminated drinking water."

Did I -- did I read that correctly?

A. Yes.

Q. Okay. And again here in the Foreword, it's stating that the historical exposure data needed for epidemiological studies; correct?

MR. DEAN: Object to the form of the question.

THE WITNESS: Can you repeat the question?

BY MR. ANWAR:

Q. It's stating here historical exposure data is needed for the epidemiological studies that ATSDR is performing; correct?

A. Yeah.

Q. Okay. And that was the purpose of the Hadnot Point/Holcomb Boulevard model; correct?

MR. DEAN: Object to the form of the question. Mischaracterizes prior testimony.

THE WITNESS: Well, my understanding is -- is the purpose of the model was to reconstruct or to estimate how concentrations of these contaminants varied in time and space.

BY MR. ANWAR:

Q. For the epidemiology -- epidemiological studies; right?

MR. DEAN: Object to the form of the question.

THE WITNESS: Well, I think that's stated here that that's the ultimate goal, but, again, the model itself doesn't know or care what the purpose of the use of the output would be.

BY MR. ANWAR:

Q. And, again, if we turn to page A182.

A. What page?

Q. A182.

MR. DEAN: A182? It only goes to A164.

MR. ANWAR: Oh, I'm sorry. I must have put the wrong one there. Sorry.

BY MR. ANWAR:

Q. Okay. We can skip that. That's fine.

And earlier you talked about the conception or earlier we discussed the sentence in your book about the importance of the conceptual model, forming the conceptual model in relation to efficiency and accuracy of the model.

Do you recall that?

A. I do.

Q. Okay. And the conceptual model, to be clear, for both of the ATSDR models, Tarawa Terrace and Hadnot Point, was to estimate monthly contaminant concentration levels for EPI studies?

MR. DEAN: Object to the form of the question.

Last time. I'm going -- next time I'm going to instruct him not to answer your question because you've asked it now, according to my calculations, at least 110 times, and his first answer is all that you needed.

So if you don't like his answer, move on to some different subject, but this is the last time. I'm going to let him answer it, but next time I'm going to ask him to instruct him not to continue answering your questions.

BY MR. ANWAR:

Q. The answer is correct; right?

MR. DEAN: Object to the form.

THE WITNESS: Can you repeat the question?

MR. ANWAR: Okay. And your -- Kevin, I'm going to say, your objection is noted. You know as well as I do the rules with issues to objections to form in a non-suggestive manner. I'm going to ask you to limit your speaking objections. You keep making speaking --

MR. DEAN: Well, we can call the court because I can have this court reporter read me how many times you've asked that same question, and we can get the judge on the phone and ask him how many times you get to ask him that question. It's the same one.

MR. ANWAR: During -- during the next break --

MR. DEAN: Do you dispute you've asked him the same question more than 10 times?

MR. ANWAR: During the break, I'm happy to do that. Let me focus on my questioning.

BY MR. ANWAR:
Q. The question is the conceptual model -- you would agree the conceptual model, as -- as confirmed by the statements we've just read from the -- from the actual reports, the conceptual model for ATSDR's Tarawa Terrace model and Hadnot Point model was to estimate contaminant concentration levels for EPI studies; right?
MR. DEAN: Object to the form of the question.
THE WITNESS: No.
BY MR. ANWAR:
Q. What was -- what was the conceptual model then?
A. The conceptual model is your idea of how the system works, how the flow system works. Your understanding of what constitutes an aquifer versus a confining layer.
The conceptual model is relevant to how you structure the model. It's not -- it's not a description of the purpose of the model.
Q. Okay. And that's -- that's a -- I appreciate that clarification.
The conceptual model that was

developed for the purpose of the ATSDR Tarawa Terrace and Hadnot Point/Holcomb Boulevard models was developed in mind of the actual purpose for which the model was being used, which was exposure estimates for EPI study; correct?

MR. DEAN: Object to the form of the question.

I'm not sure if anybody would understand that question.

THE WITNESS: I don't know what was in their mind when they developed the conceptual model.

BY MR. ANWAR:

Q. Okay. Now, in your report, you give a couple examples of other instances where -- well, let me back up for a second.

As it relates to the Hadnot Point/Holcomb Boulevard model, can you point me to any statement in the ATSDR reports stating that that model was intended to be used for exposure determinations in individuals in the real world?

MR. DEAN: Object to the form.

THE WITNESS: I would have to reread the whole report carefully and see if it says that. I...

BY MR. ANWAR:

Q. Having read the reports in preparation for your deposition, as you sit here today, can you -- can you -- are you aware of any such statement in the reports?

MR. DEAN: Object to the form.

THE WITNESS: Well, I believe that the Foreword that we just went over describes that the ultimate purpose is to evaluate the potential for health effects from exposure to volatile organic compounds.

BY MR. ANWAR:

Q. Okay. Can you point me to anywhere in the -- in the Hadnot Point/Holcomb Boulevard reports that states that particular model was intended to be used in litigation as part of a causation analysis for individual plaintiffs?

MR. DEAN: Object to the form --

THE WITNESS: I --

MR. DEAN: -- of the question.

THE WITNESS: I don't recall

seeing anywhere in the reports that
litigation was mentioned. So I would
have to say no.
BY MR. ANWAR:
Q. Okay. Now, in your rebuttal report, you identified two examples of hindcasting models; correct? Other examples of hindcasting models; correct?
A. I think I identified two models where that had been done but had never been called hindcasting.
Q. Okay.
A. And that wasn't -- that was just done as part of the modeling exercise, as part of the model output. It just wasn't the main purpose of those models, and it was just a consequence of the modeling, but in effect that's what was done.
Q. And that was the Rocky Mountain Arsenal in Colorado example; correct? One of them?
A. One of two examples was from the Rocky Mountain Arsenal, which I'm very familiar with because I had done the modeling and I had written the reports about it.

Q. And the other one is the Lawrence Livermore National Laboratory example; correct?
A. Correct.
Q. Now, the Rocky Mountain Arsenal examples wasn't about reconstruction -- reconstructing contaminant concentrations to determine exposures in individuals; right?
A. The issue of determining exposures has nothing to do with the model, in the sense that you're trying to develop a model that simulates the system based on your understanding of the physical and chemical --
THE VIDEOGRAPHER: Counsel, could please fix your mic. I'm not picking up your questioning.
BY MR. ANWAR:
Q. Earlier you mentioned that you had been deposed related to the Rocky Mountain --
A. Yeah, I'm not sure I finished answering the previous question --
Q. Okay.
A. -- because of the interruption.
But I think what I was going to add was that the assessment of health effects is

external to the development of the model. It's not in the groundwater flow and transport models. It has no impact on the groundwater flow and transport model.

You're doing the best you can to develop the models that simulates -- reproduces the historical distributions, but that model development should not be influenced by what the output might be used for.

MR. ANWAR: Okay. I am handing you what is being marked as Exhibit 10.

(Document marked for identification as Konikow Exhibit 10.)

BY MR. ANWAR:

Q. Now, this is the article that you wrote about the Rocky Mountain Arsenal study; correct?

A. Yes.

Q. Okay. And in the Rocky Mountain Arsenal study -- and actually if you want to look at your report for this, it's on page -- it's on page 3 of your rebuttal report if you want to jump back to -- to that.

A. This? Okay. Wait. The rebuttal report? Page 3? Okay.
Q. You state at the start of the second full paragraph:
Hindcasting was accomplished as a part of a study at the Rocky Mountain Arsenal. Contamination problem in which I developed and calibrated the groundwater flow and transport model. The Rocky Mountain Arsenal began operations in or about 1943. Groundwater contamination problem was recognized in 1954 and 1955."
Did I read that correctly?
A. Yes.
Q. Okay. And so to the extent that you are estimating contaminant concentrations or anything in the past, it was over that 12- or 13-year period from -- date from 1954, 1955 back to 1943; right?
A. Yeah. Well, that was the first period there was no data. There were several other periods for which there were no data.
Q. Okay. And you say there were no concentration data were available for the first 13

years of operation; correct?

A. Correct.

Q. And in Camp Lejeune for both the Hadnot Point/Holcomb Boulevard and the Tarawa -- Tarawa Terrace models, those models are attempting to reconstruct historical contaminant concentrations over a 30-year period; right?

A. Yes.

Q. Okay. From observed data in 1982, contaminant concentration level in 1982 till 1953 or earlier; correct?

A. Correct.

Q. Okay. So if we turn to the Introduction, if we turn back to Exhibit 10, which is your article on Rocky Mountain Arsenal, on page 1, there's -- on page numerical 1, there's an Introduction there; right?

A. Correct.

Q. Okay. And it says:

"The contamination of a ground-water resource is a serious problem that can have long-term economic and physical consequences that might not be easily remedied. Although the prevention of ground-water contamination provides the most satisfactory result, the capability to predict the movement of dissolved chemicals in flowing ground water is also needed in order to (1) plan and design projects to minimize ground-water contamination."

Did I read that correctly?

A. Yes.

Q. So that -- that was one of the uses for the model; correct?

A. That's potential use of models.

Q. Okay.

A. I don't believe I was talking specifically about this model, but I was talking about models in general.

Q. Okay. Number 2. "Estimate spatial and temporal variations of chemical concentrations."

Correct?

A. Yes.

Q. Number 3. "Estimate the traveltime of a contaminant from its source to a ground-water sink (a discharge point, such as a stream, spring, or well."

Correct?

A. Yes.
Q. Number 4. "Help design an effective and efficient monitoring system."
Correct?
A. Yes.
Q. And then number 5 is "Help physical and economic feasibility of alternative reclamation plans for removing contaminants from an aquifer."
A. "Help evaluate."
Q. "Help evaluate." Thank you.
"Help evaluate physical and economic feasibility of alternative reclamation plans for removing contaminants from an aquifer and (or) preventing the contaminants from spreading."
Right?
A. Right.
Q. And those were the purposes of this model; correct?
A. Well, those -- those were listed as general purposes for groundwater models -- groundwater contamination models. I don't think those six bullet points -- five bullet points were meant to be narrowly applied to the Rocky Mountain

Arsenal. It was more of a general introduction, but yeah, that certainly would apply to the Rocky Mountain Arsenal model.

Q. If you turn to page 40 of the model.

A. 40?

Q. Excuse me. 40 of the exhibit of your study.

THE VIDEOGRAPHER: Sir, please try and be professional. It's making very muddy record.

MR. ANWAR: Okay.

BY MR. ANWAR:

Q. And so 40 there's a Summary and Conclusions; correct?

A. Yes.

Q. The Summary and Conclusions, if you go down to the third full paragraph.

A. Which paragraph?

Q. Third full paragraph.

A. Okay.

Q. "The predictive accuracy of the model is most limited by adequacy of the input data."

Did I read that correctly?

A. You did.
Q. And do you agree with that statement?
You wrote it.
A. Yeah, I think I do. Yeah. Yeah.
Q. Okay.
A. Yeah, I wrote it 50 years ago. So I'm just making sure I still agree with it.
Q. Those are the questions I have about that exhibit.
A. Okay.
Q. And so the other example you gave was for the Lawrence Livermore National Laboratory site; is that right?
A. Yes.
Q. And I think in the -- in your rebuttal report, you reference it as a study in groundwater authored by Rogers; is that right?
A. That was Rogers, who's with the Lawrence Livermore National Laboratory, or at least he was when he wrote the article.
MR. ANWAR: Okay. I'm going to go ahead and mark this as Exhibit 11.
(Document marked for

identification as Konikow Exhibit 11.)
BY MR. ANWAR:
Q. Is this the article by Rogers that you were referring to --
A. Yes.
Q. -- in your report?
A. Yes.
Q. And in the Abstract there, it states that:
"Failure to incorporate retardation factors in solute transport predictions can lead to serious miscalculations of the degree of contamination and the time required for remediation."
Did I read that correctly?
A. Yes.
Q. And do you still -- do you agree with that?
A. Well, yeah, I mean, retardation factors would certainly be considered if a particular constituent is being retarded by chemical reactions or biological reactions of any kind.
Q. And under Introduction, it says:

"A ground-water model can only
be -- can be only as accurate as useful -- and
useful as the degree to which the modeled flow and
transport mechanisms completely represent the
significant characteristics of the system."
Do you agree with that?
A. Yeah, in general. Sure. Yeah.
Q. Now, the modeling for the Lawrence
Livermore National Laboratory site in California,
it wasn't attempting to estimate historical
contaminant concentrations for exposure
determinations in individuals; right?
A. Well, for one thing, the purpose of
the model and what it's used for has nothing to do
with how well the model is calibrated. That's
something that comes after the model. So to me
that just seems irrelevant to assessing the model.
Q. But the purpose of this Lawrence
Livermore National Laboratory site model wasn't to
attempt historical contaminant concentration
exposure levels in individuals; right?
A. The model -- the purpose of the
model was to reproduce what was going on in the
system. So.

Q. And what was being -- what was -- what was --

A. So as a natural consequence, this was a problem that had many analogies to Hadnot Point/Holcomb Boulevard. The contamination based on the historical understanding is believed to have started in the early 1940s, 1942 or '43, and a contamination problem was recognized decades later. And the first time for which there is any measurements of concentrations was around 1982 to '85. So I don't remember the exact year.

Q. The --

A. So to run the model to analyze what was there now -- we're in 1992 when it was done -- they had to start from that initial condition, a period of -- I don't know what -- 30 years when there was no data available and then calibrate to the later data. But part of that is your -- the model is in effect historically reconstructing the distribution during that time in which it.

So in principle, it's very similar to what was done in Tarawa Terrace.

Q. But the information that this model produced wasn't used for exposure estimates --

A. I don't --
Q. -- in individuals?
MR. DEAN: Object to the form of the question.
THE WITNESS: I have no idea what it was used for.
BY MR. ANWAR:
Q. Can you point to -- can you direct me to anywhere in the -- the article where the purpose is identified as estimating concentration levels for exposure determinations in individuals?
MR. DEAN: Object to the form.
THE WITNESS: I don't think so.
MR. ANWAR: Okay. You can set that aside.
We've been going for a little while. Now might be a good time to take a lunch break.
MR. DEAN: How long you want to take? 30 minutes?
MR. ANWAR: What do you guys think? 30? 45?
MS. SILVERSTEIN: I think 45.

MR. ANWAR: Okay. Yep.

MR. DEAN: See you back 1:30.

MR. ANWAR: Sounds good.

THE COURT REPORTER: We are going off the record. The time is 12:46 PM.

(Whereupon, at 12:46 p.m., a luncheon recess was taken.)

AFTERNOON SESSION

(1:43 p.m.)

LEONARD KONIKOW, PHD

called for continued examination and, having been previously duly sworn, was examined and testified further as follows:

EXAMINATION (CONTINUED).

THE VIDEOGRAPHER: We're back on the record. The time is 1:43 PM.

BY MR. ANWAR:

Q. Good afternoon, Dr. Konikow.

A. Good afternoon.

Q. Hope you had a good lunch. We are back on the record from a lunch break.

Are you okay to continue?

A. Yes.

Q. Okay. During your lunch break, did you discuss the substance of your testimony with your lawyers at all?

A. No.

Q. Okay. When we left off prior to the lunch break, I had asked you some questions about the Rocky Mountain Arsenal study that you had worked on.

Do you recall that?
A. Yes.
Q. I wanted to ask you. You mentioned that you sat for a deposition related to that work.
Do you recall what year that deposition took place?
A. No, I don't. It -- I looked to see if I had any records of it, and I couldn't find any. It was probably in the early to mid-'80s. It could have been earlier. It could have been a little later. I don't. I know where it was, but I don't know even what year it was.
Q. Where did the deposition take place?
A. It was in the Sheraton Hotel in Reston.
Q. Oh, in Reston out here.
A. Yeah.
Q. Okay. Thank you.
I wanted to ask you about some of the opinions in your report.
So if you want to direct your attention back to Exhibit 2, which is your rebuttal report, and I wanted to start by focusing

on page 6 of your rebuttal report, which is
Opinion 1.
A. Okay.
Q. And there, you know, I don't want to read the whole thing, but there -- there you offer some opinions about in response to Dr. Spiliotopoulos, and it concludes by saying, in the third paragraph you say:
"Dr. Spiliotopoulos overstates the lack of data for the Camp Lejeune groundwater system."
Is it your opinion that Dr. Spiliotopoulos overstated the lack of historical concentration data available for ATSDR's water modeling efforts related to Camp Lejeune?
A. Well, that doesn't say concentration data. It says he overstates the lack of data. So I take that mean to all data related to the model including hydraulic data, water data, and he's implying or stating that there is a lack of data.
Q. Is it your opinion that there was a lack of historical concentration data available for ATSDR's modeling efforts at Camp Lejeune or

related to Camp Lejeune?
A. Well, as far as I know, it's factual that there was no data between 19 -- are we talking Tarawa Terrace or the other one or all of them?
Q. For concentration -- observed data for concentration levels, let's start with Tarawa Terrace and then Holcomb Boulevard?
A. Prior to 19 -- yes, there were no -- best of my knowledge, there were no concentration data available prior to 1982.
Q. Okay. And you'd agree that the concentration level data for any of the VOCs at issue at Camp Lejeune -- TCE, PCE, vinyl chloride benzene -- prior to 1982 does not exist in terms of real-world data; correct?
MR. DEAN: Objection.
THE WITNESS: In terms of what?
BY MR. ANWAR:
Q. So you'd agree that prior to 1982, concentration level data for any of the VOCs at issue at Camp Lejeune -- TCE, PCE, vinyl chloride, benzene -- it doesn't exist?

MR. DEAN: Object to the form of the question.
THE WITNESS: Well, my answer would be, I don't know for sure that it doesn't exist, but I have not seen any and I saw no reference to any.
MR. ANWAR: Okay. I'm going to mark an exhibit.
Mark this as Exhibit 12.
(Document marked for identification as Konikow Exhibit 12.)
BY MR. ANWAR:
Q. This is -- so this is Volume II of the transcript from the 2005 ATSDR expert panel.
Would you agree with that?
A. Yes.
Q. Okay. And on the front of the -- the front of the transcript, it states that the meeting review -- meeting peer review panel was held at Century Boulevard in Atlanta, Georgia on Tuesday, March 29, 2005.
Do you see that?
A. Yes.
Q. Okay. And is that consistent with

your understanding about when the peer --

A. Well, I don't remember the address, but, you know, that seems to be when the meeting was held.

Q. Okay. And you don't have any reason to disagree with that; right?

A. No.

Q. Okay. Now, when you -- when you participated in both the 2005 and the 2009 expert peer review panels, were you aware that the conversations were being transcribed?

A. I probably was.

Q. Were you aware that these transcripts now exist?

A. Yes.

Q. And is it fair to assume that whatever discussion that took place both in 2000 -- at the 2005 expert panel and the 2009 expert panel, those were your -- your honest thoughts at that time?

A. I would think so.

Q. Okay. You wouldn't have any reason to attend an expert peer review panel and lie or make anything up; right?

A. Absolutely not.
Q. Okay. So I wanted to have you turn to page 47, and then at the bottom of 47 line 25 it starts by saying -- and then it will go on to page 48:
"DR. KONIKOW: Well, you have very limited data against which to calibrate your model. Okay. And you know, in the period that you were collecting data, the wells were contaminated. Okay. So if you're going to run the groundwater model, it's a question of how do you get from zero to that level of concentration that you're calibrating. You start with an initial condition of no PCE in 1954. Okay."
Did I read that paragraph correctly?
A. You read it correctly, yeah.
Q. Okay. And when you said, "Well, you have very limited data against which to calibrate your model," those -- those were your words; correct?
A. Apparently.
Q. Okay. And do you have any reason to disagree with those -- those words?
MR. DEAN: Object to the form

of the question.
And you're also providing him -- not providing the context in which the -- his comments are for the several pages before that.
BY MR. ANWAR:
Q. Do you have any reason to disagree with what you said?
A. (Reviews document.)
Well, yeah, they were talking about the calibration. No, I don't disagree with it.
Q. And it says "You start with an initial condition of no PCE in 1954" --
A. Yeah, that --
Q. -- we're talking about Tarawa Terrace; right?
A. Yeah. Maybe that should have been '53. I don't remember the time.
Q. And then the next paragraph you state:
"And then you start your model running. And there's going to be speculation upon assumption built into that, and you'll get a range of responses. My hypothesis or my guess would be

that all roads will lead to contamination by 1968. You may want to do the modeling to demonstrate it. Maybe I'm wrong."

Did I read that correctly?

A. You read it correctly.

Q. And you said "there's going to be speculation upon assumption built into that"; right?

A. That's what it says.

Q. What did you mean by "speculation upon assumption built into that"?

A. Well, I assume that I was talking about the boundary conditions and other assumptions built into the model. In other words, get the model run, it has to have specific numbers for where fluid comes into the system, where it leaves the system, where solute mass is added to the system and so on.

And for the period where there was, you know, no record, you know, that those estimates have to be reconstructed from the best data available.

So for recharge to the aquifer, you look at precipitation records and maybe the estimates of soil properties that you could, and you make a reasonable estimate of recharge but, you know, it's not an observation.

And, you know, the same with the mass loading. You know, for Tarawa Terrace, they knew where the source was, but, you know, there was no one recording the people dumping the PCE. So you had to make an assumption or approximation about an average rate, and even with an average rate, you don't know the specific rates.

It may have been higher one week and lower the next week, and there's no way to get that variability. So you would do your best to estimate long-term average rates.

Q. Got it.

And in that second paragraph, you go on to state:

"My hypothesis or my guess would be that all roads will lead to contamination by 1968."

Right?

A. That's what it says, yes.

Q. Okay. And when you said 1968, you're referring to 1968 as the start of the epidemiological study that ATSDR was wanting to perform; right?

A. I presume so. Again, this was 20 years ago. I don't remember exactly what my thoughts were.

Q. And you go on in the third paragraph to say:

"But you want -- the only possible outcome that would differ would be a later arrival, and that may be the first few years there's no exposure. I think that's unlikely, but that's what you want to evaluate, and that's probably best -- the best you could hope from -- from all of these models."

Did I read that correctly?

A. You read it correctly.

Q. Okay. When I -- when I read this section of the transcript, it -- it appears to me that the question that you're addressing is whether -- in terms of mass loading whether PCE would have contaminated the aquifers by the start of the EPI study.

Is that -- is my understanding correct?

A. Well, that's my under --

MR. DEAN: Object to form.

THE WITNESS: I'm sorry. Did you?

MR. DEAN: I just -- objection.

THE WITNESS: Okay. My, you know, understanding at the time and from the preliminary documents I read this, I thought as a reviewer my obligation was to question pretty much everything about the groundwater flow and transport models.

I don't think I really thought that there would be an arrival later than 1968. I was just giving them a probing question.

BY MR. ANWAR:

Q. Okay. Do you know for a fact -- well, let me -- let me back up.

When you say in the third paragraph, "the only possible outcome that would differ would be a later arrival, and that may be the first few years there's no exposure," you're acknowledging there the possibility that the PCE -- that Tarawa Terrace was not contaminated on day one in 1953; right?

A. On day one?

Q. Yeah.

A. I don't know that that's acknowledging it, but I think it -- the first day it's probably not contaminated. It takes time. If they're dumping this in a drain or on the land surface, it takes time to get down to the aquifer.

Q. Contaminants, you know, if you're pumping PCE onto a land surface, it doesn't immediately go into the aquifer; correct?

A. Correct.

Q. It needs to travel through the subsurface; correct?

A. Through the unsaturated zone.

Q. Okay. Of the subsurface; correct?

A. Yes.

Q. Do you have any understanding of how -- how long it takes for PCE to travel generally or -- let's start generally.

A. You know --

MS. BAUGHMAN: Objection.

THE WITNESS: -- it's hard to
generalize, but it depends on the
individual circumstances.
BY MR. ANWAR:
Q. Was -- did any discussion take place in the context of Camp Lejeune at the expert peer panel -- peer review panel about how long it would take PCE to travel from the ground through -- through the subsurface into the aquifer?
A. I don't recollect that, but I would expect that the issue was mentioned and discussed somewhere. But I don't recall it.
Q. And in your -- in the transcript here, you're saying it could be a few years later after ABC Cleaners started operating; right?
A. No, I don't think that's the case.
Whatever is said there, I thought that was an extremely unlikely but, theoretically possible, outcome. But, no, I thought from the time they started dumping it, you're talking about days to weeks before it reaches the water table, at most a month or two.
I mean, because you're talking about disposable of a dense nonaqueous base liquid.

That substance is going to sink pretty fairly -- pretty quickly towards the water table. Some of it getting dissolved on the way down and, you know, we're talking mostly about how it's moving in solution, not as a dense separate phase.

Q. Okay. We'll return to mass loading.

If you could turn to -- I think your might already there, but I'm looking at page 49 line 14 through 19.

And it starts "DR. KONIKOW."

Are you with me?

A. Yes.

Q. Okay.

"DR. KONIKOW: But I'm guessing the outcome is still going to be, from the start of your epidemiological study to the end, Tarawa Terrace residents were exposed, which, if you could support that, it kind of mediates the need for more refined modeling because it's not going to yield anything more."

Did I read that correctly?

A. You read it correctly.

Q. And here in -- in the 2005 expert peer review panel, the focus of the discussion appears to be what you need for the -- the type of information you need for the ATSDR epidemiology -- epidemiological study that was -- was going to be performed; right?

A. Well, I think the focus was on the development of the transport model to compute the concentrations needed for that, but I think the focus of the modeling of our discussions that I was commenting on was not the epidemiological studies or the exposure. It was on the transport model. You know, there were comments about the epidemiological study, but that only in the sense of that that's what the results were going to be used for.

Q. So, and if we read it again:

"But I'm guessing the outcome is still going to be, from the start of your epidemiological study to the end, Tarawa Terrace residents were exposed, which, if you could support that, it kind of mediates the need for more refined modeling because it's going to yield -- it's not going to yield anything more."

Those are your words --

A. Yes.

Q. -- correct?
A. Yes.
Q. And when you say, "if you could support exposure at the start of the EPI study, it kind of mediates the need for more refined modeling because it's not going to yield anything more than that," what did you mean?
A. I'm not sure. Looking at this, I'm not sure what I meant by "more refined modeling." Yeah, I'm not sure. I don't remember.
But -- yeah. I don't know. You know, I didn't read carefully the several pages before this to look for context of that comment.
Q. Okay. But you're not denying that -- when you say -- scratch. Strike that.
When you say "because it's not going to yield anything more than that," what did you mean?
A. I assume that it meant it would yield the concentration distributed over time and from that the concentration in the water supply wells and that's -- that's what you'd expect from it.
Q. Okay.

A. Certainly these models were not going to assess human health effects from these models themselves. That's a totally other different thing that has to be used. But these models provide the input to that type of assessment.

Q. I will say, aren't you saying here -- so as an outside observer or someone who didn't participate in this panel, what it looks like you're saying here is that the best that the TT model -- the Tarawa Terrace modeling can do is determine whether the population at Tarawa Terrace would have been exposed or not?

MR. DEAN: Object to the form of the question.

THE WITNESS: No, that's not what I --

BY MR. ANWAR:

Q. Because you say --

A. -- meant.

Q. -- "it's not going to yield anything more than that"?

A. I meant the concentration at the location of the water supply wells is I think what

I was referring to. By, you know, "more refined modeling," perhaps I meant with a finer grid or a finer time step or something, but, again, I don't recall exactly what I meant by that term.

Q. Okay. So it's your testimony today that you have no recollection of what your words here mean?

A. Well, I wouldn't say that.

The specific term "more refined modeling," I don't recall what I was thinking at that point, but the general gist there I think is still clear and I would agree with.

Q. If you were asked to describe a more refined model in present day terms, how does a more refined model compare to a simpler model?

A. Well, a more refined model could be solving the same governing equations but do it over a much finer grid with a much better definition of hydraulic properties.

Hydraulic properties is something you don't have to go back in time to get because they remain constant in time. So you could drill more wells, get more pumping tests, get a better definition, maybe use a new geophysical method, get a better definition of the porosity distribution, and that would be a more refined model with possibly smaller grid spacing and better definition of hydraulic parameters.

A more refined model might be one that includes more processes that weren't included in the transport model. I'm not sure what exactly that would be, but maybe instead of using a retardation factor, it tried to represent the actual chemical and biogeochemical processes more accurately than the simplified approximation of using the retardation factor.

So you could have a more refined model in terms of the processes that affect the concentration as it's being transported, but, you know, the use of a retardation factor is a common, standard way of simplifying all the reaction terms.

Q. When -- when you start developing a new model, do you start with a more refined model or do you start with a simpler model and then build towards a more refined model?

A. Well, we try to start as, you know, after we build the conceptual model of what's going on, we'll try to build as simple as possible and see if we need to, you know, refine the grid spacing, add more processes, anything like that.

So yeah, general rule is, you know, you develop a conceptual model about what the governing processes are, what needs to be considered, and then you develop a model.

You discretize it at some grid spacing that seems reasonable based on your judgment and experience, and you assess whether or not that's adequate one way or another, usually through numerical experiments. And if it's not, use a finer grid, and if it's adequate, you either stick with it or maybe even based on computational efforts you might decide to use a coarser grid to reduce the computational time.

Q. Does the term -- and I may -- may mispronounce this, but does the term "parsimony" mean anything to you?

A. Parsimony.

Q. Parsimony?

A. Yeah. It's basically a fancy way of talking about the simplicity or complexity of the model. Parsimony implies you use the simplest possible approach. You want a parsimonious model.

Q. Okay. Why is that?

A. Well, the more complex a model is, the harder it is for the modeler and the analyst to understand what the model is doing. And you want to -- it's obviously better if you understand what the model does. The simpler the model is, the more you can understand what is going on in the model mathematically.

If you have a multitude of reaction terms and transport terms and all in the same model and something unexpected happens or something showing up, you're not sure exactly why that's happening. There's too many things to do, to look at.

So, you know, you always want to use the simplest possible model, but the difficulty is always assessing how do you know that it's not too simple. And there's judgment calls in there and discussions with colleagues and so back and forth.

It's not just a perfectly objective type of assessment. You need some judgment calls and decisions as to what level of complexity to build in. It's not necessarily that one is wrong or one is better, but sometimes there's, you know, in modeling, particularly in the older days, there was always a trade-off with computer resources because you were much more limited 20, 30 years ago in terms of computer capabilities than you are today. So that always factored into it in terms of efficiency versus, let's say, complexity and accuracy.

Q. Okay. In terms of adding complexity to a model, are there circumstances under which adding complexity to a model could increase the uncertainty or decrease the accuracy of the model?

A. I suppose. I mean, if you add more and more processes, then you're going to require more and more parameters that need to be defined. And if you don't have good ways to measure those parameters, then you're in effect adding more uncertainty even though you're representing more processes.

So it's not always a good thing to do, and, again, it may mask what's really happening in terms of what's causing things to happen.

Q. Okay. Thank you.

On page 7 of your rebuttal report, Exhibit 2. I'm going to be jumping --
A. What page?
Q. It's --
A. 7?
Q. I'm going to be jumping back and forth between your rebuttal report and probably the transcript. So it might be good to have both side by side or -- or I can tell you. Let me do it this way.
There is a reference in your report, it's in Opinion 2, where you mention that Dr. Spiliotopoulos -- Spiliotopoulos says that the results are conservative. You said:
"Dr. Spiliotopoulos says this results in conservative estimates of estimated monthly contaminant concentrations. It is not clear what is meant by 'conservative' or why that is not a good trait. He also says the results are biased high."
If you'd like to read it, it's in Opinion 2 page 7.
But do you recall that portion of your opinion?

A. Yeah, I'm looking at it now. Yes.
Q. Okay. And so if you go back to the transcript that we were just looking at, the 2005 transcript.
A. Yeah.
Q. On page 49. You question in your report:
"It is not clear what is meant by 'conservative' or why that is not a good trait."
And right after 14 and 19, the discussion we were just having about your comments, Mr. Maslia responds:
"Then from the standpoint of being conservative from a public health standpoint, let's assume we refine our groundwater understanding and we get" -- and then he goes on.
When we're talking about -- sort of as reflected in Mr. Maslia's statement there, when we're talking about conservative in terms of ATSDR's Camp Lejeune modeling, we're talking about from a public health standpoint; right?
MR. DEAN: Object to form.
THE WITNESS: I -- I don't recall what he was talking about, but he

says "from a public health standpoint."
BY MR. ANWAR:
Q. What does "conservative" mean to you from a public health standpoint?
A. To me that implies being very careful and safe on what you're doing and not going beyond the basis of the data and supporting modeling studies. You know, it could mean other things.
Q. Would you agree that conservative from a public health standpoint could mean being health protective?
MR. DEAN: Object to the form.
THE WITNESS: I'm -- yeah, you know, I'm not a health expert or an epidemiologist. So I'm not sure what common usage of that means, but that sounds okay.
BY MR. ANWAR:
Q. Because, I mean, we've discussed this.
The modeling was being used for -- to produce information for an EPI study; right?
MR. DEAN: Object to form of

the question.

THE WITNESS: Yeah.

MR. DEAN: You asked 122.

BY MR. ANWAR:

Q. Okay. And from a public health or safety standpoint, wouldn't you err on the side of making assumptions and using inputs that you consider sort of results of exposure that's at greater risk to the public?

A. I guess I think I need a more specific example, but maybe repeat the question.

Q. So, for instance --

A. Yeah.

Q. -- we were talking about mass loading a moment ago; right?

A. Yeah.

Q. And there was a question whether mass loading started on -- for Tarawa Terrace whether it started in 1953, the day that ABC Cleaners opened; correct?

A. Yeah.

Q. Okay. And I think at least in the passage that we discussed, there was a discussion about whether or not the mass could have

traveled -- it would have taken a couple years for the mass to travel through the aquifer so that --
A. To where?
Q. In Tarawa Terrace. The mass. We're talking about the Tarawa Terrace model.
A. To travel from where to where?
Q. From the dumping on the ground from the dry cleaner to the subsurface into the aquifer.
A. No, we did not say.
I said that it would probably take days to weeks, maybe a month or two. That's what I would -- that I would estimate was the travel time from disposal by the dry cleaners into the land surface until it reaches the water table, which I would think was on the order of 20 feet below the land surface.
Q. Okay. Let's -- let's take what you're saying out. We'll return to your statements.
But let's say, for instance, the question was whether you decide the concentration started mass loading immediately into the aquifer in 1953 or 1960.

And if you were deciding between those two start dates, from a public health standpoint, isn't it more health protective to assume -- to assume more people were exposed than less to protect those people?

MR. DEAN: Object to form.

THE WITNESS: I'm not qualified to answer that.

But what I will say, from the perspective of the model, being protective of public health really should not enter into your assessment of mass loading, hydraulic properties, or anything else related to the model should not be influenced by any perception of health effects. That would not be sound application of groundwater modeling.

BY MR. ANWAR:

Q. And are you saying that -- well, why not?

A. The development of a groundwater model should be based on your understanding of the hydrogeologic framework of the boundary conditions. Mass loading is one type of boundary condition, and it should be based on hydrogeological and hydrochemical evidence.

You know, basically I don't see why you would, you know, in developing, doing your best scientific engineering efforts to develop a sound model, a reliable model, what you put into that data set of input parameters, or input data sets, should reflect your understanding of the aquifer system and the stresses on it.

And it should not -- that by itself should not be influenced by what you think the outcome might be or how you might protect human health. Protection of human health is not a component of groundwater modeling.

Q. Are you saying that ATSDR, as a public health agency and performing this -- this modeling related to Camp Lejeune, didn't account for protecting human health?

MR. DEAN: Object to the form of the question.

THE WITNESS: In my mind and in my recollection of everything that was described, there was an impartial scientific objective assessment to get

the best estimates of the input
parameters, and I could -- I did not see
any evidence that the selection of
parameters, boundary conditions, initial
conditions were influenced by ATSDR's
health mandates.
BY MR. ANWAR:
Q. Why would a public health agency
perform groundwater modeling for estimating
contaminant concentrations without considering its
mission to protect public health?
MR. DEAN: Object to the form
of the question.
THE WITNESS: I would hope
that they would want to get the best
possible scientific estimate of how those
contaminants move through the ground.
The estimate of the truth --
and, again, it's clearly estimating what
had happened historically -- is what
needs to be known.
They don't need to know an
estimate that would be protective of
human health. They need an estimate of

what actually happened.

BY MR. ANWAR:

Q. Okay. Based on this conversation that we've been having, are there any parameters that you would consider undesirable? Let's start generally.

A. Undesirable with respect to what?

Q. Well, let me strike that.

Are there any parameters that in evaluating ATSDR's water models that you determined to be undesirable?

A. Again, I'm not sure what you mean by "an undesirable parameter."

I mean, there are parameters in the model which basically reflect coefficients in the governing equations. They're all there because it's believed they're part of the governing processes. So a characteristic of desirability just is inappropriate and irrelevant.

Q. Now, I want to turn back to the opinion or critique you offered of Dr. Spiliotopoulos in terms of overstating the lack of historical concentration data available.

Could you please turn to page 193 of

the transcript that you're looking at.

A. This is from the 2005? Volume II from 2005?

Q. Correct.

A. Repeat the page.

Q. 193.

A. 193?

Q. Correct.

A. Okay.

Q. And in the middle of the page starting at line 11, you're sort of concluding -- it's towards of the panel. You can see the transcript. It's towards the end of the transcript.

"DR. KONIKOW: Well, again, I second all the comments that have been made up to now. I again just reiterate what the groundwater modeling and the transport modeling that ultimately we're limited in what we can do in terms of the available data. I mean, you know, we don't have concentration data before 1980 or '82, and so everything we do for looking at distribution before then is going to be a little fuzzy."

Did I read that correctly?

A. Yes.
Q. And those are your words; right?
A. Yes.
Q. What did you mean by "and so everything we're going we do" -- so -- strike that.
What did you mean by "and so everything we do for looking for at distribution before then is going to be a little fuzzy"?
A. Talking about before 1982 or so, the period in there. That the modeling -- when I say a little fuzzy, but what that means is you're going to make some prediction, decide, you know, your best calibration, your best fit.
But you have to recognize that there's confidence limits about that and there may be a band of uncertainty and that you have to, you know, assess that and consider that and, you know, not take the one prediction of mean as the gospel, but you have to consider -- and this is some of the things that ATSDR did.
They present many graphs with a band about their best fit calibration, and this is a way to reflect -- well, I use the term "a little

fuzzy," which is not really a scientific term but, you know, it recognizes that you have to -- that there's uncertainty in the estimate. There's uncertainty in the results. Your best fit model gives you, you know, a precise estimate, but you have to recognize that it could be above it or below it.

Q. And --

A. And I think that's kind of the consideration of that was followed with good practices by ATSDR and presented their results clearly showing, well, in that term "fuzziness" but they really showed a band about the estimate for different sources of uncertainty.

Q. And there's uncertainty in the results prior to '82 because, as you say there, "we don't have concentration data before 1980 or '82"; right?

MR. DEAN: Object to the form of the question. I'm not sure what the question was.

BY MR. ANWAR:

Q. Correct?

A. We have a very, I believe, high

confidence at the start of the period that there was initial conditions and initial concentrations that were, zero and then we have no data until about 1982 or so, and so that's what the model was used to reconstruct how that might be.

And the model basically is saying that there are certain processes we know govern the fate and transport of dissolved constituents and the movement of groundwater, and the way we make our estimation or calculation of the concentration there, we do it in a way that is consistent with everything we know about the physics.

Q. You just described uncertainty, and I just want to confirm.

That uncertainty exists because there isn't concentration data before 1982?

A. It exists for more reasons than that. It exists because the uncertainty in the definition of the hydraulic conductivity. There's some uncertainty in porosity. There's some uncertainty -- well, every parameter there's some uncertainty. Nothing is known exactly.

The KDs and RFs, the retardation

factor, these are all engineering approximations for the processes that in reality are much more complex. They're not a true and precise representation of all the processes that that causes.

It's an engineering process that -- approximation that is very common in modeling and very well accepted and it's almost, you know, it's there because it's a necessity. It helps keep the model as simple as possible. It keeps you towards parsimony, but we know it's an approximation.

The real processes that control retardation are probably nonlinear, they're not instantaneous, and they vary in space and they could vary in time. If you look at a retardation factor or a KD for one constituent, it may actually depend and vary depending on the concentration of a different constituent.

And, you know, all these -- none of those complexities are incorporated into the RF or into a KD. So they're simple -- simplifying approximations, and that's what we do in effect to some degree or another with everything in the model.

MR. ANWAR: Understood. Thank you.

Give me one second. I'm going to grab a document.

Let's go off the record for one second.

THE VIDEOGRAPHER: We're going off the record. Time is 2:28.

(A recess was taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 2:45 PM.

BY MR. ANWAR:

Q. We're back on the record after a very short break.

Thank you for bearing with me, Dr. Konikow.

I am handing you -- well, are you okay to continue?

A. Yes.

Q. And did you speak about the substance of your testimony with your --

A. No.

Q. Okay. With your lawyers during the

break?

A. With what?

Q. With your lawyers during the break?

A. No.

MR. ANWAR: Okay handing you what's being marked as Exhibit 13.

(Document marked for identification as Konikow Exhibit 13.)

BY MR. ANWAR:

Q. And sort of still on the topic of Dr. Spiliotopoulos's -- well, still on the topic of your criticism about Dr. Spiliotopoulos's -- Spiliotopoulos's statement on the lack of historical data, I've handed you the expert panel summary from 2009.

Would you agree with that?

A. Yes.

Q. Okay. The title on the document is "Expert Panel Assessing ATSDR's Methods and Analyses for Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point, Holcomb Boulevard, and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina."

Did I read that correctly?
A. Yes.
Q. And the date of the expert panel is identified -- the 2009 panel as April 29 to 30, 2009; correct?
A. Yes.
Q. Okay. So I'd like you to turn to page 99.
Page 99 is labeled "Appendix E" to this, the expert panel summary that I just handled -- handled -- handed you.
Do you see that there?
A. Yeah.
Q. Okay. And it -- I'll represent to you that it appears to be comments submitted by you. I'm not sure if it was before or after the expert panel.
Do you recognize this document?
A. My recollection is that these were questions submitted before the panel before we met.
Q. Okay.
A. And the answers were prepared before we met, not with all the information given at the

panel.

Q. Okay. And so I wanted to turn your attention to the middle of the page -- page starting "CHARGE TO PANEL" in all bold.

Do you see that there?

A. "CHARGE TO PANEL"? Yes.

Q. Okay. And the question is: "Do the data analysis and computational methods provide an adequate level of accuracy and precision?"

Correct?

A. Yes.

Q. Okay. And your comment there states:

"The approach taken appears to be quite reasonable, as far as can be told from the available information and with exceptions noted or discussed below, but indeed the level of accuracy and precision may still not be adequate because of the paucity of data and complexity of contaminant sources during the time period when the history is to be reconstructed."

Did I read that correctly?

A. Yes.

Q. Okay. And then you go on to say:

"The adequacy will depend in large part on the reliability and soundness of the groundwater flow and transport models that will be developed (but which have not been adequately described in the reviewed documents). As noted in comments below, the approach used to estimate reaction rates appears to lack a firm theoretical basis for providing confidence in the accuracy and precision of calculated values."

Did I read that correctly?

A. You read it correctly.

Q. Okay. And these are your words; correct?

A. Apparently.

Q. And you said you submitted this before -- these -- these comments before the panel -- expert panel in 2009?

A. Before we met, yes.

Q. Okay. And they were specifically in response to questions that were issued before you met for the 2009 panel?

A. As I recall, before we met, they sent us a short list of -- I don't remember -- four, five, six questions that they requested we answer as best we could based on the knowledge we had. And I think they had sent us some documents to review ahead of time, but it was not a comprehensive presentation of everything done at the site.

Q. Do you recall what documents they sent you to review ahead of time?

A. I do not.

Q. This summary report was published after the expert panel had taken place, though; right?

A. Yes.

Q. Okay. And your comments were attached as an appendix; correct?

A. Apparently, yes.

Q. Okay. And so in that first sentence, you say:

"But indeed the level of accuracy and precision may still not be adequate because of the paucity of data and complexity of contaminant sources during the time period when the history is to be reconstructed."

When you say "the level of accuracy and precision may still not be adequate because of the paucity of data," what do you mean by "paucity of data"?

A. I think -- and, again, this is from 15 years ago. I think I was referring to the source terms and the lack of observed concentration values in the, you know, 30-year period or so.

But the source term, you know, is an obvious, important characteristic for the model or probably for the model parameter. And it was clear that for the Hadnot Point/Holcomb Boulevard area, there were many more sources -- potential sources of contamination than there were for the previous Tarawa Terrace -- Tarawa Terrace models.

And I thought that added more complexity and uncertainty to the -- what would be the overall model results.

Q. Do you recall how many sources there were for Hadnot Point/Holcomb Boulevard?

A. I thought there were tens of potential sources, dozens of sources, individually numerous storage tanks, industrial areas where things were going on, different buildings had different activities. There were just a multitude of potential sources.

Q. The last sentence in that paragraph:

"As noted in comments below, the approach used to estimate reaction rates appears to lack a firm theoretical basis for providing confidence in the accuracy and precision of the calculated values."

What did you mean by that?

A. I don't recall. I assume the "reaction rates" is referring to either absorption reactions and/or the degradation term. I don't recall what exactly I meant there.

Q. If you turn the page to page 100, there is a second question there that starts with an ellipses "reconstructing historical contaminant concentrations."

Do you see that there?

A. Number 2?

Q. Yes.

A. I see it.

Q. Okay. And 2a there states "anticipated data analysis and model modeling complexities?"

That was the question; right?

A. I guess, yeah.
Q. And your response there:
"Overall, the task at hand is an enormously difficult and challenging one, and there are numerous difficulties confronting a successful completion. There are numerous sources of uncertainty both in the data analysis and the modeling results. Attempts should be made throughout the course of the project to quantify, as well possible, the degree of uncertainty in each stage of the work. In the transport modeling, the issue of estimating the appropriate magnitude of the dis --
A. Dispersivity.
Q. -- dispersivity -- thank you -- coefficients is a difficult one for which there is no simple answer or standard. This will certainly be clouded by the use of the finite-difference solution method in the MT3D transport model, and the effects of numerical dispersion on calculated early arrivals and breakthroughs, as well as on peak concentrations, must be carefully considered and evaluated, and alternative solution methods and discretizations considered."

Did I read that correctly?

A. You did.

Q. Can you elaborate a little bit here on what you meant by "the task at hand is an enormous -- enormously difficult and challenging one, and there are numerous difficulties confronting a successful completion"?

A. Well, you know, I think in any groundwater model, flow model or transport model, that's ever been developed, they face an enormously difficult challenge in representing the hydrogeologic framework in a mathematical way, as well as defining all the stresses on the system and so on.

In that sense, all the problems I faced here are problems that every groundwater model ever made over real system faces the same challenges. The degree of data available just varies.

I emphasize again that my answers to these questions were done before we had any presentation by the technical people at ASTDR -- ATSDR on what they actually did.

We had some preliminary draft

documents, which I don't recall what they were, but these answers that are prepared were prior to receiving any feedback or any answers on the questions.

So I had questions, but this was before I got any answers, but these are all issues that every modeler -- groundwater modeler always faces.

You know, here, particularly at the Hadnot Point, there was, you know, probably a more complex set of source terms than in many studies, not in all studies but in many problems.

Any specific comment you want me to address in a little more detail?

Q. Sure.

Before I ask you about specific comments you made, I think you stated that every groundwater model faces sort of these challenge.

Does every groundwater model estimate contaminant concentrations that are now used -- that are now being attempted to be used to determine exposure on individuals?

A. I doubt it but, you know, again, that end use of the modeling results really should not influence the development of the model to any degree. The model -- the people who develop groundwater models are going to look at the hydrogeologic framer, the stressors, all the parameters in the model and do the best possible job they can to define the input data.

And the definitions of the input data for the model should not be affected by what they perceive as the ultimate use of the model, and many descriptions of groundwater models in the literature describe the groundwater model, the reliability, sensitivity, all of those things, but they very often do not describe what the model results may have been used for by other people.

Q. I understand that you're saying now that the -- the model results really -- and you should correct me if I'm misunderstanding your testimony.

What the model results are used for are really not relevant to performing the model; is that right?

A. They're all -- they're only relevant to the extent that you want to make sure the model will yield results that are relevant to the people paying for the model development.

In other words, if you know they're going to use it for health studies based on what you predict in the -- the concentration history in water supply wells, if that's, you know, what it will be used for, then you want to, you know, kind of make sure anything related to that gets special emphasis in being as reliably estimated as possible.

So it's just a very general sense that that would have feedback into the model but, you know, in general, the standard of practice in developing a groundwater model anywhere is you make your best effort at every parameter that goes into it.

But where it might influence, well, if you know this, then you might say, we have to drill a couple more wells or we have to invest more money and, you know, that kind of feedback that you would do to do a better study.

But if you don't have that opportunity to, you know, spend another five years drilling test wells and so on, you do the best you could and that's the standard. Do the best you could based on your understanding and knowledge of the principles, the governing equation, and the mathematics.

Q. Okay. And the reason I was asking that was because sort of going back to the section Chapter 20 of your -- your book chapter, in the section discussing model design development and application, the first sentence of that section is:

"The first step in model design and application is to define the nature of the problem and purpose of the model."

Isn't that right?

A. That's what I said. I still think that's reasonable.

Q. So when you're designing a model, isn't it unreasonable to -- to divorce how the results of the model will be used from the developing the actual model itself?

A. Well, you don't want -- you don't want to divorce it in the sense of being totally ignorant of what it is. Because that may affect -- if you know the model will be used and the results will rely on your estimates of concentration in a water supply well, you're going to design your grid, your spatial discretization grid for the model to make sure it's fine enough around those observation -- around those water supply wells to feel that you will get a reasonably accurate result in those water supply wells.

Whereas, if your purpose is to look at regional flow and what might get into the river at the end, you wouldn't worry so much about having to find enough grid around the supply wells. You'd be okay instead of 50 feet okay 200 feet, you know, things like that.

So in the sense of being aware of the use of it, you want to know what the ultimate -- the end users need and what they're going to need, and that certainly can affect how you design the model.

It should not influence your selection of parameter values. It should not influence your selection of boundary, but it might influence your grid space and your time step. You know, if -- if the end user only is interested in how things change on a yearly basis, well, then you use annual time steps. If they're interested in a monthly basis, you might use monthly time steps. So in that sense, it affects how you design the model.

Q. Understood.

So turning to -- back to the 2009 expert summary comments, your comments, 2b there says:

"Which modeling methods do panel members recommended ATSDR use for reliable monthly mean concentration results for exposure calculations?"

Your comments are:

"The proposed modeling methods appear to be quite reasonable and appropriate to the task, although given the complexity and the uncertainty in the underlying database, there is no guarantee about the accuracy and reliability of the results; those will need to be assessed as the work progresses. Within the broad framework of using MODFLOW and MT3D, details of the approach and implementation must be carefully evaluated, and alternatives considered, to assure the maximum chance of achieving reliable results."

Did I read that correctly?

A. You did.

Q. Okay. And what did you mean there by, although in the first sentence, "The proposed method -- the proposed modeling methods appear to be quite reasonable and appropriate to the task," and then you go on, "although given the complexity and uncertainty in the underlying database, there is no guarantee about the accuracy and reliability of the results"?

What did you mean by "the complexity and the uncertainty in the underlying database"?

A. Well, I mean, I think we've said this several times already that there's a period in which there were no observations of concentration over a period of a number of years until the early '80s.

The hydrogeologic framework everywhere always has uncertainty in it for every case, not just Camp Lejeune.

There's multiple sources, you know, it's a complex subsurface environment. For the Hadnot Point, you had very complex source terms, at least in the sense that they were in many areas, and there were no direct observations that I recall of what leaked when. They had to make assumptions.

And I was just, you know, again, this is before we had the presentations, and I was cautioning, you know, be careful, be as accurate as possible, evaluate the uncertainty and, you know, consider alternative approaches and alternative considerations.

It was just these are just, you know, good general warnings and guidelines for any important modeling project, and, you know, this was before I heard what they did or saw their end results.

Q. Okay. So is it your testimony that your -- so we've looked at a number of statements from the 2005 transcript, as well as now the 2009 expert panel summary document where you raised -- you pointed to the lack of historical data and questioned -- raised questions about uncertainty and whether accuracy could be obtained.

And you've noted that this was before you actually sat through the 2009 expert panel.

Do you no longer hold the concerns that are reflected in all, you know, in your own words in the transcripts and in the summary documents?

A. Some of my concerns -- all my concerns, I mean, these, all the issues that were brought up were responded to. I had concerns about numerical dispersion because in the MT3D model they used a central finite-difference scheme to solve the governing equations.

The reason for doing this is that that's much more numerically efficient computer. The simulations will take less real time with the finite-difference method than with the TVD method, and so I cautioned them to assess alternatives and be aware of the numerical dispersion as a possibility.

And I saw in the later reports that they followed up on that, and they did testing and they compared it with a method of characteristics model and with a TVD model. And these refer to just the specific numerical methods used to solve the solute transport equation. That's a governing equation. There's nothing different in the equation.

So just alternative numerical methods that were available at that time, and they -- they, I guess, took my advice and they made assessments. And I looked at the results, you know, later on or recently reviewing the documents, and I was very impressed at how little difference it made.

Everything I saw. So. Oh, sorry. Okay. I was drifting off the record.

Q. Okay.

A. Everything I saw showed that there was negligible effect of the solution method, indicating that numerical dispersion was not a problem.

Q. When you say after sitting through the expert panel and when you looked at the final product again that they addressed your concerns.

When did you look at the final reports again?

A. The final reports were -- I don't know -- sometime after 2013, whenever they were published, but I, you know, I looked at them again in the last month or two. I don't remember exactly when I first saw the final products.

Q. So you looked at -- you looked at the reports again after you had been retained as a litigation expert; correct?

MR. DEAN: Objection to the form.

THE WITNESS: You mean recently I've --

BY MR. ANWAR:

Q. Correct.

A. Yes, I -- I looked at every one of the reports for both Tarawa Terrace and Hadnot Point. I read -- reread some of them in more detail and more slowly and some of them in less detail less slowly, but I did go every one of them.

Q. Is there any document or anything that you can point to reflecting that your concerns that you raised at the expert panels and that's reflected in the summary -- the summary report, is there any document you can point to prior to your retention as an expert reflecting that the concerns had been addressed?

A. Yeah. I think the content is in the

reports, that they did tests for grid spacing to look at the possible effects of oscillations and numerical dispersion in the solution. They -- I don't remember which report it's in, but I did -- I do recall seeing it that they tested it and, you know, there was not a problem there in terms of any substantive effect on the accuracy of the solution with the method that they did use. And I'm talking about the numerical accuracy of the solution.

Q. I guess what I'm asking --

MS. BAUGHMAN: Wait. Were you finished?

THE WITNESS: I was going to say a little more but, you know, --

MR. DEAN: Go ahead.

THE WITNESS: -- I was essentially finished.

BY MR. ANWAR:

Q. Go ahead if you'd like to say anything more.

A. Well, and I can't remember, again, where it was but, you know, the whole issue of numerical dispersion as it might be influenced by a Courant number being exceeded or a Peclet number being exceeded. These are one of the ways to look at it and control to make sure your grid spacing and time stepping is not so big that it creates inaccuracies in the solution and, you know, I raised it as a question.

I didn't know that. I had no assessment that there were numerical deficiencies there, but I raised it as a question. They addressed it. It's in described in some of the reports -- I don't remember which ones -- and everything looked fine.

They describe that their Courant number was consistently less than 1 and the Peclet number consistently less than 2, and these are kind of standard criteria that you want to see met in solving the transport equation for groundwater.

Q. I guess what I'm asking is: Can you -- can you point to any document or anywhere where you expressed that your concerns had been addressed prior to your retention as an expert in this litigation?

MR. DEAN: Objection to the form.

THE WITNESS: Where I -- you mean where I said they were addressed?
BY MR. ANWAR:
Q. Correct.
A. No. I mean, I felt they were addressed, but I would have no reason to write that anywhere once my service on the panel was done.
Q. And --
A. Which was done after my service on the panel that they prepared, and so I was never asked for anything until I was hired for this litigation.
Q. And now your feelings are reflected in your -- your rebuttal expert report; is that right?
A. No. My rebuttal report is commenting on Spiliotopoulos and Hennet's report. It's not commenting on my original concerns.
Q. Okay. I noted that in a number of places -- well, let me start.
I want to turn your attention back to your -- your rebuttal report, and on page 2 sort of the end of your Introduction section, you

state:

"I hold these opinions to a reasonable degree of scientific certainty."

A. At the top of the page?

Q. Correct.

Do you see that?

A. Yeah. Yes, I do.

Q. And my question is to you: What do you mean there by a "reasonable degree of scientific certainty"?

MR. DEAN: Object to the form. It calls for legal conclusion.

THE WITNESS: Well, let me read --

BY MR. ANWAR:

Q. Sure.

A. -- the background.

(Reviews document.)

Okay. I think to summarize what I meant is that the opinions I express in here in terms of critiques or reviews of what was said in those expert reports, I stand behind them. I think there's a scientific basis for my comments and they're based on my, you know, 50 years of experience as a hydrogeologist and groundwater modeler and that, yeah, I stand behind these opinions that are in this report.

Q. Okay. Are you opining that the simulated monthly contaminant concentrations produced by the two ATSDR models, Tarawa Terrace and Hadnot Point/Holcomb Boulevard, are accurate to a reasonable degree of scientific certainty?

MR. DEAN: Object to the form.

THE WITNESS: I -- I think they're accurate to a reasonable degree. I think they're as likely as not to represent what happened.

There's, you know, there's a band of uncertainty about the results that their or the calculations by their best fit parameters and best fit model, but the calibrated results, I think, are scientifically defensible based on state-of-the-art modeling and standard practices in the field of groundwater.

BY MR. ANWAR:

Q. You mention the phrase "as likely or not."

What does that term mean to you?

A. It means, as far as I could tell, I mean, I think I've seen that somewhere in all the documents I've been reading.

You know, it means this could be exact or maybe it's not, you know, exactly what happened. But in assessing the likelihood of this being right, it's just as likely to be highly accurate or -- or not. It may be off, but everything is done with a recognition of uncertainty.

But these are the best estimates and they're consistent with standard practices and, you know, that's -- we don't know with certainty that it's accurate and precise and represents exactly what happened, but there's a good chance that it is.

Q. It sounded like you were saying it's as likely as it's right as it is wrong.

Is that what you're saying?

A. Well --

MR. DEAN: Object to the form.

THE WITNESS: I don't know if that's exact. I won't say that's exact.

What I meant is, well, these are good estimates and they're based on scientifically defensible approaches with state-of-the-art tools. There's no reason not to believe them.

BY MR. ANWAR:

Q. So the phrase "as likely or not" is a phrase that actually comes from the statute that created this litigation.

A. Okay.

Q. And I'm just wondering: Have you ever used that phrase before prior to -- to your -- your expert work in this litigation?

A. Not that I remember. It's possible I did, but I don't recall.

Q. Where did your understanding about "as likely or not" come from?

A. The words. What it sounds like it means.

Q. Did you understand that's a legal standard in the statute that we're litigating?

A. I did not know it was a term in a statute, no.

Q. And you're not a lawyer; right?

A. Absolutely not.
Q. And you're not offering any sort of legal opinions; correct?
A. Nope. That's correct.
Q. I wanted to -- let's -- let's turn to the page 32 of your report.
MR. DEAN: Page what?
MR. ANWAR: 32.
MR. DEAN: 32.
MR. ANWAR: Correct.
BY MR. ANWAR:
Q. Let's focus on -- so this is the Conclusions section of your report.
Do you see that?
A. Yes.
Q. Okay. And that second paragraph states:
"Although Dr. Spiliotopoulos repeatedly questions the accuracy of the ATSDR model and its calibration, I don't see any evidence that it is unacceptably inaccurate."
What do you mean by "unacceptably inaccurate"?
A. That there would be obvious errors

in or results that are based on errors in the calibration of the model or in the use of parameter values.

Q. Are there acceptable inaccuracies?

A. Sure.

Q. What are some of the acceptable inaccuracies?

A. Well, I mean, if you say the hydraulic conductivity is 10 feet per day, but somehow our measurement says it's 12 feet per day or 8 feet per day, that's an acceptable inaccuracy.

First of all, you would never really know what the true value is, and it depends on many things in how you measure it, the method of measurement the scale of the measurement and so on. So let's say the truth is a little elusive.

Q. But there are inaccuracies; right?

MR. DEAN: Object to form of the question.

THE WITNESS: Every model is a simplification of complex reality. It involves approximation, assumptions, and averaging.

So yes, there's -- there's always uncertainty and certainly errors in every model, and what you try to do in standard practice is assess how serious those errors might be, how they might affect the results.

You do sensitivity tests and uncertainty analysis to help assess what confidence you should have in the model because we recognize that the model is not the reality.

BY MR. ANWAR:

Q. At the bottom of the Conclusions, that last paragraph that spills onto the next page, you start:

"In my opinion, ATSDR has done an admirable job in completing a challenging task of using hindcasting with a calibrated model to reconstruct credible concentration distributions in time and space prior to the availability of data from chemical analyses of groundwater samples in the mid-1980s. In the face of missing historical data, the ATSDR's models provide useful input to epidemiological studies."

Did I read that correctly?
A. Yes.
Q. I think earlier we had discussed -- I had asked you the purpose -- I had asked you questions about the purpose of ATSDR's model and the fact that the data, the information would be used for epidemiological studies.
Do you recall that?
MR. DEAN: 123 now. Yeah.
MR. ANWAR: Okay.
MR. DEAN: We all do.
THE WITNESS: Yes, I do.
BY MR. ANWAR:
Q. And in response to some of those questions, you -- you made clear you're not an epidemiologist; right?
A. Yes.
Q. So what is the basis for your opinion there "the ATSDR models provide useful input to epidemiological studies"?
A. My understanding was the epidemiological studies required first concentrations in the water supply wells, but ultimately concentrations in the water treatment

plants. That was my understanding of what was needed, and that's my understanding of what the modeling provided.

Therefore, I said, well, that's useful. It's providing useful input. That's why they wanted the models and the model -- the models provided that. So my inference was that was useful.

Q. And so if we skip a couple lines ahead, there is -- starting with the fourth line down, there is --

A. Which page?

Q. The last page, page 33.

A. Okay.

Q. It says:

"There is uncertainty in the calibrated models (as there always is in such models) and in the hindcasted results, and that is clearly recognized and evaluated. The uncertainty is not so large or unexpected as to preclude the use of the model results in the epidemiological studies or for providing mean monthly -- monthly mean concentrations for use by health professionals to estimate past exposure of residents on 'as likely than not' or 'more likely than not' basis."

Did I read that correctly?

A. Yes.

Q. Did you -- did you write that sentence?

A. I did and those --

Q. Why did you -- go ahead.

A. You know, those terms "as likely as not" or "more likely" I probably heard from the lawyers and so that was -- I felt, yeah, that was a good description, but they did not tell me what to write or how to write it or anything like that.

I mean, that's probably -- I'm sure I heard those terms from the lawyers, and so I felt it appropriate to use it --

Q. Okay.

A. -- with, you know, my perception of what that meant.

Q. Got it.

And you say:

"The uncertainty is not so large or unexpected as to preclude the use of the model results in the epidemiological studies."

And we talked about the epidemiological studies, but then you go on to say:

"Or for providing monthly mean concentrations for use by health professionals to estimate past exposure of residents on an 'as likely as not' or 'more likely than not' basis."

You're not a health professional; correct?

A. Correct.

Q. So what is -- what is the basis for your opinion that the simulated concentrations from the ATSDR models are -- do not preclude the use by health professionals to estimate past exposure of residents?

A. Well, from the health perspective, I have no basis for saying that.

But from the modeling perspective, I felt that the mean monthly concentrations were estimated on the basis of reasonable, adequate models and so that they could be relied on for other purposes. But it's certainly not meant to imply I understood the health studies.

Q. Are you offering the opinion that

the simulated concentrations produced by ATSDR models are sufficiently accurate for health professionals to rely upon?

A. I think they're the best that could be come up with. From -- I think they're reasonably accurate. I think they're reasonably reliable. I think there's uncertainty associated with them.

I think the uncertainty is clearly expressed in the analyses produced by ATSDR, and then it would be up to the health professionals to decide with that level of uncertainty is it good enough for them to use. That would not be something I would say. So yeah.

Q. Earlier we had a discussion or an exchange where I was asking you about the intended purpose or use of particular models, and I believe you told me, as a modeler, the use of the model isn't really your focus or your concentration for purposes of developing the model; is that right?

MR. DEAN: Object to form of the question.

THE WITNESS: I would design a model, develop the model, calibrate the model according to best practices in my understanding, regardless of what the downstream use of that model might be.

Although as I said before, I might refine the grid or do something particular to help meet the needs of the people paying for the model.

BY MR. ANWAR:

Q. But you're not -- and we -- we talked -- you're not a health professional yourself; correct?

A. Correct.

Q. Did you -- in forming this opinion, did you speak with any health professionals?

A. No.

Q. So it's your opinion, as a modeler, that the simulated concentrations from the ATSDR models are -- are good enough for health professionals?

A. Well --

Q. And when I say "good enough," I mean accurate enough.

A. I think they're reasonably accurate. Again, I'm not a health professional. So I really -- I really shouldn't comment on whether it's good enough for a health professional.

Q. Well, if you don't feel comfortable commenting on the results being good enough for a health professional, why do you feel comfortable commenting on the results being accurate enough for a health professional?

MR. DEAN: Objection to form of the question. It mischaracterizes his testimony 100 percent.

BY MR. ANWAR:

Q. You can answer.

A. Excuse me?

Q. You can answer.

A. Well, as a hydrogeologist and an experienced modeler, I felt that these results were reasonably reliable, and I could think of no reason that they shouldn't be used in light, you know, with consideration of the uncertainty, why they shouldn't be used for any purpose after that.

Q. How many -- if you had to estimate, how many groundwater and/or transport models have you developed yourself or evaluated throughout your career?

A. Probably on the order of half a dozen comprehensive, detailed studies and model developments that I've done. And in terms of reviewing or assessing others, probably many tens, if not well over a hundred different cases, probably even more.

Q. Of all those models, are ATSDR models -- are ATSDR's models the only one you're aware of that are -- that estimate -- that are attempting to be used to estimate exposure -- monthly contaminant concentrations for exposure determinations in individuals?

MR. DEAN: Object to the form.

BY MR. ANWAR:

Q. You can answer.

A. Well, as I mentioned earlier, the analyses for the Waste Isolation Pilot Plant used models for 10,000 years into the future, and that was for the purpose of health exposure of a potential hypothetical future farmer and so it was used for health assessments. I don't recall what the health assessment studies were or how they were done, but it was used. That was one of the purposes of that modeling.

There are many other models that I reviewed with similar characteristics, but most often I say they do not describe what the sponsors of the modeling effort were going to do with it. So a lot of times.

So I guess my answer is, they may or may not have been used for health exposure studies. I don't know because I wasn't always aware of what the ultimate purpose of the model was.

Q. Okay. There are places in your report -- and I can give you examples if you'd like -- where you -- so, for instance, on the page we were just looking at, the last line of your report, you state:

"The methods were rigorous and scientifically sound."

Correct?

A. Yes.

Q. And then there are other places throughout your report where you refer to scientifically valid methods being used and/or the models being scientifically valid, the ATSDR models.

Do you recall that?
A. I don't recall saying they were scientifically valid, but I may have said that.
Q. Okay. Well, why don't we -- why don't you turn to page 30 of your report.
A. 30?
Q. Yeah.
A. Okay.
Q. Sorry. I might have put the wrong page on. Give me a second.
Oh, I'm sorry. Yeah. It is starting on 30.
At the bottom of 30, that last paragraph has a section heading "Section 3.3 and scientific validity of ATSDR model -- ATSDR's models," and you quote an opinion offered by Dr. Spiliotopoulos there where he -- he opined:
"I do not think their results were scientifically valid because" -- or I think you quote Dr. Waddill, actually.
A. Yes.
Q. And it says:
"I do not think their results ... were scientifically valid because, you know,

science needs to be based on real-world observations and analysis ... and there were just not enough real-world measurements for this to count as scientifically valid."

And you disagree there.

And then on the next page, on page 31, the second line:

"Therefore, I would counter Dr. Waddill's statements by noting that in developing and applying the ATSDR groundwater models, that scientifically valid methods were used, and the models were based on sound hydraulic and physical principles that themselves have been tested and shown to be accurate and reliable approaches to describing and predicting groundwater flow and contaminant transport."

Did I read that correctly?

A. Yes.

Q. Okay. Is it your opinion that ATSDR's Camp Lejeune water models are scientifically valid?

A. Yes.

Q. Why do you say that?

A. The models are based on a

mathematical representation of the processes that govern fluid flow in porous media and the movement of dissolved chemicals. These equations are well accepted throughout the scientific and engineering worlds.

There's common practice, standard practice. There may be some debate in the scientific circles, particularly about the governing solute transport equation, what it should look like but, nevertheless, it is a standard form. And these equations and the numerical methods to solve them are widely accepted as being scientifically valid and appropriate and useful.

So these -- these are the models and methods that ATSDR used and applied and, you know, I think what they do is estimate how water fluxes and water levels and solute concentrations, how they change over time in a way that is consistent with the widely accepted principles reflected in the governing equations.

This is -- this is valid science. This is, you know, well accepted. You know, there's very few people that would argue with that, you know. So I think, yes, it is scientifically valid.

MR. ANWAR: Okay. I'm going to hand you an exhibit that I'm marking as Exhibit 14.

(Document marked for identification as Konikow Exhibit 14.)

BY MR. ANWAR:

Q. This is an editorial that was coauthored by you and a J.D. -- you pronounced it earlier -- Bredehoeft?

A. Bredehoeft.

Q. Bredehoeft. Entitled "Ground-Water Models: Validate Or Invalidate"; correct?

A. Correct.

Q. And we can -- we can read through this a little bit, but the first bolded section there -- so it was originally -- let me take a step back.

This editorial was originally published in 1993; correct?

A. The editorial? It says reprinted from 1993. The ideas expressed in here are really based on a more comprehensive analysis and article that Bredehoeft and I published in, I believe, 1992.

Q. Okay. What is the name of that publication?

A. I think it was "Advances in Water Resources" is the name of the journal.

Q. And then this editorial was republished in "Groundwater" in 2012; correct?

At the bottom note.

A. Yes.

Q. So the first paragraph focuses on validation and it states:

"The word validation has a clear meaning to both the scientific community and the general public. Within the scientific community the validation of scientific theory has been the subject of philosophical debate."

And then you reference Karl Popper.

Going to the second paragraph there, you state:

"To the general public, proclaiming that a ground-water model is 'validated' carries with it an aura of correctness that we do not believe many of us who model would claim. We can place all the caveats we wish, but the public has its own understanding of what the word implies. Using the word 'valid' with respect to models misleads the public; 'verification' carries with it similar connotations as far as the public is concerned.

"Our point is this: using the terms 'validation' and 'verification' are misleading, at best. These terms should be abandoned by the ground-water community."

Did I read that correctly?

A. Yes.

Q. And so when you're describing ATSDR's model as scientifically valid --

A. I never said that their model was valid. I never said it was validated. I never said anything about validation of the models.

I said the -- I try to avoid using the term "valid" or "validation." I used it once or twice in terms of overall broad scientific validity reflecting that it's a widely accepted method.

Q. I think I just asked you the question, is it your opinion that ATSDR's models are scientifically valid, and your response was yes.

Is it?

A. Well, okay, but, you know, if you read the paper, what I don't want to imply is that the model is perfect or that there is no other model within the realm of infinite possibilities of combinations of parameters that would not do as well in terms of accuracy.

So it's not a unique model. It's valid in a broad sense of that term, but there is no exercise that validated their model. But it's valid scientifically in the sense of using state-of-the-art methods.

Q. What do you mean "there was no exercise that validated ATSDR's models"?

A. They went through a calibration, which involved history matching, and that calibration yields a best fit to the parameters, but it's not the only possible fit. History matching by itself does not prove that the model was valid, that it was the absolute truth.

We know it's not. That's why we do uncertainty analysis and sensitivity analyses.

Q. Your -- your report is directed to an audience of people that are not modelers; correct?
A. Which report are you referring to?
Q. I'm sorry. Your rebuttal expert report in this case; correct?
It's directed towards an audience that all aren't necessarily modelers; correct?
A. Yeah. I mean, it's aimed at you and others that aren't hydrogeologists, as well as aimed at technical experts in hydrogeology.
Q. Isn't using the terms "valid methodology" or "scientifically valid" or describing the model as "valid," isn't that, as you state in your own words here, misleading?
MR. DEAN: Object to the form of the question.
THE WITNESS: Well --
MR. DEAN: Mischaracterizes his prior testimony. He's already answered that question.
THE WITNESS: Let me emphasize that bringing up this topic of validity was not mine. It was brought

up -- I'm quoting from Spiliotopoulos. He raised the issue and so I'm trying to address it.

It is not -- it's not a terminology that I would normally use for the very reasons we discussed and summarized in that editorial.

BY MR. ANWAR:

Q. And the first sentence of that second paragraph:

"To the general public, proclaiming that a ground-water model is 'validated' carries with it an aura of correctness that we do not believe many of us who model would claim."

"Using the word 'valid' with respect to models misleads the public."

Isn't describing ATSDR's models as scientifically valid or the methodology they used as scientifically valid, isn't that intended to carry with it an aura of correctness that you acknowledge?

A. I don't think they ever said that they validated their model. I don't think that terminology was ever used with respect to their modeling of the results.

The ATSDR is very clear and very transparent about recognizing uncertainty in the results.

Q. They -- go ahead.

A. So they're not anywhere in my reading implying that they have the right truth or model or that they validated it in the sense of it being the ultimate pinnacle of correctness. I don't think they ever implied that. They certainly never say that, and I think that's why we use.

What they've done clearly in many, many, many plots of results, they show the calculations based on their best fit calibrated model, and they show upper and lower bounds about that that reflect some range of consideration of uncertainty in one or more parameters.

So I think they're very clear in expressing that they have not validated the model in the sense that people could misinterpret it to mean that they have an aura of correctness and certainty about their results.

Q. ATSDR didn't validate their model

because they couldn't validate their model; right?
MR. DEAN: Object to the form of the question.
BY MR. ANWAR:
Q. There wasn't sufficient data to validate their model; correct?
MR. DEAN: Object to the form.
THE WITNESS: That's very misleading as I read it because there is never ever any groundwater model for which there is sufficient data to say (indicates) you've validated it. It just doesn't exist.
There is always uncertainty. Every model ever developed for groundwater has uncertainty associated with it, and no competent hydrogeologist would claim that they have the truth.
BY MR. ANWAR:
Q. What is your understanding of why ATSDR didn't validate their models?
MR. DEAN: Object to the form of the question.
THE WITNESS: Repeat the

question.

BY MR. ANWAR:

Q. What -- having reviewed the reports, the Tarawa Terrace reports and the Hadnot Point/Holcomb Boulevard reports in preparing for your deposition and offering expert opinion in the case, why didn't ATSDR just validate their two models?

A. Well, the title of the paper I published in 1992 with John Bredehoeft is groundwater models cannot be validated. That did not refer to ATSDR or Camp Lejeune. It referred to every groundwater model ever developed or potentially developed in the future.

It's in our opinion -- and not everyone agrees, but in our opinion, no groundwater model could be validated in the sense that the public might perceive the term to imply that you have the right model to the exclusion of any other possibility.

So if ATSDR had claimed that they validated the model, I would have come down on them very hard, severely criticized them for saying that, but I think they knew better than to say that.

Q. Okay. Describing a groundwater -- groundwater model as scientifically valid or the methodology that was used as being scientifically valid doesn't mean that the output, in this -- in this case the simulated concentrations produced by ATSDR's models, are accurate; right?

MR. DEAN: Object to the form.

THE WITNESS: It depends how you mean "accurate." They're not precisely the truth because we don't know the truth. They're not, you know, they're reasonable and they represent what's going on, but there's uncertainty about it.

It could be a little higher. It could be a little lower. This is the best estimate in the middle. It's a moving trend based on a very reasonable model that solves the governing equations.

The equations for which we know represent the processes, but the coefficients in the equation are not known precisely, and they are never known precisely or accurately.

BY MR. ANWAR:

Q. Okay. I think you stated or I believe it's listed on your reliance materials that you reviewed Jones and Davis's original postaudit report; correct?

A. I read it. It was probably a couple of weeks ago. I didn't give it a technical review in great depth, but I did. I looked at it, yeah.

Q. Did you also look at their -- I can't recall, so I apologize if I asked you this already.

Did you also look at their rebuttal expert report submitted in this case?

A. I think I did, yes.

Q. There is a portion in their report where they state:

"Based on this postaudit, we can find no significant evidence that would invalidate the analysis performed by ATSDR with the original model."

Are they using the term "invalidate" then incorrectly?

MR. DEAN: Object to the form.
THE WITNESS: Well, I would assume so. You know, the general belief, John Bredehoeft and I and many others believe that you can invalidate a model, but you cannot validate it. And by invalidating, you show that there are significant errors from what's going on.
So if you -- the basic reasoning -- I'm not sure who said this first but, you know, if you have a model, you have best fit, your history match, and all of that. That builds confidence in the model, but it doesn't prove you have a valid model.
If you make a prediction and that prediction turns out to be wrong by some substantial degree, you have in effect invalidated the model and you try to get a better model.
But if the next prediction, you know, that prediction you made turned out to be really close, that builds more confidence, but it still doesn't prove

that you validated the model because the very next prediction might be erroneous.
So the kind of philosophy -- philosophical argument is that you can never validate the model in any kind of literal sense, but you can invalidate it by showing that it was inaccurate.
BY MR. ANWAR:
Q. Isn't validation a history matching, a form of history matching?
A. What I would argue is that they are not equivalent. History -- if you match history very well, that doesn't mean you validated the model. It means you have more confidence in the model. The model is probably pretty good.
Q. If you have history matched very well, why does that not validate the model?
A. Because the next prediction could be off. You may not have data for a particular point or thing where it may have been an error. You never have enough to say, this is the perfect model and it's a valid model or you validated it. Because you make a prediction, that could turn out to be wrong.

So the general cautiousness that you want to say is that you've got a good model, a reasonable model. We've matched the history, the historical data that we have. We have a good calibration, and we think this is an appropriate model, a reasonable model for the purposes that we're using it.

But we don't say that it's validated because I would argue that you can never validate a model because you never, you know, you just don't know what will happen in the future.

Q. So my understanding of calibration and validation is -- and you should correct me if I'm wrong -- is essentially that you -- when you're calibrating the model, you're attempting to adjust parameters to match observed parameters such that the simulated results matches closely as possible observed values that you're running the model against.

And validation is taking a set of observed values that you didn't use as part of the calibration and then comparing the simulated models against sort of a separate set of observed data.

Is my understanding right?

A. I would say it's not right, but it matches the perception of many other people. You know, I think there are people who believe that.

I would counter that in groundwater systems, you can almost never have independent data sets. If you have, you know, your observations say, well, let's save this for the (indicates) what you might call validation, you're not blind to that data. You know what it is. It's not.

You know, in drug approval, they would never say that that's acceptable for a drug test because you are aware of what those values were. You weren't blind to them, and they're not an independent set of data.

You never have an independent set of data in a historical groundwater. Everything is linked and in groundwater systems, even if you can compare it with surface water systems, surface water, without the issue of validation, you could get a fairly independent set of responses in a river flow data if you go down a year or two in time in response to different precipitation events.

In groundwater systems, the responses are much more buffered and much more slower, and the behavior of a groundwater system a year in the future depends to a large degree on what it was at the start of that year.

You don't get independence and that restricts your ability to even talk about validation with an independent data set because it's so difficult to get in groundwater system anything that approaches an independent data set, and I would argue that still revealed validation if you had.

Q. I guess the reason I asked -- part of the reason I asked that question: If it's your opinion that you can't validate a model ever under any circumstance, how can you ever calibrate a model? How can you say that any model --

A. The calibration has nothing to do with validation in the sense. You can calibrate. What you do in model calibration is adjust parameters and boundary conditions and maybe some other processes, maybe your numerical grid, maybe your time step. You adjust lots of things so that the results match the historical changes that you've seen. You could do this. It doesn't depend on any condition (indicates) called validation.

It's the process of model calibration is the process of parameter restoration in effect, and that's why automatic or automated parameter estimation models are so useful because they make the whole process faster and more efficient to adjust parameters to get what could be a statistically best fit.

Q. Is it possible to adjust the parameters in a model in such a way that the -- that you successfully -- let me -- let me start -- strike that.

Talk to me about the concept of nonuniqueness.

MR. DEAN: Object to form.

THE WITNESS: Excuse me?

MR. DEAN: Object to form.

BY MR. ANWAR:

Q. What is nonuniqueness in modeling?

A. Well, that's basically the concept that when you calibrate a model, you have a set of parameters that you feel give you the best fit but that may not be the only combination of parameters that give you approximately an equally good fit.

You know, there's, you know, if you -- if your result is a sum of 10, 5 plus 5 gives you 10 or 6 plus 4 gives you 10, and in terms of the fit, they're both equally good.

Q. And so when we're talking about calibrate -- adjusting parameters to calibrate a model, there -- there are many different possibilities of combinations of parameters that could calibrate the model in the sense that the simulated values match the observed values; correct?

A. As well as possible. What you do that -- I mean, it's not an unbounded process. What you do is you consider the -- how good the fit is and the quality and the errors and the mean error and all the other statistical measures of the fit. And you adjust parameters until that error measure gets smaller and smaller, and continued changing of parameters basically yields no improvement, no further improvement in fit, and that's why you say, well, that's as good as we could do.

Q. And simply calibrating a model or -- excuse me -- simply adjusting parameters in a way that to calibrate a model doesn't mean the model is good or accurate if the input parameters are unrealistic; correct?

A. Well, one of the guidelines for adjusting parameters during history matching during calibration is you have to keep those bounded within reasonable limits. You know, that's, you know, whether you're doing by trial and error or with an automated method, you don't have an unlimited range to adjust parameters.

You can't have a negative value of hydraulic conductivity. You know, you have to be consistent with principles and your geologic knowledge and other maybe more subjective criteria, but it's not an unbounded universe.

Q. The statistical analysis that you're talking about to -- to ensure that the model is appropriately calibrated and the parameters fall within a certainty bound, ATSDR didn't do that statistical analysis for the Hadnot Point/Holcomb Boulevard model; right?

A. I'm not sure what you mean. I mean, they did a model calibration. They were measuring the goodness of fit. They -- my understanding is that they used the PEST software to help with the calibration and parameter. That PEST automatically calculates all those measures of fit and that's how it does the calibration, by minimizing some objective function that's related to the error.

Q. Okay. Why don't we take a quick break.

A. Sure.

MR. ANWAR: A short break.

THE VIDEOGRAPHER: Going off the record. The time is 3:51 PM.

(A recess was taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 4:05 PM.

BY MR. ANWAR:

Q. We are back on the record from a short break.

Dr. Konikow, are you okay to continue?

A. Yes.

Q. Okay. And did you speak with your lawyers about the substance of your testimony?
A. No.
Q. Okay. I wanted to ask you.
Can a postaudit be used to validate a model?
A. No.
Q. Why not?
A. Because a model can't be validated.
Q. And looking back at your -- this editorial, it is, I think, Exhibit 13.
A. 14.
Q. 14. Thank you.
If you turn to the next page, there is a section on Postaudits, and you state there:
"Several postaudits have been performed to evaluate the accuracy of predictions made using -- sorry, lost my place -- made using supposedly validated -- 'validated' models. Compared to the number of model studies, the number of postaudits is small. There are numerous problems in examining past predictions; often the stress placed on the system was quite different from that used in the model analysis.

"The results of the current set of postaudits suggests that extrapolations into the future were rarely very accurate. There are various problems with the models: the period of history match was too short to capture an important element of the model, or the conceptual model was incomplete, or the parameters were not well-defined, etc. Our experience suggests that models are more useful as tools used by the hydrologist to understand the system rather" -- it says "that" but I think it's -- "than as tools to predict future response. Our record of 'validating' models is not encouraging."

Did I read that correctly?

A. Yes.

Q. Okay. So you can use a postaudit to evaluate the accuracy of the predictions of a model; correct?

A. No.

MR. DEAN: Object to form.

THE WITNESS: That's not correct.

BY MR. ANWAR:

Q. Okay.

A. You could use the postaudit to assess the accuracy of the predictions made by the model, how good the model was, but it just would not prove that you had a valid model.

Q. Okay. And why -- why wouldn't it prove that you have a validated model?

A. Because if you use the model, the same model to predict another year into the future, that may be very wrong. That prediction may be wrong and, therefore, that would prove you had an invalid model. It would invalidate the model.

So when you use a postaudit to assess the accuracy of the prediction, if it turns out -- which doesn't always happen -- if it turns out that the prediction was fairly reliable and acceptably accurate, it helps build confidence in the model. You're building confidence in the model. You feel better about the model.

You just have not proved that it is a valid model. You have not validated the model because the next prediction could be very much in error with the same model, and that would invalidate the model.

Q. Okay. Understand.
Can you pull up Exhibit 12. It is the 2005 transcript of the expert summary, day 2.
A. Which one is 12?
Q. It's the transcript of the expert panel. I think we have only given you one of those so far. Should be one of the thick ones.
A. Yeah, thick ones. This is 9. 13.
Q. There you go.
A. 12. Okay.
Q. Could you turn to page 46?
A. Okay.
Q. Okay. So just for frame of reference purposes, the 2005 expert panel was focused on ATSDR's Tarawa Terrace model; correct?
A. Yes.
Q. And so starting at line 14, there's a discussion going on and you chime in at line 14. You say:
"But the point -- one of the points is that you really -- your study isn't starting until 1965."
And Maslia says '68 and you say '68.
"That gives you 14 years from the

time ABC Cleaners started. So the value in doing the groundwater flow and transport model will be to, you know, start as best as we -- or as best we know. They were introducing contaminants into the soil at least through the septic tanks very shortly after they started, maybe a year, maybe instantly, maybe a year, maybe two years at most. That gives you 12 years for it to reach the water table and spread."

"The" -- going into the next page.

"The groundwater flow and transport models accounting for uncertainty" --

A. I'm not sure where you're reading from now.

Q. On page 47 line 1.

A. Okay. Okay.

Q. Just continuing from where we were reading.

"The groundwater flow and transport models accounting for uncertainty, heterogeneity, and so on will give you a range of arrival times, but I'm guessing the bulk of your realization will get contaminant reaching the wells in that 14-year period."

Did I read that all correctly?
A. Yes.
Q. And it sounds like in this exchange, you're talking about here mass loading at Tarawa Terrace; correct?
A. Well, we're talking about, yeah, the solute load. Yeah, when the source got to the water table and then spread down to TT-26 and so on.
Q. And the way I read your comments here is that, you know, you say:
"ABC Cleaners, they were introducing contaminants into the soil at the very least through the septic tanks very shortly after they started, maybe a year, maybe instantly, maybe a year, maybe two years at most. That gives you 12 years for it to reach the water table and spread."
You're discussing --
A. I did not mean that it would take 12 years to reach the water table.
Q. Okay.
A. I meant that it would reach the water table, and then it had 12 years to spread. Until that, you know, 1968 time.

Q. It does sound like you're saying here, though, that the contaminants wouldn't reach the water table on day one; right?

A. On day one? Probably not.

Q. And you indicate that "maybe a year, maybe two years at most"?

A. Yeah, I really think it would be less than that.

Q. But at this time, you stated "maybe a year, maybe two years at most"; right?

A. Yeah, that's what I said. Yeah.

Q. And, again, when you're referencing 1968, you're talking about the starting point of the EPI study that ATSDR was performing; right?

A. I believe so.

MR. ANWAR: Okay. I'm going to hand you what I'm marking as Exhibit 15.

(Document marked for identification as Konikow Exhibit 15.)

BY MR. ANWAR:

Q. This is the transcript from day 1 of the 2009 expert panel; right?

A. Apparently, yes.

Q. And it's dated April 29, 2009 there; correct?
A. Yes.
MS. BAUGHMAN: Did you hand us one?
MR. ANWAR: Yeah, it's right there.
BY MR. ANWAR:
Q. I'd like you to turn to page 89.
And in the middle of the page there, your name is highlighted starting on line 7.
Do you see that?
A. Line 7.
Q. On page 89?
A. Yes.
Q. You see that?
A. Yes.
Q. It says:
"DR. KONIKOW: The Tarawa Terrace with the first arrival in November '57, if that was actually several years later, maybe even four or five years later, would that have any effect on the health study since the health study is '68 to '85?"

Did I read that correctly?
A. You read it correctly.
Q. And so you're -- you're raising whether an even later contaminant mass loading date would impact the -- the EPI study that ATSDR was performing; correct?
MR. DEAN: Object to the form.
THE WITNESS: I seem to be talking about the first arrival, and I am inferring that might be talking about TT-26, but I don't see. I haven't carefully read right now the preceding several pages.
So when I said "first arrival," I'm inferring that meant at TT-26, but I'm not positive that's what we were talking about.
BY MR. ANWAR:
Q. Okay. TT-26, was that the -- was that the primary source in Tarawa Terrace?
A. I believe so.
Q. Or that was the source was ABC Cleaners, but the TT-26 was the most contaminated well; correct?

A. Most contaminated well, yes.
Q. Okay. And so if we go on to read, Mr. Maslia states:
"We actually did, Mustafa Aral did some well scheduling optimization and did different scenarios with different wells other than the ones that we calibrated for the model. And you could shift from '57 to '60, but during the course of the study it did not significantly affect at all the higher concentrations.
"They all tended towards that level of that chart, the graph that shows in the finished water that all that it shifted was, other than if you shut down, for example, TT-26. If you shut down TT-26, both the data and the model would show that your finished water went down to practically no contamination at Tarawa Terrace. But if you shifted the cycling so that it didn't hit or arrive or pass the MCL, say, as you said, 59, 60, 61, whatever, did not significantly affect the higher concentrations in the finished water."
Did I read that correctly?
A. Yes.
Q. Okay. And because TT-26 was the --

I guess the most contaminated well, it sounds like he's saying -- Mr. Maslia -- that if you shut it down, the contamination levels went to nearly zero; correct?

A. He said that they would. He didn't say they shut it down. He said -- I believe he implied if you shut down TT-20 -- TT-26. That was because that was the main source, not the only but the main source, of contaminated water to the Tarawa Terrace Water Treatment Plant. If that wasn't pumping, then there would be few, very few contaminants showing up in the Water Treatment Plant.

I think that's what was implied there.

Q. Do you recall the extent of data available about the pumping history for TT-26?

A. I recall seeing it. I can't recite the details of it, but I know they had a graph showing when it was operating, and there was another graph showing estimated pumping rates from that and other wells. So yeah.

Q. Would you agree that there was incomplete data about the pumping history of

TT-26?

MR. DEAN: Object to form.

THE WITNESS: To the best of my knowledge, there was not a complete record of when the well was pumping and how much it was pumping. That had to be reconstructed also.

BY MR. ANWAR:

Q. And one of the assumptions that ATSDR made was to assume that the well was pumping unless there was a historical record confirming that the well was not pumping; correct?

A. Well, I don't know exactly what they assumed but, you know, certainly in terms of, they had methods to estimate what the average monthly pumping rate was. And if the well is shut down for a day or two during a particular month, then maybe your average withdrawal for that month would be a little lower.

But for the model, you would still a sum -- assume that it's pumping at that slightly lower rate but over the whole month, and it wouldn't make any significant difference in the results.

But as I recall, there were only two extended periods of non-operation of TT-26 before it was finally shut down, but I don't think that implied that it was never shut down. I think there was some statement that typically they cycle through all the different wells that supplied water, and so it was routine for any individual well to be shut down for a short period of time.

I think that's normal when you have multiple wells in a well field supplying it. I think it's normal to cycle through using different ones to meet the demands at the time.

Q. Okay. And so your recollection of the way ATSDR handled -- handled the model with respect to missing pumping history is that they cycled through?

A. No, that wasn't part of the reconstruction. That was part of the operation.

That the normal operation of wells, I believe, included cycling through different combinations of well pumping at any time, any particular time during the whole history, in other words.

So no one is saying that, the

Department of the Navy or anyone. They're not saying that TT-26 pumped continuously from the beginning to end of their pumping period before there was, you know, a longer break for servicing.

The normal operation includes short sequences in which the well is turned off, maybe minor servicing, but that's normal and it doesn't affect the model.

Q. How did ATSDR handle TT-26 for purposes of the historical reconstruction period?

A. You mean --

Q. The pumping. How did ATSDR handle the pumping schedule for TT-26 for purposes of the historical reconstruction period dating back to 1953?

A. I don't have a precise recollection of method they used, but it was well-documented in the report. I had read it. I just don't recall the details of it, but my recollection is that there was some estimates based on water demand, you know, how much the water treatment plants needed, and how that might have been apportioned among the different wells supplying it.

So there was some correlation,

regression analysis and reconstruction, and it is -- let me emphasize again that in all groundwater models, you require an estimate of the pumpage from all wells in the area and it is, I'd say, beyond common, it's almost in every case the models have to reconstruct the pumping history and make estimates of it.

Q. Understood.

A. It is rare that over a historical period you would have very precise records of pumpage.

Q. Let's turn to page 201, and starting at line 6 your name is highlighted there for comments you made; correct?

A. Yes.

Q. Okay. So it says:

"DR. KONIKOW: So then the question is how do you go, you'll calculate a mass, but then how do you go back in time and use that to estimate what the mass loading rate is over the duration of the model? The Tarawa Terrace situation you had essentially a point source with a known location and a fairly constant -- constant over time disposal rate. Here I'm not sure how you're going to reconstruct the history of mass loading."

You're referring to Hadnot Point and Holcomb Boulevard; right?

A. I believe so.

Q. Why are you not sure how they're going to reconstruct the history of mass loading at Hadnot Point and Holcomb Boulevard?

A. Well, I wasn't sure because there were multiple sources. There was very little record. There were underground storage tanks that were leaking. They could discover where they were but not necessarily when they started leaking.

There were aboveground storage tanks. There were poor practices in industrial facilities. There was -- there were, you know, just multiple potential sources, and this was a logical question, I thought. How are you going to reconstruct it?

Well, I mean, they went ahead and reconstructed it, and they documented the methods they used and, you know, I mean, they did it. There's uncertainty associated with that.

MR. ANWAR: All right. Okay.

I'm going to hand you a different exhibit. Fortunately, it's another one of these big transcripts. I am marking this exhibit as Exhibit 16.

(Document marked for identification as Konikow Exhibit 16.)

BY MR. ANWAR:

Q. Now, in your report, quickly jumping back to Exhibit 2, on page 9, it is -- yeah, on page 9, you include a graphic F16 from the Tarawa Terrace reports.

Do you see that there?

A. Yes.

Q. Why did you include that graphic?

A. (Reviews document.)

Well, reading back, it looks like Dr. Spiliotopoulos included that in his report, and I wanted to discuss it. So I thought it might be of value. I didn't include too many figures in my report, but this is one I thought was worth including.

It --

Q. Go ahead.

A. Do you want me to comment on that

figure or...

Q. Sure.

A. Well, as I say here, he's commonly talking about the model being biased high or that the estimates were biased high in it. You know, I think he, you know, sort of cherry-picking results that emphasize that and ignoring the results that might counter it.

To me this, the figure that apparently he used in his report, is really the kind of results you want to see. The simulated results at the time of five of these observations falls right about a level of 800 when the observations range from about -- I don't know -- 3 or 30 up to about almost 1600. That is the simulated value falls right in the middle of that range, and to me that's a good estimate of -- a good illustration of where the model is doing a really good job.

It's -- that's, you know, when you're faced with the variability in the observed data over such a short time at one point in time, which sometimes it's hard to explain but, nevertheless, there it is. You can't expect the model with monthly time steps to match every single one of those values. You want it to match the central tendency of those values, and that it did almost perfectly.

Q. Is it your opinion that this F16 figure shows a well-calibrated model?

A. Well, that it seems to be. It certainly is not evidence of anything being biased high.

And one of the things to note is that this is the record at TT-26, which was the most important water supply well in terms of contributing contaminants to the Water Treatment Plant.

If you could have said, without seeing the simulated results, where would you have wanted the model to be at that point in time, I would say right at 800.

Q. And so it's your opinion that -- just to be clear, it's your opinion that Figure 16 shows TT-26 at least -- let me -- let me ask that again.

Is it your opinion that with respect to TT-26 the model -- this figure demonstrates the model is calibrated well?

A. At least at that point. Again, it doesn't prove there's a perfect match everywhere. It's just at this point, boy, you couldn't do any better. That's an important point. That location is an important location.

Q. Okay. Let's -- is it your opinion that ATSDR's Tarawa Terrace model does not overestimate contaminant concentrations?

A. I think there was evidence at some locations that it was too high, particularly TT-23. It was not a good match at that location, but in, you know, it's a model. You know, calibration yields some, you know, it's a best fit. Best fit by definition means at some point it's too high. At some points it's too low.

In this case, you know, for the Tarawa Terrace model, I think, you know, that's certainly true. In some places, it's too high. In some places, it's too low. It may be a little too high at more places than you'd like. So there is a slight, but I think it's not. I think Spiliotopoulos overstated the degree to which it overestimates.

Q. Turning back to -- I forget -- Exhibit 16, which is the transcript I handed you. This is day 2 of the transcript -- excuse me.
This is the transcript for day 2 of the 2009 expert panel.
A. Yes.
Q. Do you see that?
A. Yes.
Q. Okay. It's dated April 30, 2009; correct?
A. Yes.
Q. Okay. If you turn to page 216 in the transcript.
A. 2-1-6?
Q. Correct.
Are you there?
A. Yes.
Q. Okay. Your name is highlighted there in the middle starting on line 5.
A. Yes.
Q. It states:
"You kind of mentioned earlier that you have quite a lot of variability over short periods of time in the observed concentration."

Which is what I think you were just talking about?
A. Yes.
Q. And the next line is:
"That's really going to be a big obstacle to calibrating the model."
Did I read that correctly?
A. That's what I said at the time.
Q. Okay. And those are your words; correct?
A. Apparently.
Q. And Mr. Faye responds:
"It was and it is."
And you respond:
"Look at Figure F-16" the one we just discussed in your report. You say:
"Look at Figure F-16 in your Tarawa Terrace report. You have this simulated curve that's coming up, a nice smooth curve, and then there's one point in, I guess, 1985, where you have five frequently, sampled -- you have five frequently, samples collected over a short period of time."
And then you go on to say:

"And they have a range much greater than the long period of the --"

And then Mr. Faye cuts you off:

"I know. I know, Lenny. Let me make a comment on that. In part -- in part of my comment I'll reference, for example, the Table C-7, if you want to check that out."

And then he goes on to explain a lot the reasons for variability of concentration data.

I just wanted to confirm it.

As -- as of the 2009 expert panel, it was your belief that the figure that we were looking at demonstrated that calibrating the model was going to -- it was going to be a big obstacle to calibrate the model; right?

MR. DEAN: Objection to the form.

Read the next few pages of the transcript for him in context, not just a section on it.

MS. BAUGHMAN: You can read as much of it as you want before you answer.

BY MR. ANWAR:

Q. Well, let me ask this.

A.   Okay.
Q.   On page 216, the quote from lines 5 to 9, those are your words; right?
A.   Yes.
Q.   Okay. That's -- we can move on from that.
A.   I assume I was talking about the Hadnot Point/Holcomb Boulevard model there.
Q.   Why do you assume you were talking about the --
A.   Because this was an expert panel on the Hadnot Point/Holcomb Boulevard model.
Q.   Why would you immediately then refer to F16?
A.   By "immediate," I'm not sure what you mean by immediately, but this is page 216 on the second day. So it wasn't immediate.
Q.   No. I guess I mean: You make the comment about being a big obstacle to calibrating the model. Mr. Faye responds "It was and it is" and then you say "Look at F-16 in your Tarawa Terrace report."
A.   That refers to Tarawa Terrace.
Q.   Okay.

A. I can't -- I can't say that the previous comment was about Tarawa Terrace.

Q. Okay. So the -- the obstacle to calibrating the model was at Hadnot Point/Holcomb Boulevard?

A. I --

MR. DEAN: Object to the form.

THE WITNESS: I'm not sure, but that's -- without reading back, I think that's what we were talking about, but I'm not positive.

BY MR. ANWAR:

Q. Okay. Fair enough.

MS. BAUGHMAN: Just for the record, he didn't have time to read the pages before and after for context.

MR. ANWAR: The record may reflect that.

I'm going to hand you what I'm marking as Exhibit 17.

(Document marked for identification as Konikow Exhibit 17.)

THE WITNESS: Thank you.

BY MR. ANWAR:

Q. Exhibit 17 is a copy of Chapter F for the Tarawa Terrace model; correct?
A. Yes.
Q. And so I wanted you to turn to page 33. It's page F33, and on page F33 there's a figure, Figure F12; correct?
A. Yes.
Q. And Figure F12 is comparing observed PCE concentration versus simulated PCE concentration for the Tarawa Terrace model; correct?
A. Yes.
Q. And would you agree that Figure F12 shows the model to be overpredicting PCE concentrations?
MR. DEAN: Object to form.
THE WITNESS: I would agree that there are more data points above the solid line than below it, but what I would note is that at the real critical important high concentrations, the fit is very good.
I would also note that there are many or at least several duplicative

samples in here that really present a little bit of an unfair picture in that they're, you know, they reflect samples collected within a day or two at the same location and, therefore, shouldn't be plotted in a way that seems to give equal weight to each value.

BY MR. ANWAR:

Q. If you --

A. I think I discuss that in my expert report.

Q. But you would agree that F12 demonstrates that the model overpredicts. TT model is overpredicting; correct?

MR. DEAN: Object to form. Asked and answered.

THE WITNESS: It's a limited number of points. There are some points there that probably shouldn't be there. It doesn't include the agreement at locations or for data points where there were non-detects reported.

But in terms of what's shown in Figure 12, there are more data points above, but that's not -- this is just for a limited number of observation points. It's not a reflection of the reasonableness of the whole model.

BY MR. ANWAR:

Q. Would you agree that calibration targets are subjective?

A. Targets?

Q. Yeah.

A. I would say so.

Q. And then, therefore, whether a model is calibrated is a subjective assessment as well?

A. Partly subjective. I mean, as a hydrogeologist, you would have a good sense as to whether or not you have a reasonable calibration, but that assessment is certainly at least in part subjective.

Q. What does the location of the observed concentrations relative to the line in Figure 12 tell you about the calibration and the fit of observed versus simulated concentrations?

A. Tells me at the high concentrations, the model did a really good job. Knowing some of the basis of some of the data, I think some of the points probably should be lumped together and not shown as separate independent points. They're not independent samples.

It's a very -- relative to the number of calculations done in the model, this is an extremely, extremely small sample. But that's part of the problem that there just aren't that many observed concentrations certainly over time.

But yeah, I -- yeah, I mean, this table shows more values above that line of a perfect match than below it.

Q. And there in the text right above the last paragraph on F33, it says:

"Both results indicate that simulated PCE concentrations moderately to substantially overpredicted observed concentrations at water-supply wells."

Correct?

A. That's what it says.

Q. Okay. So ATSDR in its report indicated that the PCE concentrations were moderately to substantially overpredicted, right, at the water supply wells?

A. Well, what they said what you read

there. I would argue that they themselves gave equal weight to those points, and I argue in my expert report I point out that they should really consider the overall accuracy at each of the observation wells, which gives you a different picture. Not a perfect picture, but it gives you a different picture of the nature of the overprediction and the calibration.

And in my expert -- expert report, I think pointed out at 73 percent of the locations, the fit was within their calibration targets as opposed to the image given by in the report itself and as pointed out by Dr. Spiliotopoulos.

Q. Did you say 73 percent fell within the calibration standard?

A. In terms of the location, the individual wells. I can look in the report and see exactly what I said, but I think that's what I said.

Q. Okay. It's okay.

A. Yeah.

Q. We can -- we can come back to that.

Would you agree that groundwater data gets more independent the further apart the data sets are in time?

MR. DEAN: Object to form.

THE WITNESS: I'm not sure I understand the question.

BY MR. ANWAR:

Q. Okay. Scratch that. We'll come back to that.

I guess the reference to that -- so let me -- let me backtrack to that -- that last question quickly.

I think you said -- and you correct me if I'm wrong -- that data points are -- the data points for -- it was F16 that we were looking at -- were not independent because they were too close in time; correct?

A. I don't remember if I said that they weren't independent. I said, you know, in Figure -- F-16 we're talking about?

Q. Correct.

A. I said they're close in time and they have a very large spread or a large variance in the values. The individual. The five values that are collected at this scale it looks like within a few days or so of each other show a large range in concentration from close to 1600 to, you know, 10 or 20 or 30, very low value.

And that's a degree of change that I would not have expected in such a short period of time in the same location, and yet there it is. So I don't doubt that it happened. It's certainly been observed in other areas where you get such a big change in concentration.

So I don't understand the reference to independence, but each of those five samples were collected at the same location at slightly different times and they showed widely varying values.

MR. ANWAR: Okay. I'm going to hand you what is being marked as Exhibit 18.

(Document marked for identification as Konikow Exhibit 18.)

BY MR. ANWAR:

Q. This is an article that you published in "Groundwater" in 1986; right?

A. Yes.

Q. It's entitled "Predictive Accuracy of a Ground-Water Model - Lessons from a

Postaudit"?

A. Yes.

Q. I just had a couple questions about this article.

A. Okay.

Q. If you could turn to page 178.

A. 178?

Q. Correct.

A. Okay.

Q. There is Figure 8 there.

A. Yes.

Q. And you describe it as:

"Relation between predicted and observed changes in water level in the Tempe-Mesa-Chandler area of the Salt River basin, Arizona, 1964 to '74. Solid line shows where predicted equals observed values."

Did I read that correctly?

A. Yes.

Q. Okay. And it's very similar to -- understandably different site, different model, but the presentation itself is very similar to the figures we just looked at for -- for Tarawa Terrace; correct?

MR. DEAN: Objection to form.
THE WITNESS: In a certain sense, yeah.
BY MR. ANWAR:
Q. It's comparing observed versus predicted --
A. Yeah.
Q. -- values?
A. Yeah.
Q. And so if you -- underneath there, there is text under Assessment and Prediction. Second paragraph states:
"The relationship between the predicted and observed changes in water levels is illustrated in Figure 8. If the predictions were relatively accurate, the data should plot along (or close to) the 45 degree line connecting equal values of predicted and observed changes. Instead, data from all but three wells fall below that line, indicating poor accuracy and the presence of bias in the model predictions."
Did I read that correctly?
A. Yes.
Q. And in this article, you stated that

the model indicated poor accuracy due to the fit of the simulated concentrations, the observed versus simulated on the line; is that right?

A. Can you say that again?

Q. Sure.

In this article, you said because the simulated or predicted values fell below the 45 degree line --

A. Yes.

Q. -- that it indicated poor accuracy and presence of bias in the model predictions; correct?

A. Yes.

Q. And why is that?

A. The scatter was very large and the magnitude of the errors of the differences was very large. Much larger than in the example from Tarawa Terrace.

Here you have where the observed water level -- let's see -- some of the points where it's observed at zero change, they observed a drawdown or a negative change of more than 160 feet.

And errors in the groundwater flow

model, you know, more than 50 feet to 100 feet is really large, and here there were quite a few that were really very large in terms of the magnitude of the error. But, you know, clearly, you know, this would reflect a bias.

Q. Okay. Those -- those are the questions I have about that document.

Let's take a quick two-minute break. Thank you.

A. Sure.

THE VIDEOGRAPHER: We're going off the record. The time is 4:54.

(A recess was taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 5:01 PM.

BY MR. ANWAR:

Q. We're back on the record from a short break.

Dr. Konikow, are you okay to continue?

A. Yes.

Q. Okay. I wanted to ask you a couple questions about -- about each of the two models.

So for Tarawa Terrace, ATSDR used a

simple mixing flow-weighted average model to compute PCE concentrations delivered to the Tarawa Terrace Water Treatment Plant; right?

A. Yes.

Q. And that was from all active supply wells and subsequently to the Tarawa Terrace water supply network.

Does that sound right to you?

A. That sounds right, yes.

Q. Okay. And they did the same thing for Hadnot Point, correct, used a simple mixing model?

A. I believe that's what they did.

Q. And so you'd agree that ATSDR didn't model -- or strike that. Let me ask.

You'd agree that neither the Tarawa Terrace nor the Hadnot Point/Holcomb Boulevard models included calculations for contaminant losses during storage treatment or distribution; right?

A. I believe so.

Q. Meaning you'd agree?

A. Yes.

Q. Okay. So the models don't take

into -- neither Tarawa Terrace model nor the Hadnot Point/Holcomb Boulevard model take into account VOC losses during the water distribution process; correct?

A. My recollection of the expert peer panels is that there were experts there in volatilization and water treatment processes, and they stated, as best I could recollect, that there was not significant volatilization or losses of the VOCs for these particular water treatment plants. And so seemed to me as an expert reviewer of the work that that seemed like a reasonable assumption.

Q. So -- so the models don't take into account VOC losses; correct?

A. The inference was that there are no VOC losses to account for.

Q. So they don't take into account losses that they don't account for; correct?

MR. DEAN: Object to the form.

THE WITNESS: They don't take into account losses that don't exist.

BY MR. ANWAR:

Q. Okay. I think earlier you mentioned

reviewing Sabatini's rebuttal report; correct?
A. Let's say I read it. I, you know, in the sense reviewing it in the sense of having read it, but it was not a technical review of Sabatini's report.
Q. And Dr. Sabatini acknowledges that VOC losses do occur in the water distribution process; right?
A. Very small. You know, he was talking about maybe, as I recall, maybe a 6 percent loss, but it was -- he implied that this was pretty negligible, as I recall.
Q. And you would agree whether it's 6 percent, or some other number, the ATSDR models don't take into account those losses; correct?
A. The groundwater flow and solute transport models that I reviewed did not include the Water Treatment Plant. So what was done to the water distribution model I did not look closely at, but I know that they did not include a volatilization loss in that model.
You know, the data from the Water Treatment Plant, in effect, they were computing what it was, but that didn't go into the model

calibration. It really was a -- I mean, what they ended up doing in the end is increasing the confidence in the groundwater flow and transport models because there was a pretty good match between their estimated concentrations in the Water Treatment Plant and what was actually observed there. So, but that was without considering volatilization.

Q. Okay. Thank you.

I wanted to talk to you a little bit about the retardation factor. You addressed that?

A. Yeah.

Q. You addressed some of Dr. Spiliotopoulos's -- Spiliotopoulos's -- it's been a long day --

A. Yeah.

Q. -- opinions --

A. Yes.

Q. -- about the retardation factor and the variables in calculating the retardation factor; correct?

A. Yes.

Q. Okay. Can you explain to me what a retardation factor is?

A. Okay. The retardation factor reflects that some constituents, like PCE, are somewhat reactive with the solid grains of the aquifer, and they would tend to sorb or ion exchange onto the solid grains.

This means as a net, the net average velocity -- because of sorption and desorption reaction going on, the net velocity of that constituent can be slower than the net average velocity of the water itself.

So you could constituent, you know, it's moving in with the groundwater due to advection. It's spreading a little due to dispersion. But at the same time, some of it gets sorbed and some keeps moving. And then that sorb thing may come off again, desorb and then start moving.

And the net effect of all the sorption, desorption, ion exchange, all the other things going on, reactions or the complex reactions, the net effect is assume that you can on the average represent it with a retardation factor that really represents the ratio of the average velocity of the constituent to the average velocity of the water. So that if a retardation factor is 3, the constituent moves at one-third the velocity of the water.

Q. Okay. Would it be fair to say the higher -- and you should correct me if I'm misunderstanding this -- but the higher the retardation factor, the longer it takes for the contaminant to travel through the water or the subsurface in the water?

A. I think that's fair.

Q. Okay. And the same sort of relationship exists between bulk density, which is a variable of the retardation factor; correct?

A. I'm not sure I understand the question.

MR. DEAN: Object to form.

BY MR. ANWAR:

Q. Sure.

So bulk density is a variable of the calculation for the retardation factor; correct?

MR. DEAN: Object to form.

THE WITNESS: It's one of the factors that go into estimating the retardation factor if you want to calculate it based on other factors. I mean, it really comes down to the fact that the retardation factor is a component of the transport equation.

The bulk density, the KD, and the other terms in there are not directly in the governing equation. They're not in the model.

The model kind of externally, you know, it asks for input of KD and bulk density, and then it calculates the retardation factor, and then the solution of the transport equation is based on the retardation factor.

So the, you know, the bottom line is that, you know, the parameter to be calibrated on, the parameter to be estimated really is the retardation factor, not -- not individual estimates of bulk density or KD.

BY MR. ANWAR:

Q. I guess what I was getting at is: If the bulk density increases, doesn't the retardation factor necessarily increase as well,

assuming the other variables remain constant, KD and --
A. Well, sure, but you can't assume that. You know, again, it's -- the parameter that counts is RF. So, you know, for the calibrated model, if you want to say the bulk density is higher, you have to say the KD is lower in a compensating way.
Q. Okay. Dr. Spiliotopoulos pointed out to two errors in ATSDR's Tarawa Terrace model in calculating the retardation factor; correct?
A. He pointed out an error in estimating the bulk density using a wet bulk density instead of a dry. That, and I think they acknowledged. They agreed that that was an error.
Q. And didn't he point out an error in KD as well?
A. I don't recall that but that's...
Q. So if we go to page 10 of your report.
A. Okay.
Q. In the middle of the page under the first paragraph of Opinion 3, middle paragraph you talk about the error that Dr. Spiliotopoulos

caught relating to bulk density, correct, for bulk density?
A. Yes.
Q. Okay. I think maybe I'm misremembering.
But in any event, the middle of the page a little further down it says:
"However, as Dr. Spiliotopoulos himself admits, this significant impact on RF does not actually occur because the calibration process compensates for an overestimate of PB by estimating a value for KD that appears to be too low. Recall that neither of these two parameters are used directly in the transfer model."
Did I read that correctly?
A. Yes.
Q. And so I think what -- if I'm understanding you, you acknowledge that the bulk density was overestimated; correct?
A. And I'm also saying it didn't make any difference.
Q. I understand that.
But you agree that the bulk density was overestimated; correct?

A. Yes, for the Tarawa Terrace.
Q. And you agree that the KD was too low; correct?
A. Well, in the sense that the model was calibrated to RF, and so if row B was too high, then KD had to be too low. This is the whole concept of compensating errors. That's the essence of a model calibration.
Q. But the errors exist is my point; correct?
A. Yes.
Q. And I understand that it's your opinion that they offset each other, so it's not an issue; correct?
A. Well, I think it's -- yeah, it's my opinion. It would also be the opinion of others.
Q. Now, the values used for -- the parameter values used for the retardation factor calculation -- and I think you acknowledge this in your report. I can find the precise place if I need to.
But the values -- the parameter values used to calculate the retardation factor differ between the Tarawa Terrace model and the

Hadnot Point/Holcomb Boulevard model; correct?

A. I believe there was a small difference. Yeah. I think one was 2.9 and the other is 3.3 or something on that order. A small difference but, yeah, a difference.

Q. And that's even though Tarawa Terrace and Hadnot Point were both on Camp Lejeune; correct?

A. Nothing wrong with that. That's a small difference. If you look at the hydraulic conductivity maps, you see much bigger differences over much shorter distances. This is not unexpected in a geologic environment or geologic framework.

Q. And I can pull out the report if you need me to show it to you, but ATSDR states in its report in the Hadnot Point/Holcomb Boulevard study that -- excuse me -- it states in -- yeah, in the Hadnot Point report, Holcomb Boulevard report that sorption in the Hadnot Point/Holcomb Boulevard study area is assumed to be similar to sorption in the study area of -- for Tarawa Terrace.

A. In terms of the process?

Q. Okay.

A. Yeah.
MS. BAUGHMAN: Object to the -- you didn't show him the document, right? You need to show him the document before he answers that.
THE WITNESS: So I think -- I mean, it sounds to me like you're saying they're saying sorption process is sorption process in both areas.
BY MR. ANWAR:
Q. Okay. And wouldn't that dictate that the parameter values for -- wouldn't that suggest that the parameter values between Tarawa Terrace and Hadnot Point/Holcomb -- and Holcomb Boulevard should -- should --
A. Be the same?
Q. -- be similar, the same?
A. Well, they are similar, but they're not the same, and it does not imply that they would be identical.
Q. Okay.
A. Or necessarily close. I mean, again, if you look at the hydraulic conductivity map, for which there are a fair number of aquifer

tests and slug tests and so on, you find much better. You see a much bigger variability between Tarawa Terrace and Hadnot Point in terms of the precise estimates of hydraulic conductivity. Another important parameter.

MR. ANWAR: Okay. I'm going to hand you what I'm marking as Exhibit 19.

(Document marked for identification as Konikow Exhibit 19.)

BY MR. ANWAR:

Q. This is one of the documents that was produced to us last night that was in your possession --

A. Yeah.

Q. -- Dr. Konikow; is that right?

A. That's correct.

Q. Okay. And it is a letter to you from Morris Maslia on behalf of ATSDR providing Mr. Maslia or I guess -- yeah -- ATSDR's responses to your review comments; correct?

A. It's Bob Faye's responses.

Q. Bob Faye's responses. Okay. Thank you.

And I think earlier you had indicated that -- we had a discussion about the issues you raised with respect to limited data for both the models that ATSDR performed and other concerns that were raised, and I think you said that you reviewed the reports recently and those issues had been addressed; correct?

A. The issues had been addressed, and I think some of the details of those are expressed by Bob Faye in this response letter.

Q. Now, in this response letter, Bob Faye, on behalf of ATSDR, doesn't agree with all of the concerns that were expressed; correct?

A. That's correct. That's normal.

Q. And so is it your testimony that this response or this response along with your recent review of the ATSDR reports is what satisfies your -- your belief that the -- your concerns were addressed?

A. Yeah, I think they -- I think they seriously considered every comment and suggestion that I had made and that the expert panel had made, but that doesn't mean they have to accept every one. It's just that I think they did

seriously consider every one of them.
And, again, you know, they're the ones who worked for years on the site. I only looked at it for a few hours.
Q. The major concerns that are listed here, are these the major concerns you raised?
A. This is an outcome of my review of the Chapter F draft report. So yeah, these are issues that I raised, I believe.
Q. And number 1 there is:
"The lumping of two aquifers and one confining unit into the superficial model layer 1."
Correct?
A. Correct.
Q. What was your concern? What was the concern you raised there?
A. Well, I was concerned that -- I mean, it's always -- in developing a model, there's always a conflict between lumping and dividing in a general sense, you know. How much do you want to lump? How much do you want to divide?
My concern was that if there was a

continuous low permeability confining layer lumped in the middle of a single model layer, it might not adequately reflect the vertical velocities through the system.

The responses were, I think, alleviated my concerns, pointing out that the material above the confining layer was generally typically for most of the time unsaturated and really would not be included in the model, and if it had been, would have generated numerical difficulties.

They pointed out that the confining layer is discontinuous, that it's sandy, and that material would -- there was good hydraulic connection through that layer.

And considering everything, I thought, okay, that's a reasonable explanation.

Q. Okay. Is there any part of Robert Faye's response to your concern number 1, major concern number 1 that you disagree with?

A. (Reviews document.)

No. It's an explanation of things that I hadn't fully appreciated at the time I did the review.

Q. Number 2 of your major concerns:
"The use of a finite-difference method to solve the governing transport equation (which causes substantial numerical dispersion, especially if time steps are too large)."
What was your concern there?
A. My concern was that just the finite-difference numerical solution itself can cause calculated concentrations to increase, to spread where it's not related to the physical process of dispersion, and that was my concern. That's a recognized issue sometimes with the finite-difference numerical method for solving the transport equation.
So that was a concern. I think it was a reasonable concern to make sure that they had considered this, evaluated it, and that it wasn't a significant issue.
Q. Did this response satisfy you?
A. Yes. The response, I mean, I think it pointed out that they did carefully consider the Peclet number and the Courant number and that they did testing for grid spacing and time stepping.

Some of this is shown on page 16 where they compared calculations at two wells at three different times for using a one day time step compared with their one month time step that was actually used in the model, and it's an incredibly small difference.

So that is telling me that this is not a problem. It's not an issue. I mean, the differences are in the, you know, 4th significant figure, which is just --

Q. The first --

A. -- not one to be concerned with.

Q. The first sentence of the response to number 2 about the finite -- finite-difference method is:

"First of all the reviewer probably has no idea whether or not using a code based on finite-difference methods caused substantial -- 'substantial' or insubstantial numerical dispersion during solution of the Tarawa Terrace fate and transport model."

Would you agree that you had no idea whether or not using a code based on finite-difference methods caused "substantial" or insubstantial numerical dispersion during solution of the Tarawa Terrace fate and transport model?

A. For the case of the Tarawa Terrace model, I did not know whether or not it caused substantial numerical dispersion, which is why I was -- and I suspected he didn't know either, and this is why I brought the issue up.

Because in the literature, the issue of numerical dispersion related to finite-difference solutions is in the literature, and that it can under certain circumstances cause substantial numerical dispersion.

By "substantial" I'm not sure exactly what that means, but it can cause numerical dispersion due to the solving of the equation rather than due to the physical processes. This is a recognized issue in solute transport modeling and solving the equation.

As a reviewer, I felt he had to -- because they were using the finite-difference method, I felt he had to address it more carefully than he had.

Q. Okay. Number 3 on the next page, page 4 states:

"The reliability of the estimate of the biodegradation rate constant based on the assumption that concentration declines observed at one location over a period of several years can be explained solely by biodegradation."

What was your concern there?

A. I don't remember all the details of that concern, but I think the way they estimated biodegradation rates. I'm not positive. I think they looked at some condition where the concentration decreased over time, and they used that as a basis for estimating the degradation rate.

And I was raising a concern that how well could they isolate the degradation due to biodegradation versus a reduction in concentration due to advection and dispersion, and, you know, I don't remember in detail what -- how they actually did that calculation. I just don't remember.

Q. And the first line of the response there on number 3 is:

"The authors never claimed that the biodegradation rate computed using field data was reliable or the sole reason for the observed

decline in PCE concentration."
Did I read that correctly?
A. Yes.
Q. So is Robert Faye saying here that the biodegradation rate computed using field data wasn't reliable?
MR. DEAN: Object to form.
THE WITNESS: What I think the implication is, the bottom line is that he's saying that it's a parameter that had to be estimated with the calibration process. It's a parameter, just like the retardation factor.
It's a parameter that you couldn't rely completely on the calculation. You had to use it as a parameter in the calibration method.
It's a parameter that had to be estimated just like the retardation factor, and you adjust the values of these within some reasonable range to yield the best fit for the overall simulation.
And I think what he's saying

here is that he recognizes that this is a parameter to be adjusted during the calibration.

BY MR. ANWAR:

Q. To your knowledge, did ATSDR test higher biodegradation rates for TT, for Tarawa Terrace?

A. I believe they did.

Q. Did you evaluate the range of biodegradation rates that ATSDR considered?

A. I -- I'm sure I looked at it, but I didn't do a detailed evaluation of it. I'm pretty sure I did not, but I think certainly at the time I did the review, I was aware of what they did.

Q. Do you recall the biodegradation rate that they ended up using for Tarawa Terrace?

A. Yeah. Yeah. I mean, here they're talking about .0005 in that range, and so I assume they went up and down from 0005 to a higher value and a lower value. I don't recall exactly what the range was.

Q. Number 4 on page 4 states:

"The exclusion of concentration data collected in monitoring wells from the calibration basis."

Why was it a major concern to you to exclude concentration data collected in monitoring wells for calibration?

A. I'm not sure if it was a major concern compared with some other things. It was a concern, and I didn't understand why if they had concentration data from a monitoring well or from a point, why they would not use that in the calibration.

I'm -- I'm, you know, he gave an answer, but I'm still not sure why. If I was doing it, I probably would have used those values, with the recognition that it's a sample from a point rather than a pumping well that brings in lots of water.

So I think that was kind of his basis for not using it is that it was sampling an extremely small volume of the aquifer.

I would have, you know, I, you know, if I was doing it, I would say, well, it's still a point within the volume and I would have -- I would have looked at it and, you know, I might -- unless I saw some reason not to, I would have used it in the calibration.

But he had a reason for not and, you know, we may disagree on that.

Q. Okay. So that may be at least one area where you disagree in terms of these comments?

A. Well, to some extent. You know, it's certainly not a fatal flaw in the calibration. It's a -- it's his way of looking at it and I, you know, he had experience in the area. He worked it for years.

I only, you know, spent two days reviewing it. So, you know, that's -- I didn't have the hands-on experience he did, but -- but from what I, you know, I probably would have used the monitoring well data as part of the calibration.

Q. Okay. The number 5 there on page 5 identifies as a concern that you had:

"The use of a much larger mass loading rate than apparently was indicated by the field data in order to improve model calibration."

Tell me about that concern.

A. I don't remember the details of why

I said that. I can't remember.

Except that there must -- there probably was some indication or initial estimate of what the mass loading rate was, and it was adjusted in the model calibration to achieve the best fit, and that calibration indicated a much higher mass loading rate.

And, you know, it's -- it's an issue, again, I don't recall the details of.

Q. So Robert Faye in his response starts by saying:

"First of all please note that field data did not indicate a mass loading rate. The computations of PCE mass in the saturated and unsaturated zones described in the report were the result of a highly interpretative, somewhat subjective calculation using field data."

Do you see that there?

A. Yes.

Q. What is -- what was your reaction to that response to the concern you had expressed?

A. You know, I don't remember my reaction at the time but, you know, you're looking at it now. He's explaining what he did, maybe a

little more clearly than was in the report.
You know, he's saying that there's some subjectivity and approximations that went into that calculation, which itself is not surprising considering the nature of the sources.
Q. Did you disagree at all with the mass loading rate ATSDR chose to use?
A. Not per se, no. No.
Q. Do you disagree with the start date for contamination that ATSDR chose to use for Tarawa Terrace?
A. No, it seemed reasonable.
Q. Between the Tarawa Terrace model and the Hadnot Point and Holcomb Boulevard model, do you view one model as better or more accurate than the other?
MR. DEAN: Object to form.
THE WITNESS: Both models, I think, are reasonable, using well accepted state-of-the-art methods. I think both models are quite acceptable. I think their predictions are reasonable, with the recognition of uncertainty.
The Tarawa Terrace model

clearly had a better defined source term and that, you know, probably yields a little more confidence in that model. A little more confidence in the results.

But the numerical solutions I think are good numerical solutions in both cases given the assumptions about the stresses on the system and the parameters.

I mean, they're basically the same model in the sense that they're both using MODFLOW and MT3D, which are both good models.

BY MR. ANWAR:

Q. The Hadnot Point/Holcomb Boulevard site was more complex to model than Tarawa Terrace; right?

A. In the sense of source terms and mass loading, yes. Other than that, I think they're equivalent.

Q. There were more sources at Hadnot Point; correct?

A. Yes. Yes.

Q. There were -- were there more wells

to examine in Hadnot Point/Holcomb Boulevard?
A. Probably a few more. I think -- yeah, I think there were more. I don't recall the numbers, though, but...
Q. Was Hadnot Point/Holcomb Boulevard a generally larger area to model?
A. It was somewhat larger, yeah, and also they -- for the transport, they broke it down into two separate MT3D models. One focusing on the landfill area and another focusing on the industrial area. So there wasn't one MT3D model for the Hadnot Point/Holcomb Boulevard. There's one flow model.
Q. The Holcomb Boulevard/Hadnot Point model also included a water distribution model to simulate connections between Hadnot Point and Holcomb Boulevard; right?
A. I believe so.
Q. And that was an additional complexity introduced into the Hadnot Point/Holcomb Boulevard modeling; correct?
A. I guess you could say that. I don't think that was a major complexity, but yeah, it was an additional factor.

Q. Could you turn to page 10 of this document.
A. Okay.
Q. In the middle of the page, so page 46 to 49.
A. 59?
Q. 59. Excuse me. Thank you.
It looks like Robert Faye agrees with a suggestion you made, and it says "A sentence has been added to the report."
Do you see that?
A. Yes.
Q. And then underneath that, he discusses biodegradation rate again and he says:
"Disagree. This criticism was previously addressed under Major Concerns, item #3," which we just discussed. "The reviewer's suggestion to simulate PCE concentrations using a degradation rate of zero and adjust the field data by simulated changes is not accepted. Adjustments to field data using such simulated changes would not add any additional certainty -- any additional -- would -- excuse me -- adjustments to field data using such simulated changes would add

additional uncertainty to an already uncertain process."

Do you agree with what he's saying there?

A. I think it's a reasonable perspective and so, yeah, I certainly would accept that comment.

Q. You had suggested, according to this document, "to simulate PCE concentrations using a degradation rate of zero and adjust the field data by simulated change -- and adjust the field data by simulated changes."

What did you mean by that?

A. First of all, I don't remember precisely what I suggested. I don't have that original comment in front of me.

But just from what it says here, I'm assuming I had suggested whatever biodegradation rate he used, I said rerun it with zero and assess, you know, see what difference is. What -- what -- assess at least qualitatively what the impact of that biodegradation is.

But I don't recall it precisely or at all exactly what I said there, but it was a suggestion. He didn't. He disagreed, and I think that's fine.

Q. Okay. On -- if you skip down a couple of the page 59 comment.

A. Yeah.

Q. It says "Mass loading" and Robert Faye says:

"Disagree. See comments under Major Concerns, item #5. The reviewer seems to assign a high degree of accuracy and credibility to the PCE mass computation that is unwarranted. As explained previously, the computation of PCE mass was a highly interpretative and somewhat subjective -- highly interpretative and somewhat subjective process frequently based on questionable data."

Did I read that portion correctly?

A. You read it correctly.

Q. Do you have any understanding of what means when he says "the computation of PCE mass was a highly interpretative and somewhat subjective process frequently based on questionable data"?

MR. DEAN: Object to the form.

THE WITNESS: You know, I'm -- right now I'm not sure what he meant. I don't recall at the time if I understood what he meant. I'm just -- I'm just not sure.

Except that he's -- he's saying that the computation of PCE mass, there's a lot of uncertainty there seems to be what he's saying, and I certainly don't disagree with that.

I don't -- I don't recall assigning a high degree of accuracy to it, but he seems to imply that I did or at least he inferred that I did. I don't think I would have, but I don't know.

BY MR. ANWAR:

Q. That's what the document states; right?

A. Yeah.

Q. He goes on to say in the rest of that:

"Field data applied to the PCE mass computation were limited both spatially and vertically. The computation was accomplished regardless of data limitations to provide an estimate of a minimum mass loading rate to use to begin model calibration."

Is that right?

A. Okay. Tell me again which paragraph you're reading. The first paragraph on page 59 or the second one under that? Sorry. I lost track.

Q. No, it's okay. It's okay. I think you -- you addressed what I was asking you.

MR. ANWAR: Let's take a short break. I think I'm close to wrapped up. I just want to check my notes.

THE VIDEOGRAPHER: We're going off the record. The time is 5:43 PM.

(A recess was taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 5:51 PM.

BY MR. ANWAR:

Q. Okay. A few more questions for you, Dr. Konikow.

A. Okay.

Q. I appreciate you're willingness to speak with us. I know it's been a long day.

I wanted to ask you.

In terms of parameter estimation or determining parameters as inputs in the model, generally speaking, is it better -- is a parameter that reflects the real world better than one that doesn't?

A. That seems like a reasonable statement.

MR. ANWAR: Okay. Okay. I'm handing you what I'm marking as Exhibit 20.

(Document marked for identification as Konikow Exhibit 20.)

BY MR. ANWAR:

Q. And I will just represent to you that this is ATSDR's response to a critique that the Navy offered about the Tarawa Terrace modeling.

Have you seen this before?

A. Not that I recall.

Q. Okay. Did you review the Navy's critique of the Tarawa Terrace model in forming your -- the opinions in your rebuttal report?

A. No, I don't remember seeing this.

Q. Okay. If you could turn to

page -- I'm going to have to identify it by the Bates ranges. It's the page ending 33271.

A. Say that again.

Q. So at the bottom, there's a little Bates stamp that says "CLJA_WATERMODELING."

A. Yes.

Q. And then there's a number. It's the one at the end that says 33271.

A. 33271?

Q. Correct.

It's in the middle of the page, there is a comment from the Navy labeled 7.1.

Do you see that?

A. Yeah.

Q. Okay. And so I just wanted for context to provide you the -- or show you the comment that ATSDR was responding to.

The Navy stated:

"However, all comparisons did not fall within the calibration range. At the Water Treatment Plant, 12% of the simulated PCE concentrations failed the calibration standard ... at the water supply wells, a majority (53%) of the simulated concentrations fell outside of the

outside the calibration standard."
Did I read that correctly?
A. You read it correctly.
Q. Is that consistent with your understanding of the calibration for the Tarawa Terrace model?
MR. DEAN: Objection to the form of the question.
THE WITNESS: I'm not sure, but I've seen that 53 percent number, I think, in Alex Spiliotopoulos' in his report, and I disagree that that was a fair assessment of the accuracy.
BY MR. ANWAR:
Q. Okay. If you turn the page, ATSDR responds -- well, ATSDR starts responding on the prior page, but their response goes on to the next page.
So on the page ending 33272, I just wanted to ask you about a portion of their response.
A. Okay.
Q. The very last paragraph there states:

"To address the issue of the intended use of the water-modeling results by the current ATSDR epidemiological study, the Department of Navy should be advised that a successful epidemiological study places little emphasis on the actual (absolute) estimate of concentration and, rather, emphasizes the relative level of exposure. That is, exposed individuals are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to the true -- 'true' (measured) PCE concentration. This rank order of exposure level is preserved regardless of whether the mean or the upper or lower 95% of simulated levels are used to estimate the monthly average contaminant levels. It is not the goal of the ATSDR health study to infer which health effects occur at specific PCE concentrations -- this task is for risk assessment utilizing approaches such as meta-analysis to summarize evidence from several epidemiological studies because a single epidemiological study is generally insufficient to make this determination."

And then it goes on:
"The goal of the ATSDR epidemiological analysis is to evaluate exposure-response relationships to determine whether the risk for a specific disease increases as the level of the contaminant (either as a categorical variable or continuous variable) increases."
Did I read that correctly?
A. I think you read it correctly, yeah.
Q. What do you understand ATSDR to be saying in this response?
MR. DEAN: Object to the form of the question.
You want him to comment on what ATSDR is saying, right?
MR. ANWAR: Isn't that what he's doing anyway?
MR. DEAN: No. Object to form.
MR. ANWAR: That's his role as an expert.
THE WITNESS: I think what they're saying is that the exposure

levels are considered in terms of a ranking based on how -- where it is in the scale and that it's not based on the actual concentration value.

So it's like a high, low, medium or, you know, some -- something on that scale rather than 95.3 to 89.9 or anything like that.

So but, again, I'm, you know, I'm certainly not an expert in epidemiological studies, so I'm not sure what all the implications here are.

BY MR. ANWAR:

Q. It appears to me he's saying, for the purpose of a successful epidemiological study, at least the one ATSDR was conducting, and I'm quoting, it says:

"Places little emphasis on the actual (absolute) estimate of concentration" and then it goes on to say "regardless of how far off the estimated concentration is to the 'true' (measured) PCE concentration."

Based on that, it appears to me he's saying that for this model for the purpose that it was intended for in terms of providing information for epidemiological studies, it doesn't matter what the absolute concentrations levels are produced by the model and it doesn't matter if they're inaccurate.

Do you agree with that?

MR. DEAN: Object to the form.

THE WITNESS: Well, it depends what you mean by "inaccurate" because if you, you know, you still want it accurate in the sense of what's high is high and what's low is low, what's in the middle is in the middle.

You know, the actual concentration level we already know has uncertain -- that's computed we know has uncertainty associated with it.

So there's, you know, it's naturally going to be imprecise and, you know, you can't say it's going to be 99.5 micrograms per liter because it might be higher or lower because of all the uncertainty in the model.

But you certainly want

consistency in the model. You want the model to, you know, have a good mass balance. You want, you know, the numerical solution should be accurate for the conditions in terms of solving the equation.

I think all of those conditions are met.

What exactly they mean by a rank order I'm not precisely sure, but I would imply that some -- this is somehow related to exposure levels, but I don't completely understand that.

BY MR. ANWAR:

Q. Does this response change or inform anything that you've stated today about the -- the accuracy of the model predictions, the simulated contaminant concentrations produced by the ATSDR models?

A. No. No. I mean, I'm not evaluating the model from a perspective of the health exposure studies.

I'm evaluating it in terms of the solution to the equation for the initial conditions, the boundary conditions, the estimated parameters, and everything related to that.

So, you know, the concentrations in the Water Treatment Plant, to the best of my knowledge, were not used for the calibration but served as a way to increase confidence in the model.

These were computed by the mixing model that you mentioned a few minutes ago, which was really subsequent to the MT3D modeling.

So it's kind of like a next -- I wouldn't call it independent, but it's a -- it's a kind of standalone process that estimated the concentrations in the Water Treatment Plant based on what the computed results of the model.

And these were not part of the calibration, to my best recollection, but it certainly served to increase confidence in the model because those, you know, where they did have observed data, it generally looked reasonably good in terms of matching the -- you know, what this mixing model did to estimate the concentrations in many cases agreed closely with what was observed.

Q. Okay. As a -- those are the

questions I had about this document.

As a member of the National Academy of Engineering and as someone that has served on National Research Council committees in the past, were you aware that the National Research Council also issued a report on ATSDR's water modeling efforts?

A. I believe it was 2009?

Q. Correct.

A. Yes, I was aware of that.

Q. The report itself addressed sort of epidemiology -- epidemiological and broader issues, but there was a portion focused on --

A. Yeah.

Q. -- exposure assessment and the water modeling.

Were you aware of that?

A. I -- I read the charge of the committee, and the charge of the committee really focused on epidemiological studies and health effects. The charge to the committee did not -- actually did not mention the groundwater modeling at all, but obviously the groundwater modeling was what led to the estimates. So that was a legitimate domain for their discussions.

But, you know, the committee, I looked at the committee membership. You know, I think there were 10 or 11 members. There was only one who had any expertise in groundwater. The rest were medical and health effects and epidemiologist experts because that was the main charge to the committee.

Q. Who was the one expert that was the groundwater modeler?

A. Professor Clement.

Q. Okay. And what are your opinions about -- so let me back up.

Are you aware of what the NRC said about ATSDR's water modeling efforts?

A. I looked at that report. I don't recall their exact comments.

Q. Do you have any opinion about the National Research Council's comments on the ATSDR water modeling efforts?

A. I think I had a few comments because Spiliotopoulos made some comments about it. So I think I had some comments in my rebuttal report about it.

Q. Do you remember what those comments are?

(Mr. Dean no longer present).

A. I see that it's not a huge report. I can probably find it pretty quickly.

One of my comments was that of all the members of the panel, there was only one who was an expert in groundwater, and that's a really minority on an NRC panel.

What I recall about Clement publishing an article in "Groundwater" about model complexity, and he was using the case study of ATSDR, I presume based on his experience on the NRC panel, and he was critical of the ATSDR model and then that was in the published article.

Then Morris Maslia published a very detailed response that was published in the journal to his comments, and I thought he did an excellent job countering all of the criticisms.

And then Dr. Clement had a reply to the responses, in which the first thing he said was that "My analysis should not be considered a review of the ATSDR modeling," which to me countered everything he had said in the first article about what he did say was that the purpose of his article was to generate discussion about model complexity in general and he did not intend to, you know, as a criticism.

What he implied to me is that he did not do a technical in-depth, detailed review of the ATSDR models, which was very disappointing.

His response, the first words pretty much wanted to set aside any criticism and concern about the ATSDR models. He backed off of with what, I think, were his criticisms. He couldn't defend them.

Q. Do you -- do you know Professor -- I think is it -- Prabhakar Clement?

A. I have met him occasionally. I have had a few e-mail discussions with him. When I was an editor of "Groundwater Journal," he had submitted a discussion article and so we discussed that.

Q. Have you spoken with him at all about Camp Lejeune?

A. No, not that I recall. No, I don't think so.

Q. Do you have any opinion of Professor

Clement?

A. Not really. I don't know his work that well. He hasn't published as much as other people in the groundwater field, but I know he, you know, he certainly is trained as a groundwater specialist.

Q. And in order to -- to have served on the role on for the National Research Committee, he had to have been elected as a member of NRC by his peers; right? Or no?

A. No, absolutely not.

Q. Okay.

A. You -- most people who serve on NRC committees are not members of the Academy.

Q. Okay. Do you know if he is?

A. And all those committees that are, I was not a member of the Academy when I served on those committees, and most of the people on the committees were not members. So it's kind of two different things.

Q. Okay. Understood. That makes sense.

Do you by chance, do you know if he's been elected to --

A. I am 99.9 percent sure that he was not.

MR. ANWAR: Okay. I'm going to hand you one last exhibit.

(Document marked for identification as Konikow Exhibit 21.)

BY MR. ANWAR:

Q. Exhibit 21, and I'll just represent to you this is the chapter about "Exposure to Contaminants in Water Supplies at Camp Lejeune" from the NRC report. The larger report from -- from -- about Camp Lejeune.

Have you seen this before?

A. This is the 2009 report?

Q. Correct.

A. Well, I looked at the 2009 report, but I, you know, I don't specifically recall seeing this.

Q. Okay. I just wanted to ask you a few questions about --

A. Sure.

Q. -- some of the conclusions they made at the end.

If you turn to the second to last

page of the document. It's ending in 516.
A. Okay.
Q. The second paragraph states:
"ATSDR applied best practices and cutting-edge modeling approaches to predict the complex groundwater-contamination scenario at Tarawa Terrace."
Would you agree with that statement?
A. Yes, sounds like a compliment.
Q. "The ultimate outcome of the modeling was average monthly predictions of the concentrations of contaminants in the water supply to which people could have been exposed. Although ATSDR recognized and tried to account for the limitations and uncertainties associated with developing its models, it is extremely difficult to obtain quantitative estimates of historical levels of PCE -- excuse me -- exposure to PCE and its degradation products reliably on a monthly basis."
Do you agree with those statements?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Well, I mean, I

thought it was a challenging exercise and
difficult also, but they did it.
BY MR. ANWAR:
Q. It goes on to state:
"Reporting such model predictions without clear error bounds gives the impression that the exposure of former residents and workers at Tarawa Terrace during specific periods within a given year can be accurately defined."
Would you agree with that statement?
A. Well, I don't -- I disagree that the predictions were presented without clear error bounds. I thought pervasive in all the ATSDR reports was -- were discussions of error bounds, uncertainty, you know, how the results could vary under a different range of assumptions.
So I thought they did a nice job presenting clear error bounds.
Q. Can I ask you.
I guess for someone who may have been at Camp Lejeune, a former service member or a resident there, who was interested in looking at ATSDR's simulated concentrations, looked at the reports or turned to the reports.

Based on your experience, would a layperson be able to understand the concepts and the uncertainty analysis presented in ATSDR's report?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I'm not sure what a layperson would understand or get from it. I think it's just highly variable with a person depending on how much background they have in statistics and math and geology, if they have any background at all or how much. You know, I think that understandability in the public would be highly variable.

BY MR. ANWAR:

Q. "It is the committee's judgment" -- so this paragraph goes on.

"It is the committee's judgment that ATSDR's model is suitable only for estimating long-term exposure quality. From that perspective --"

MS. BAUGHMAN: Qualitatively.

MR. ANWAR: "Qualitatively."

Thank you. I'm sorry.

BY MR. ANWAR:

Q. I'll read that again.

"It is the committee's judgment that ATSDR's model is suitable only for estimating long-term exposure qualitatively. From that perspective, a single exposure category of 'exposed' appears to be applicable for persons residing or working at Tarawa Terrace at any time during 1957 to 1985."

Do you agree with that statement?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I -- I -- I don't. No, I don't think I do because, you know, you know, there they seem to be relating it to either exposed or not exposed and ignoring any of the scale of variability in the concentrations.

So I think the ATSDR models were better than that.

BY MR. ANWAR:

Q. Okay. That last paragraph on that portion says:

"Efforts at historical reconstruction of exposures at Hadnot Point will be even more problematic. The contamination scenario at Hadnot Point is so complex that the committee judges that only crude estimates of contaminant concentrations in the water supply can be obtained."

Do you agree with that statement?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Not completely and, again, I point out that before I served on the Hadnot Point/Holcomb Boulevard expert peer review panel, I was quite skeptical myself and, in that sense, at that time maybe I would have agreed with this statement.

But I learned a lot. They explained a lot. I saw the final reports. I think they did a good job modeling, a reasonable. Modeling results are reasonably reliable.

I think there's certainly more uncertainty there than probably in the

Tarawa Terrace model, but I think -- I think they were successful in putting together a reasonable model.

They explained all their assumptions and approximations, and there clearly are assumptions and approximations underlying the models, underlying that. So that, you know, it's there, but it's a good model.

BY MR. ANWAR:

Q. When we're talking about successful in terms of putting together a good model, ATSDR, do you think they were successful in putting together a good model for providing information to an epidemiology -- EPI study, epidemiological study?

MS. BAUGHMAN: Object to the form.

THE WITNESS: In recognition that the epidemiological study did not make an assessment based on the actual concentration level in the calibrated model, but rather a ranked form that kind of removes some of that.

But, you know, without any
understanding of their epidemiological
studies, it seemed like the output from
the models provided something that would
be useful for them.
BY MR. ANWAR:
Q. Okay. And when you say the model was successful, ATSDR was successful, and it was a good model, are you saying that it was successful and a good model for the purpose of estimating exposure in individuals?
A. I don't know.
MS. BAUGHMAN: Objection.
Form.
THE WITNESS: I don't know
how it was used for exposure. I didn't
look at the exposure studies or the
epidemiological studies. So I really
can't --
BY MR. ANWAR:
Q. Okay.
A. -- say.
Q. Last question.
Do you -- what -- what is your

opinion of Robert Faye?
A. Of Robert Faye?
Q. Yeah.
A. He seems to be a competent hydrogeologist, primarily in the, you know, in the practical application end of hydrogeology. He's not an academic in the sense of producing papers on research and theory, but I think he has a lot of experience and knowledge in terms of field applications, studies, the reality of geology and the hydrogeologic framework and the use of models.
Q. When is the last time you spoke to him?
A. Way more than 10 years ago.
Q. Okay. I really appreciate your time today and your patience with my questions. I think that's all I have. I'll pass the witness.
A. Thank you.

EXAMINATION

BY MS. BAUGHMAN:
Q. Dr. Konikow, I just have a few questions for you.
A. Yeah.
Q. You were just asking -- asked

questions about what you meant by successful in terms of the ATSDR models.

Do you have an opinion about whether ATSDR was successful in estimating the mean monthly concentrations of contaminants at Tarawa Terrace?

A. At Tarawa Terrace? I think those were reasonably reliable. Again, always reasonable in light of the uncertainty and the error bounds about it. I think the calibrated models were provided -- they were successful in providing estimates and in assessing the uncertainty in those estimates. So I think that, yeah, I would say they were successful.

Q. And do you have the same opinion for Hadnot Point?

A. I do. Again, there it was a more complicated problem and, you know, many people probably would have thrown their hands up and said, we can't do it. But they did it and, you know, I think the important thing is they carefully documented all of their assumptions, how they got at mass loading, pumping rates, pumping schedules, and assessing uncertainty in those as well as uncertainty -- assessing uncertainty in many of the physical parameters.

Q. Okay. If an end user wants to use the mean monthly concentrations for an epidemiology study versus an individual exposure, right, how if at all would that change -- (cell phone) -- let me -- let me start over.

If an end user wanted to use the mean monthly concentrations to estimate an individual's exposure as opposed to for purposes of an epidemiology study, how if at all would that change how the model would be developed?

And I'm asking you in your expertise as a hydrogeologist.

MR. ANWAR: Object to form.

BY MS. BAUGHMAN:

Q. In other words, if you're using the mean monthly concentrations for individual exposure as opposed to an epidemiology study, does that change how you develop the model?

A. It should not. You know, again, I think I said it earlier, maybe this morning.

But what the end user does or intends or wants really should have minimal impact on the development of the model, other than to make, you know, if the end user, who's paying for the model study, says, I need an estimate at this point in space, then, okay, you make sure that you calculate it at that point in space.

But the model itself should not be affected by the end use of it. In other words, the model should do the best job they can. Get the most accurate result they could. Calibrate the model, document the model and its accuracy, and then use the results whatever you want to use it.

Q. And just to be clear, if -- if a medical doctor wanted to use the mean monthly concentrations to calculate an individual's exposure as opposed to for some other purpose, like an epidemiology study, would that change how the hydrogeologist gets to what the mean monthly concentrations are?

MR. ANWAR: Object to form.

BY MS. BAUGHMAN:

Q. From a modeling perspective?

A. Should not, no.

Q. Okay.

A. I don't think it would.
Q. Okay. Is there a difference between the words "valid" and "validated" or "validation" in terms of hydrogeology and water modeling?
A. These are terms that not everyone agrees on their meaning or intent, but it's very common that just using the word "valid" by itself is generally okay. You're saying that it's appropriate for what it's being used for.
The word "validated" it has, I think, more of an implication that you've got the right model and you prove that you got the right model, and that's generally not accepted in science that, you know, for all the reasons in my published paper.
Q. So if when you use the phrase "scientifically valid," is that another way of saying that ATSDR adhered to generally accepted methodologies?
A. That's -- yeah. You're using standard practices, common practices, well accepted, well-documented methods and approaches that are well accepted, in other words, yeah.
MS. BAUGHMAN: Okay. Thank

you. I have no other questions for you.

MR. ANWAR: I have nothing either.

Thank you for your time today.

MS. BAUGHMAN: You're finished.

THE WITNESS: Okay. Thank you all.

THE VIDEOGRAPHER: Please stand by.

We're off the record at 6:23 PM. This concludes today's testimony given by Dr. Konikow.

(Signature not waived, the deposition concluded at 6:23 p.m.)

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DECLARATION UNDER PENALTY OF PERJURY

I declare under penalty of perjury that I have read the entire transcript of my Deposition taken in the captioned matter or the same has been read to me, and the same is true and accurate, save and except for changes and/or corrections, if any, as indicated by me on the DEPOSITION ERRATA SHEET hereof, with the understanding that I offer these changes as if still under oath.

Signed on the ______ day of ____________, 2024.

____
LEONARD KONIKOW, PHD

CERTIFICATE OF REPORTER

COMMONWEALTH OF VIRGINIA)

I, Denise Dobner Vickery, a Registered Court Reporter and Notary Public of the Commonwealth of Virginia, do hereby certify that the witness was first duly sworn by me.

I do further certify that the foregoing is a verbatim transcript of the testimony as taken stenographically by me at the time, place and on the date herein set forth, to the best of my ability.

I do further certify that I am neither a relative nor employee nor counsel of any of the parties to this action, and that I am neither a relative nor employee of such counsel, and that I am not financially interested in the outcome of this action.

DENISE DOBNER VICKERY, CRR,RMR
Notary Public in and for the
Commonwealth of Virginia

My Commission expires: March 31, 2026
Notary Registration No. 126014

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EXHIBIT 13

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION

IN RE: CAMP LEJEUNE)
WATER LITIGATION,)
)
Plaintiff,)
) No. 7:23-CV-00897
vs.)
)
UNITED STATES OF)
AMERICA,)
)
Defendant.)

VIDEOTAPED DEPOSITION OF: NORMAN L. JONES
FEBRUARY 14, 2025
9:13 A.M. TO 4:34 P.M.

Location: UNITED STATES ATTORNEY'S OFFICE
111 South Main Street, Suite 1800
Salt Lake City, Utah

Reporter: Vickie Larsen, CCR/RMR
Utah License No. 109887-7801
Nevada License No. 966
Notary Public in and for the State of Utah

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Also Present:

McKayla Largin, videographer

Present by Zoom:

Alanna Horan
Bill Williams
Dennis Reich
Deanna Havai
Tim Thompson
Morris Maslia
Jeffrey Davis
Allison O'Leary

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I N D E X

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E X H I B I T S

process-based models in
hydrology

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February 14, 2025 9:13 a.m.

P R O C E E D I N G S

THE VIDEOGRAPHER: Good morning. We are going on the record at 9:13 a.m. on February 14, 2025. This is Media 1 deposition recording of Dr. Norman Jones, In the Matter of Camp Lejeune Water Litigation filed in the District Court for the Eastern District of North Carolina, Case Number 7:23-CV-00897.

This deposition is being held at the Attorney General's Office in Salt Lake City, Utah.

My name is McKayla Largin. I'm the videographer. And Vickie Larsen is the court reporter.

Will counsel please state who they represent for the video record.

MR. ANTONUCCI: Giovanni Antonucci for the United States.

MS. SILVERSTEIN: Kailey Silverstein for the United States.

MR. ANWAR: Haroon Anwar for the United States.

MS. BAUGHMAN: Laura Baughman for the plaintiffs.

MS. BOLTON: Devin Bolton for the plaintiffs.

THE VIDEOGRAPHER: Will the court reporter please swear in the witness.

NORMAN L. JONES,

called as a witness, having been duly sworn, was examined and testified as follows:

EXAMINATION

BY MR. ANTONUCCI:

Q. All right. Good morning.

A. Good morning.

Q. Please state your full name.

A. Norman Lovell Jones.

Q. And can you please state your current address.

A. 4174 North 430 East, Provo, Utah.

Q. Well, good morning, Dr. Jones. My name is Giovanni Antonucci, as you just heard. I'm an attorney for the Department of Justice. I represent the United States in the Camp Lejeune Water Litigation that's currently pending in the District Court for the Eastern District of North Carolina.

Dr. Jones, have you ever had your deposition taken before?

A. Yes.

Q. How many times have you had your deposition taken before?

A. Once.

Q. And what was the nature of the case in which you were deposed?

A. I was the class representative on a class action lawsuit against the Traeger company. And I can't remember the exact date, a year and a half, two years ago, I had a seven-hour deposition as part of that.

Q. Is the Trager company the same company that manufactures grills?

A. Yes.

Q. Okay. All right. We'll come back to discuss that, but I'd like to get through a few more sort of ground rules, if that's all right with you.

A. Sure.

Q. So you just took an oath; right?

A. Right.
Q. Do you understand the nature of that oath?
A. Yes.
Q. That oath requires you to fully answer each question. If you're not sure of an answer or don't have a complete answer, you must still answer the question to the extent that you can.
Do you understand?
A. Yes.
Q. As you can see, a court reporter is taking down everything that we say. Because she can only record words, it's important that you answer questions verbally.
For example, you must say "yes" are or "no" rather than shaking or nodding your head. Do you agree to do that?
A. Understood, yes.
Q. Please speak at a slow pace so that the court reporter can record everything. I will do my best to do the same.
We should also try not to interrupt one another; otherwise, our court

reporter will not be able to record us accurately.

Please wait until I finish my question before you start to answer, and I will not interrupt you while you are speaking.

Sound good?

A. Sounds great.

Q. Once the deposition is complete, you'll be given an opportunity to read a transcript of your testimony and make any corrections. You will then be asked to sign it.

Is that all right with you?

A. Sounds great.

Q. Dr. Jones, only you are testifying today. You must answer to the best of your ability and you may not ask others for their help.

Do you understand?

A. Yes.

Q. If you don't understand one of my questions, please let me know and I will try to clarify. However, if you don't ask for clarification, I will assume that you

understood the question; is that fair?
A. Yes.
Q. During the deposition you may hear other attorneys say "objection" and state an objection. Unless you've been instructed not to answer the question, please answer the question after the objection has been made.
Do you understand?
A. Understood, yes.
Q. Is there any reason why you're unable to give your most truthful and accurate testimony today?
A. No.
Q. Is there any reason your memory might be impaired today?
A. No.
Q. Have you taken or do you intend to take today any medication that might affect your ability to testify accurately or honestly?
A. No.
Q. Dr. Jones, you can ask for a break at any time. Please don't hesitate to ask for breaks. All I ask is that you answer

any question that's pending before we go on the break.

Does that sound good?

A. Sounds good.

Q. Am I correct that you've been retained by plaintiff's leadership group as an expert witness in the In Re: Camp Lejeune Water Litigation pending in the United States District Court for the Eastern District of North Carolina?

A. Yes.

Q. When were you hired as an expert witness?

A. September of 2024.

Q. Do you remember the specific date?

A. I don't remember the exact date. Earlier in the month, I believe.

Q. And who hired you?

A. The -- the Bell Legal Group, I think it's called.

Q. Okay. Were you dealing with attorney Kevin Dean at that time?

A. Yes.

Q. Before you were retained, had

you ever heard about Camp Lejeune?
A. I'd heard of it, yes.
Q. Had you heard of the existence of the camp in general, or more specifically the water contamination issues?
A. I'd heard -- I was aware of the existence of the camp, and I was aware that there was some groundwater contamination at the camp, and there was some -- there was -- yeah, I was aware that it was being studied and analyzed.
Q. How did you become aware of the water contamination?
A. You know, I -- I'm not sure I remember. One of those things that I recall knowing vaguely about it, but I never investigated it deeply prior to that time.
Q. Do you recall when you first learned about the water contamination issues at Camp Lejeune?
A. No, I don't.
Q. Was it prior to 2022?
A. I don't think so, but I can't be sure.
Q. Is it possible you learned

about the issues from attorney advertising?
MS. BAUGHMAN: Objection.
Form.
THE WITNESS: I can't say. I
don't remember.
Q. BY MR. ANTONUCCI: Sure. Had
you heard about Camp Lejeune in your
professional capacity?
A. Again, I -- I don't recall. I
didn't know a lot about it, so it's hard for
me to pin down where I -- where I heard about
it. Just was vaguely aware that there was a
groundwater contamination issue there.
MR. ANTONUCCI: Okay. I am
going to ask that Exhibit 1 be marked
for identification.
(Exhibit 1 was marked for identification.)
Q. BY MR. ANTONUCCI: Dr. Jones,
please take a moment to look that over.
A. Okay.
Q. Have you finished reviewing
Exhibit 1?
A. Yes.
Q. Have you seen this document
before?

A. Yes.
Q. When have you seen it before?
A. It was sent to me, I believe, by email a few weeks ago.
Q. Okay. I'll represent to you that that's the notice of deposition and subpoena that I issued for your testimony here today.
A. Okay.
Q. Does that generally comport with your understanding?
A. That is what I would have guessed, yes.
Q. Okay. I'd appreciate it if you could turn to Attachment A, which is towards the end of the document.
So Attachment A states "Pursuant to Federal Rules of Civil Procedure 39(b)(2) and 45, the United States makes the following requests for the production of non-privileged documents, communications, and materials, including but not limited to, any electronically stored information, data, technical files, and photographs, within your possession, custody, or control:

"Number 1. All emails, letters, correspondence, text messages, conversations, chats, voicemails, data, technical files, or other communications pertaining to Camp Lejeune sent or received prior to your retention as an expert in this matter, including but not limited to, from, or with:

"Morris Maslia, Robert Faye, Jason Sautner, David Savitz, Rene Suarez-Soto, Susan Martel, Scott Williams, Frank Bove, Mike Partain, Jerry Ensminger, Lori Freshwater."

Did I read that correctly?

A. I believe so, yes.

Q. Do you have any emails, letters, correspondence, text messages, conversations prior to your retention with any of those individuals?

A. Not related to Camp Lejeune.

Q. Do you have any emails, letters, correspondence, text messages, conversations, chats, voicemails, data, technical files or other communications pertaining to Camp Lejeune prior to your retention -- excuse me -- not pertaining to Camp Lejeune from prior to your retention with any of those individuals?

A. Yes.

Q. May I ask who?

A. Morris Maslia.

Q. Okay. What sort of communications had you had with Mr. Maslia prior to your retention as an expert in this case?

A. So -- so for several years he and I both served together on a peer-review panel for a research project at the University of Alabama, and I was the chair of that expert panel and Morris was a member of the panel.

So in the context of reviewing that research project, we had correspondence.

Q. Okay. Before we discuss that more, is there anyone else on that list with whom you've had any communications prior to your retention as an expert in this case?

A. No.

Q. Other than your dealings with the expert panel and Mr. Maslia, do you have any other communications with him prior to your retention as an expert?

A. No.

Q. Okay. So you mentioned that your work with Mr. Maslia was through the University of Alabama; is that right?

A. Yes. There's a -- a National Science Foundation-funded project where the principal investigators at the University of Alabama, it also involves other universities, Louisiana State University, University of Mississippi, Auburn, a number of other smaller universities.

Q. And you mentioned serving on an -- or excuse me -- serving as the chair of an expert panel on which Mr. Maslia also served; is that right?

A. That's correct.

Q. What were you evaluating?

A. So based on the rules and protocols for that grant established by the National Science Foundation, they were required to, every year, bring in an outside panel to review their work to give feedback, make sure they're following good research standards and making good progress.

And so once a year we would read the report that they had generated, and then we would travel to Alabama and participate in a two-day workshop, presentations, and then we would write a report with recommendations and observations we make during the review process, and we did that three times.

Q. Okay. So you've mentioned providing feedback, ensuring good research standards, and good progress?

A. Yes.

Q. What is the project that you were evaluating for those criteria?

A. It was a very broad project, but the primary objective was to do research on groundwater in -- in the Southeast United States. Looking at groundwater recharge, looking at evaluating groundwater storage change, things like that.

And they also used, developed, and applied some groundwater models as part of the project.

Q. So my understanding of recharge

and storage change is that those are parameters that pertain to the amount of water contained in an aquifer; is that right?

A. Yeah, recharge is typically the water that comes from rainfall that as a portion of that eventually percolates down and enters the aquifer. It's the primary source of water to an aquifer.

And then the storage change is -- it's dependent on the water balance, how much water is coming in versus how much water is being discharged to springs and streams and being pumped out by wells.

Q. And you mentioned this was the Southeast United States. Was this the Floridian aquifer?

A. They studied, I know, aquifers in Mississippi and Alabama, and there was a very large model built in the state of Louisiana by the researchers from Louisiana State University.

Q. What was the purpose of the applied groundwater models that they were developing?

A. Partially to look at storage

change and aquifer sustainability. And, again, determination of recharge rates was one of the things that was studied.

And they're also looking at, I believe, innovative numerical algorithms and methods for analyzing aquifers, determining recharge rates.

For example, the -- they used not just in-situ data from monitoring wells, but earth observations from satellite data.

Q. So I'd like to sort of break that down a little bit more with you.

A. Sure.

Q. You mentioned that the purpose of evaluating storage change and recharge is to evaluate aquifer sustainability; am I stating that correctly?

A. That's one of the purposes, yes.

Q. Okay. What are the other purposes?

A. To -- water resource planning. When your -- groundwater is one of our most significant sources of fresh water. For example, in a drought when the stream flow is low, sometimes you pump more groundwater to make up that deficit, so it's a -- it's a large, underground reservoir.

So much of the work we do in groundwater studies is to assess how our groundwater storage is changing over time and how to characterize that and how to predict how it will respond in the future, and that happens to be one of my -- one of my areas of research as well.

Q. So if I'm understanding correctly, the purpose of this project at the University of Alabama was, at least in part, to assess sustainability for planning purposes; is that right?

A. That's one of the objectives, that's right.

Q. Okay. Can you please list the other objectives.

A. You know, it's been almost two years since our last review, so I'm not sure I could add much beyond what I've stated in terms of detail without looking up the reports and reviewing it.

Q. Sure.

A. You know, and a big part of the project is also public education and outreach. So they -- they had a lot of funding to -- to work with K through 12 and provide high school science teachers, for example, with material and understanding aquifers and aquifer dynamics.

And so it -- it was a -- it was a very broad project. They looked at machine learning algorithms for different kinds of data analysis related to groundwater data. It was very broad.

They had, I think, maybe as many as 80 people on this project. It was one of the bigger research projects I've ever seen.

Q. What was the process like to be selected as the chair of the expert panel?

A. I -- so I was the princ- -- this grant was through what's called the EPSCoR project, E-P-S-C-O-R, the EPSCoR program through the National Science Foundation.

And from 2010 to 2014 I happened to be the principal investigator of an EPSCoR grant, a $6 million EPSCoR grant featuring Brigham Young University, University of Utah, Utah State University, and University of Wyoming.

And the -- the principal investigator of the project centered in Alabama. It was an associate of mine and he was aware of that and thought that my experience and also my general background and experience in groundwater would -- would make me a -- a good pick for that role.

Q. And do you know how any of the other panel members were selected?

A. They were selected by the -- they were asked to serve on behalf of the principal investigator of that project, which is Prabhaker Clement.

Q. You mentioned previously that part of the objective of the expert panel was to provide feedback, evaluate research standards, and ensure good progress?

A. Yeah.

Q. Am I stating that correctly?

A. Right.

Q. What kinds of -- of research

standards were you looking for in this project?
A. Well, they would make presentations on -- on their findings and the methodologies they were using, review journal articles that they had published or in the process of working on and, you know, in some cases we would give advice on -- on methodology, suggestions on -- on different kinds of computer algorithms to help, you know, based on our experience.
But, overall, it was a very impressive project and they -- they've been doing excellent work.
Q. You mentioned --
A. So we didn't -- we didn't -- I don't recall any highly critical feedback that we gave. Fortunately, it's a really -- really well-run project.
Q. So you just mentioned evaluating the methodology; is that correct?
A. Yeah.
Q. How did you go about evaluating the methodology of this groundwater modeling project?

A. We would review the reports that they provided, the papers that they were -- that they had -- they were either preparing to submit or publishing, and two days of presentations that they would make each year.
Q. Were you provided with the modeling files to evaluate?
A. No.
Q. Did you perform a post-audit of any kind of their work?
A. No.
Q. I'd like for you to sort of walk me through the process of evaluating the methodology of a groundwater modeling project --
A. Sure.
Q. -- if that's all right.
A. Yeah.
Q. I guess maybe we can start with the conceptual model.
A. Yeah.
Q. My understanding is that's kind of where modeling begins; is that right?
A. That's right.

Q. So what did you do to evaluate the conceptual model of this project from the University of Alabama?

A. Well, there's not one model, there were -- there were multiple models. The -- they provided a general description of the conceptual model, and for the Louisiana model there was a presentation and some written material where they described the basic components of the conceptual model.

Q. Did your evaluation of the conceptual model involve evaluating the purpose for which the model was designed?

A. They -- they described the purpose, I believe, that -- in -- in -- for the Louisiana model, it was to look at water availability and long-term, again, sustainability, water balances.

Q. And, again, that's for planning purposes; right?

A. But that's -- I'm going by memory. I'm quite sure that's what it was, but it's been a while.

Q. Of course. Completely understandable.

The -- what you just stated, the evaluating sustainability and planning purposes. My understanding is that your primary memory of what the projects are for as it stands today is that it was a planning project; is that right?
A. They -- I -- what -- from what I recall, it's been a while, it was develop a very sophisticated model of the aquifers in Southern Louisiana to characterize the groundwater flow and the long-term changes in groundwater storage --
Q. And it was --
A. -- and then the dynamics of the aquifer.
Q. Excuse me. I didn't mean to cut you off.
That was to determine the future availability of groundwater?
A. It's one of the objectives, I believe, yes.
Q. Okay. And you can't remember any other objectives today?
A. No.
MS. BAUGHMAN: Objection.

Form.

Q. BY MR. ANTONUCCI: All right. You mentioned there were multiple models that you were evaluating. Can you provide a general overview of what those models were.

A. I don't remember the other cases as well. I'm not sure there were models as much as aquifer studies. That's the one I remember most, because it was the most significant model, Louisiana model. I'm not sure I could comment on the others. My memory is more fuzzy with regard to that.

Q. Okay. Moving on from the conceptual model. Did you evaluate their selection of a mathematical model?

A. I know they -- they used MODFLOW.

Q. Okay. Are there different options for equations -- governing equations that can be used in MODFLOW?

A. No. There's one governing equation that the model is built around.

Q. Okay. Did you evaluate the process of model calibration?

A. That was part of what they

presented, yes.

Q. Okay. What factors did you look at when evaluating calibration?

A. Just -- I -- I don't remember the details. I remember they -- they did an extensive calibration process, but it seemed fairly standard, as I recall.

Q. Do you know if they used perimeter estimation tools?

A. I don't remember for sure, but I believe they did. It's fairly typical to use automated parameter estimation on a large model like that.

Q. Is it also typical to do some manual parameter estimation as well?

A. Oh, yes. Yeah, always.

Q. Do you generally start with manual parameter estimation?

A. In general --

MS. BAUGHMAN: Objection. Form.

THE WITNESS: It's generally good practice to start with manual calibration before you engage the use of software to help calibrate a model.

Q. BY MR. ANTONUCCI: My understanding is that one of those software codes is called PEST for parameter estimation; is that right?
A. That's correct.
Q. That was created by John Doherty?
A. That's correct.
Q. Do you know if the model you evaluated used the PEST code?
A. I don't recall.
Q. What other factors did you evaluate for in your analysis of their calibration?
A. I don't recall.
Q. Did you evaluate the sensitivity analysis performed by the investigators of the study?
A. I don't recall.
Q. Is it typical to analyze the sensitivity analysis of a groundwater model when reviewing the methodology?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Will you state

that again.
Q. BY MR. ANTONUCCI: Sure.
I'll -- I'll restate my question.
When you are evaluating a groundwater model's methodology, is it typical to evaluate the sensitivity analysis?
MS. BAUGHMAN: Objection.
Form.
THE WITNESS: If -- if they performed a sensitivity analysis, you would review that, yes.
Q. BY MR. ANTONUCCI: Okay. So based on that answer, it seems like it's not a guarantee that a sensitivity analysis will be done for every model; is that right?
A. Not necessarily.
Q. Okay.
A. Yeah.
Q. How about uncertainty analysis?
Is that typically done for most models?
A. It is done for some models.
Q. Okay. What factors do you look at when you're evaluating uncertainty analysis?
MS. BAUGHMAN: Objection.

Form.

THE WITNESS: When I'm -- when you're performing a sensitivity analysis on the model? Is that the question?

Q. BY MR. ANTONUCCI: I'm asking now about as a peer reviewer --

A. Yeah.

Q. -- when you're evaluating the methodology of a groundwater model, you're looking at the uncertainty analysis. What factors do you look at?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: The methodology they use to perform the uncertainty analysis.

Q. BY MR. ANTONUCCI: Can you elaborate on that? What -- what are the sort of --

A. Well --

MS. BAUGHMAN: Objection. Form.

THE WITNESS: There are different ways one can go about an uncertainty analysis, but the general process is typically basically the same from one case to another.

Q. BY MR. ANTONUCCI: Okay. Can you explain that general process.

A. Well, typically one would first calibrate a model to come up with a best estimate of the parameters of the model and the features of the model that reproduce the -- the behavior exhibited by the aquifer in the field.

And then -- then you look at your parameters and for -- for the selected set of parameters, you look at the uncertainty in that parameter typically with the use of a probability distribution function.

And then to perform the uncertainty analysis, you generate a large number of model instances, versions of the model. In each case where -- for the parameters you've selected, you perturb the parameter value within the range of values you determined would be reasonable to expect for that parameter.

And that gives you a -- a number of models. And if you do it right, each of those models are considered equally probable.

And then you run your simulation for each of those, and then you evaluate the outcome you're looking at, and then you can get that -- that allows you to get a probability of a certain outcome or a confidence interval for a range of outcomes, and this is often called a Monte Carlo process.

Q. The uncertainty analysis is evaluating the probability of all possible model solutions; is that right?

A. Of a range of model solutions that are considered to be likely or probable as being -- or considered to be possible. Variations of the model.

Q. All right. Thank you. I didn't mean to sidetrack the discussion so much with that. I appreciate you providing that information. You can put Exhibit 1 to the side, please.

What did you do to prepare for

your deposition today, Dr. Jones?
A. I primarily reviewed the -- the ATSDR reports and our model reports.
Q. I see that you have some stacks of paper in front of you; is that right?
A. Yeah.
Q. What are those?
A. I have Chapter A, ATSDR Chapter A. Chapter F. And then I have a copy of the rebuttal report that Jeff Davis and I submitted in January of this year.
Q. And I see those are tabbed with sticky notes; is that right?
A. That's correct.
Q. What sections did you tab in Chapter A?
A. I put some tabs in for some figures that I thought -- primarily figures I thought might be useful that I think are important in the -- in the analysis -- in the review of the work, one of which is Figure A18, Chapter A. Another of which is A26 in Chapter A.
And in Chapter F I have tagged Figure F12, the scatter plot simulated versus

observed for the MT3DMS model. Page F34 which shows the -- the time series of PCE at Well TT-26 versus the observed values. And F43, which is the simulated and observed concentrations at the Tarawa Terrace water treatment plant.

Q. Did you make any handwritten notes in those?

A. No.

Q. Did you make any highlights?

A. No.

Q. Did you do anything other than tab those documents?

A. No.

Q. And I see you also have the rebuttal report; is that right?

A. Yes. In the rebuttal report I have tagged the "Summary of Opinions" page, I have tagged at the beginning of the figures page and -- or excuse me -- the figure section in case I want to refer to some of the figures. Specifically Figure 2 and Figure 5.

And then I've tagged the -- where the maps of the contaminant plumes begin in the Appendix A7.

Q. Did you make any notes in your copy of the rebuttal report?

A. No.

Q. Did you make any highlights?

A. No.

Q. Did you do anything other than tab the pages you just mentioned?

A. No.

Q. So, Dr. Jones, I'm sorry to do this, but I'm going to ask you to put those to the side to --

A. Okay.

Q. -- ensure we're looking at the same copies of the documents today.

A. That's fine.

Q. Thank you. I appreciate that.

MS. BAUGHMAN: But obviously if he wants to refer to his copies, he can.

MR. ANTONUCCI: We're going to use the copies that were produced.

MS. BAUGHMAN: He can refer to his tabbed copies if he wants to.

MR. ANTONUCCI: We can tab the

produced copies at a break.
MS. BAUGHMAN: Norm, you can -- you can look at your version if you want to, if it's helpful. It's the same thing.
MR. ANTONUCCI: All right, then I'm going to ask that those be marked as exhibit.
MS. BAUGHMAN: That's fine.
MR. ANTONUCCI: All right.
Q. So other than reviewing those documents which you've tabbed, have you done anything else to prepare for your deposition?
A. Just discussed with the legal team the format and what to expect. The procedure and methodology.
Q. When you say "legal team," are you referring to Ms. Baughman and Ms. Bolton?
A. That's correct.
Q. Are you also referring to Mr. Dean?
A. No -- there were -- I guess he was briefly involved in some of the discussions, yeah. Yeah, he was involved.
Q. Were there any other attorneys

you spoke with?
A. Not that I recall, no.
Q. Was anyone else present at those meetings?
A. Jeff Davis.
Q. Was Mr. Davis present for every meeting you had with the legal team?
A. No. Most of them.
Q. Other than Mr. Davis, was anyone else present?
A. No.
Q. Approximately how many times did you meet with the legal team to prepare for this deposition?
A. We met on Monday -- or excuse me, I'm sorry -- Wednesday of this week. We had dinner on Tuesday night. Had dinner last night.
Q. Approximately how long was your Wednesday meeting?
A. Six or seven hours, I would guess.
Q. Okay. What did you discuss in that meeting?
A. Again, what to -- how -- how a

deposition works. What -- what types of questions would -- we would expect to be asked. Don't talk over the question when it's being asked. Allow time for -- don't start speaking too soon. Allow time to make an objection, if necessary.

A lot of procedural coaching like that.

Q. Was there anything else?

A. Just a general review of the case and rebut- -- our opinions, and so forth.

Q. Were you provided with any documents in those meetings?

A. I don't recall, no.

Q. All right. Have you reviewed any of the other depositions taken in this case?

A. I reviewed the prelim- -- the draft transcript of the Mustafa Aral deposition that was taken recently. And I was on the Zoom yesterday. I watched most, but not all, of the Jeff Davis deposition.

Q. Have you reviewed any other depositions that have been taken in the Camp

Lejeune Justice Act litigation?
A. No.
Q. So you mentioned testifying in a deposition. I'm interested, have you ever testified at trial?
A. I testified at a court hearing in the -- in Carson City, Nevada, in front of the state engineer as part of a water rights dispute on two occasions where I was put under oath and questioned as an expert witness.
Q. Did you prepare a report in those cases?
A. Yes.
Q. But you weren't deposed?
A. I was not deposed, no.
Q. So you mentioned it was a water rights dispute. Can you --
A. Yes.
Q. -- explain in laymen's terms what that means.
A. So the -- the City of Las Vegas back in the 1980s decided that they needed to do something to ensure long-term water availability, and this organization later was

renamed The Southern Nevada Water Authority, it represents primarily Las Vegas, but also surrounding cities.

And they decided to pursue a groundwater development project where they would drill a series of deep production wells in some valleys in East Central Nevada, and build 300 miles of large pipe to pump that water south to Las Vegas.

It would have been a $15 billion project, would have taken estimated 27 years to build. Would have been the largest inter basin transfer in history, the largest groundwater development project in history, and it would, as you can imagine, extract a significant amount of water from these valleys.

And I represented a significant landholder. I was -- I was retained as an expert witness for a landholder in Spring Valley that was one of several parties that were protesting the groundwater project.

And, yeah, we did a bunch of modeling simulations and wrote a series of reports related to the impact that project would potentially have on the water rights, springs and streams and wells in the -- in this valley.

Q. How long ago was that?

A. I started in 2010 and the project -- it went on for ten years until it was concluded in 2020.

Q. Okay. So you already mentioned that you were deposed in a class action lawsuit where you served as a class representative. Is that suit ongoing?

A. It -- they've -- have -- there's been a settlement in the last few months, so it's -- I think it's over.

Q. Okay. Other than that class action, have you ever been involved in any other litigation personally, not as an expert?

A. Involving me? No.

Q. And you mentioned starting work for the landholder in Spring Valley in 2010. Was that your first time serving as an expert witness?

A. No.

Q. When did you serve as an expert

witness prior to that?
A. Several years prior to that I was retained as -- to do a review of a case in Montana that a colleague of mine was involved with as the primary expert witness involving groundwater contamination at a -- at a railroad facility.
Q. Who was that colleague?
A. Willis Weight.
Q. And do you recall which party you represented in that -- or excuse me -- for which party you served as a witness in that case?
A. So Willis was hired as an expert to -- on the side of some plaintiffs who lived adjacent to a railroad facility, Burlington Northern and Santa Fe, and their contention was that contaminants had leeched from an unlined pond or a poorly lined pond on the railroad facility and migrated under a neighborhood where they -- they had some drinking water wells, and that had caused some -- some health damages.
And so Willis built a MODFLOW and MT3D model simulating the migration of

the plume over to the property, and that was entered as evidence in the case.

And then the railroad hired Papadopoulos & Associates to -- to represent their side, and they -- the expert from Papadopoulos did a critical review of Willis' model.

So I was hired to review Willis' work and the Papadopoulos critique of his work and then write a report, which I believe became an affidavit that was entered in the case.

Q. So that I can understand, were you hired as an independent expert by the court or were you hired by --

A. No, I was hired by the plaintiff attorneys.

Q. Okay. So you submitted an affidavit in support of the plaintiff's reports; is that right?

A. It was based on my review of -- of his modeling and the critique of that, yeah.

Q. Other than that Montana case, have you served as an expert witness in any other cases?

A. Not that I recall.

Q. Do you know who specifically from S.S. Papadopoulos & Associates was the expert in that case?

A. I don't. It's been a number of years. No, I don't recall his name. He was one of their lead modelers, very well respected, I remember that.

Q. What was the contaminant of concern in that case? The Montana case.

A. Boy, it's been a long time. I know that it was a degreasing facility, but it might have been creosote. I wish I could remember. It's been probably 15, 20 years, yeah.

Q. Do you have an opinion about S.S. Papadopoulos as a firm?

MS. BAUGHMAN: Objection to form.

THE WITNESS: No.

Q. BY MR. ANTONUCCI: And you mentioned that your -- your colleague, Mr. Willis, simulated the flow of contamination through the -- through the

groundwater; is that right?
A. That's correct.
Q. And that was from the poorly lined pond to water supply wells; is that correct?
A. To the -- yes, to the area downgradient from the railroad facility where the water was pumped out, yeah.
Q. How far away from the pond were the water supply wells?
A. It -- it wasn't a great distance, but I -- I don't remember the exact distance.
Q. Do you know the total size of the area that was modeled?
A. I don't recall.
Q. And do you know what information was used to, for example, to select boundary conditions in that model?
A. I don't recall.
Q. Do you know what information was available in terms of heads and flow data?
A. I don't recall specifics.
Q. Do you know if there was heads

and flow data available to Mr. Willis?
A. I -- I believe there were, yes.
Q. Why do you believe that?
A. I -- if -- if there were not any data -- I know they had concentrations at the -- at the location where the water was being pumped out. That was the whole basis of the suit was they measured contaminants in their drinking water.
Q. When you say "the location where the water was pumped out," are you referring to the supply wells, the water treatment plant, or the tap?
A. I don't believe a water treatment plant was involved. There were -- I -- from -- from what I recall, there were some small wells. I believe it was actually a -- part of a -- an Indian reservation, and they had some small water supply wells they were using.
Q. So it sounds like those samples were taken at the supply wells?
A. Yes, I believe so.
Q. Do you know approximately what time span those samples covered?

A. I don't recall.
Q. Was it more than a year?
A. I don't recall.
Q. Was it less than a year?
A. I don't recall.
Q. Do you know approximately how many data points they had?
A. I don't recall.
Q. Did they have -- strike that.
With regard to the -- the head and flow data that you assumed that they had available, do you know how much of that was available?
A. I don't recall.
Q. Where do you -- in these kinds of cases, where do modelers normally get head and flow data from?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Head and flow data? Well, you track down water level measurements from observation wells. In some cases, aquifers interact with streams, either discharge to streams or streams leak

water into the ground.

Sometimes you can look at gauges on the stream to get an estimate of -- of how much water's being gained or lost, but that is a fairly standard part of the data collection phase on the modeling project is to gather all the data you can find.

Q. BY MR. ANTONUCCI: Okay. And you mentioned that it was a lawsuit brought on behalf of the individuals who drank the water from those wells; is that correct?

A. That's correct.

Q. Do you know if the purpose of the model was to determine the absolute amount of contaminants that these individuals were exposed to?

MS. BAUGHMAN: Objection to form.

THE WITNESS: I don't recall. I know part -- at least part of the purpose was to determine if, presuming water leaked from the pond, would it, given the groundwater flow directions and the timing, is it probable that it traveled -- that the contaminants were transported to that location where they could potentially be pumped out.

Q. BY MR. ANTONUCCI: So that's kind of a yes-or-no question, right? Like, could the contamination have gotten to the well in that time period or not; right?

A. Yeah.

Q. Okay. And that's the only purpose that you recall from that report?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: That is a purpose that I recall.

Q. BY MR. ANTONUCCI: What other purposes do you recall?

A. I -- I don't recall other purposes.

Q. Okay. Okay. So prior to that Montana case, had you ever served as an expert witness before that?

MS. BAUGHMAN: In litigation?

MR. ANTONUCCI: Yes, in litigation.

MS. BAUGHMAN: Object to the form.
MR. ANTONUCCI: Have you -- excuse me. I'm going to ask my question again.
Q. Prior to the Montana case, had you ever served as an expert witness in litigation?
A. I don't believe so. Not that I recall.
Q. Okay. Do you have a list of all the times you've served as an expert witness somewhere?
A. No.
MR. ANTONUCCI: Okay. All right. Actually, before we move on, I'm going to ask that the copies that you brought of the rebuttal report and Chapters A and F be marked for identification for Exhibits 2, 3, and 4.
(There was a discussion held off the record.)
(Exhibits 2-4 were marked for identification.)
MR. ANTONUCCI: Thank you for

that.

And now I'm going to hand you another document. I'll ask that this be marked for identification as Exhibit 5.

(Exhibit 5 was marked for identification.)

Q. BY MR. ANTONUCCI: Please let me know when you've had a chance to review that document.

A. I'm ready.

Q. Okay. Do you recognize Exhibit 5?

A. Yes.

Q. Okay. What is Exhibit 5?

A. This is the CV that I submitted.

Q. Okay. So if you turn to Page 1 of Exhibit 5, it looks like this document is titled "Norman L. Jones, PhD, Professor, Department of Civil & Construction Engineering, Brigham Young University"; is that right?

A. Correct.

Q. Is this a complete and accurate copy of your resum??

A. Yes.
Q. Is there anything that you would like to change or add to this copy of your resum??
A. Can you clarify what you mean by "complete"?
Q. Sure. Is -- is this the most updated iteration of your resum??
A. This is the resum? -- resum? that I am currently using when my resum? is requested.
Q. Okay. So I'm inferring from your question that there's some things that are probably left off of this resum?; is that right?
A. That's correct. It's not 100 percent inclusive of everything I've done in my professional career.
Q. Sure. What kind of things are currently listed on your resum? that's marked as Exhibit 5?
A. Oh, heavens. Consulting projects, expert witness work, workshops and courses I've taught, things like that.
Q. Have you served as a consulting

expert in litigation?
MS. BAUGHMAN: Objection to form.
THE WITNESS: A consultant -- not beyond the cases we've described.
Q. BY MR. ANTONUCCI: Okay. Your resum? mentions a bachelor's, master's, and PhD in civil engineering. Did you have any specialization or concentration in those programs?
A. Yes. My master's degree and PhD at the University of Texas, I specialized in geotechnical engineering.
Q. And is there a list of your peer-reviewed publications from the last ten years on Page 3 of this resum??
A. Yes.
Q. How many of these publications deal with groundwater flow modeling?
A. You'll have to give me a minute. I would say of these, six are -- five or six are directly related to a groundwater flow model and -- but a large number of them are for characterizing groundwater conditions, groundwater

sustainability.

Q. And how many of those deal with contaminant fate and transport modeling?

A. I'm not sure in this period -- I got to read them again. I can see at least one.

Q. So just the one?

A. I believe so.

Q. Would it be fair to say that you focus more on groundwater flow modeling than contaminant fate and transport modeling?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: In terms of my publications, yeah, I've -- my -- I've done more research on -- well, in the last ten years, the focus of my research has been more shifted to using earth observations and machine learning and data analytics to analyze aquifers.

MR. ANTONUCCI: I'd like to talk to you about that more later in the deposition. For now, it's been about an hour, would you like to take a break?

THE WITNESS: Sure.

MR. ANTONUCCI: Okay.

MS. BAUGHMAN: If you're -- if you're willing to keep going, we can. We don't have to. That's up to you.

THE WITNESS: I can keep going.

MR. ANTONUCCI: Well, I'd like to take a break.

THE WITNESS: Sure. All right.

THE VIDEOGRAPHER: Off the record. The time is 10:18.

(There was a break taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 10:28. This is Media Number 2.

Counsel may proceed.

MR. ANTONUCCI: All right. I am going to hand you what is being marked for identification as Exhibit 6.

(Exhibit 6 was marked for identification.)

MR. ANTONUCCI: Sorry, I just noticed my microphone wasn't on.

Q. I just handed you what was

marked for identification as Exhibit 6.
Dr. Jones, this is your initial expert report and materials considered; right?
A. Correct.
Q. And looking at that first page, the cover page, title is Tarawa Terrace Flow and Transport Model Post-Audit prepared for Bell Legal Group. A couple lines down, prepared by Norman L. Jones, R. Jeffrey Davis.
Is that your signature there?
A. Yes.
Q. Okay. How do you know Mr. Davis?
A. He was a former graduate student of mine when I was a young professor at Brigham Young University. And then I hired him to be a staff member in our research laboratory where we were developing groundwater modeling software.
And then I worked with him in that capacity for several years, and then even after he left the university I -- we worked together on consulting projects and

teaching groundwater and contaminant transport modeling short courses.

Q. So it's fair to say that you've worked together before your work on this case?

A. Yes.

Q. And it appears that you co-wrote this expert report; is that correct?

A. That's correct.

Q. Did you participate in the drafting process with Mr. Davis?

A. Drafting?

Q. I guess can you explain to me your -- your role in the preparation of this report.

A. Yes. We decided it would be beneficial to team up. I have certain limitations on my time given that I'm a full-time university professor, and we decided that we would work together, we could share the workload.

And so he did most of the modeling work in terms of entering the data into the GMS MODFLOW MT3DMS software and running the model simulations.

I did a lot of the post-processing and data analysis. Together we -- we reviewed the -- the data, reviewed the -- the prior publications from ATSDR, and then we -- together we drafted and edited and finalized this report.

This report also -- in the preparation of the report we utilized staff at Integral Consulting. For example, the -- the figures with the maps. We provided the model results to staff members at Integral and they helped do a lot of the formatting.

There was also a professional copy editor that reviewed the documents before we submitted them.

Q. A moment ago you mentioned that Mr. Davis used GMS, which I believe incorporates MODFLOW and MD3DMS; is that right?

A. That's correct. It's what we call a pre and post processing for MODFLOW and MT3DMS. It -- the input files to MODFLOW and MT3DMS are very large and complicated and synthesize a lot of data. And so GMS was developed to streamline and simplify that process and encapsulate it in what we call a graphical user interface.

It -- you can -- you can modify the input files through the GMS interface, for example, save the modified files, run -- and then GMS will then launch MODFLOW and/or MT3D, and then they generate a set of output files which are ingested to GMS for -- for visualization plotting.

Q. And you and Mr. Davis developed GMS for the Department of Defense; is that right?

A. That's correct. We were -- it was developed, yeah, in the early part of my career.

Q. Okay. Turning your attention back to Exhibit 6, your initial report. And, by the way, if I refer to this --

A. Okay.

Q. -- as your initial report, will you understand what I'm saying?

A. Sure.

Q. Okay. Do you agree with all of the opinions and statements made in Exhibit 6?

A. Yes.
Q. And then I'd appreciate it if you could turn to the back, because I've appended your materials considered list.
So is this a fair and accurate copy of your initial report and materials considered list?
A. Yes.
Q. Okay. Thank you, Dr. Jones. You can put that to the side.
I'm now going to hand you what will be marked for identification as Exhibit 7.
(Exhibit 7 was marked for identification.)
MS. BOLTON: For the record, a revised copy of this materials list, it was served after this initial one.
MR. ANTONUCCI: For the rebuttal report?
MS. BOLTON: No. This is the October 2024 report, so for the initial report.
MR. ANTONUCCI: Okay.
MS. BAUGHMAN: Do you want us to send that to you so that you can

mark it or?

MS. BOLTON: Yeah, it includes all of those, plus additional.

MR. ANTONUCCI: That's right. Yes, if you could send it, that would be great.

MS. BOLTON: Okay.

Q. BY MR. ANTONUCCI: Okay. Dr. Jones, I showed you what's been marked for identification as Exhibit 7. This is a report titled "Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit"; is that right?

A. That's correct.

Q. Is this the -- if I refer to this as your rebuttal report, will you understand that I'm referring to Exhibit 7?

A. Yes.

Q. Okay. And, again, it looks like it says "Prepared by Norman L. Jones" with your signature on the front page; is that right?

A. Yes.

Q. And, again, I appended the materials considered to the end of this

report.

A. Yes.

Q. Did you participate in the drafting of this report in the same way as with your initial report?

A. Yes.

Q. Were there any changes in how you and Mr. Davis divided labor?

A. No.

Q. So it's fair to say you undertook substantially the same process to draft both reports?

A. That's correct.

Q. Do you agree with all of the opinions made in Exhibit 7?

A. Yes.

Q. Do you hold every opinion in Exhibit 6, that's your initial report, as your own opinion?

A. Yes.

Q. Do you hold every opinion in Exhibit 7, your rebuttal report, as your own opinion?

A. Yes.

Q. Is there anything in either

report that you believe is incorrect or needs updating?

A. Well, there were some -- can you clarify what you mean by that? You mean in how it's written?

Q. I think you might be referring to the changes that were made to the post-audit --

A. Correct.

Q. -- in between the initial and rebuttal report; is that right?

A. Correct.

Q. So other than those changes, is there anything incorrect in either report?

A. Not that I can think of.

Q. Okay. Is there anything that needs to be updated in either report?

A. Not that I can think of.

Q. Is any portion of either report incomplete?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Not that I can think of.

Q. BY MR. ANTONUCCI: Okay. So

Exhibit 6 and 7, your initial and rebuttal reports, do these include all of the opinions you hold regarding ATSDR's groundwater flow and transport models for Marine Corps Base Camp Lejeune?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Can you clarify what you mean by that.

Q. BY MR. ANTONUCCI: Do you have any opinions on ATSDR's water modeling efforts at Camp Lejeune that are not contained in either Exhibit 6 or Exhibit 7?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Yeah, I -- I'm not sure I'm comfortable saying I would never have any other opinions than what are contained here.

Q. BY MR. ANTONUCCI: Sure. In what sort of circumstances would -- would you have a new opinion?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Well, if you were

to ask me about specific questions related to different parts of the modeling that's done in Chapter A and Chapter F by ATSDR, there may be specific opinions about that, which I'd be happy to share that it may not be 100 percent included in these reports.

Q. BY MR. ANTONUCCI: Do you intend to offer any opinions that are not in this case -- strike that.

Do you intend to offer any opinions in this case that are not contained in Exhibit 6 or Exhibit 7?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: In the context of this deposition?

Q. BY MR. ANTONUCCI: I'm referring to the entire case.

Do you intend to offer any other opinions in this case that are not contained in either Exhibit 6 or Exhibit 7?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: If requested by our legal team, I would be willing to provide additional opinions.

Q. BY MR. ANTONUCCI: As you sit here today, do you have any additional opinions about ATSDR's water modeling efforts at Camp Lejeune that are not contained in either Exhibit 6 or Exhibit 7?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Yes, there are things about their initial report that I -- I would be happy to proffer as opinions in this deposition that aren't necessarily contained in this report.

Q. BY MR. ANTONUCCI: Okay. Can you list those for me, please.

A. Well, what I'm saying is in the context of -- of this discussion, there may be specific features in the context of the Monte Carlo simulation, the -- the confidence interval, the calibration exercise that may not -- I'm uncomfortable saying every opinion I have is exclusively contained in this.

Q. So -- so to be clear, then, the answer is no, all of your opinions are not contained in your reports?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: In the context of what I just described, yes. I'm hesitant to say everything, all of my opinions are here, and then later be told I can't render an opinion on something because I was told all of my opinions are in here, if you catch my drift.
Q. BY MR. ANTONUCCI: Can you explain why all of your opinions aren't in your report?
A. These reports had a specific purpose and we were asked to do a post-audit, and then report the results of that. And then we were asked to respond specifically to a rebuttal to our post-audit offered by Mr. Spiliotopoulos.
And we -- so the purpose of these documents, to my understanding, was very specific and focused.

Q. Dr. Jones, do you understand that you've been retained as an expert in this case?
A. Yes.
Q. Do you understand the Federal Rules of Civil Procedure require you to disclose a complete list of your opinions?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: I'm not aware of that rule.
Q. BY MR. ANTONUCCI: Can you provide me with a list of the opinions you have that are not contained in your reports?
A. I don't have a list, no.
Q. Can you name a single opinion you have that's not contained in your reports?
A. I -- I would -- I would have to think about that.
Q. Okay. We'll come back to this.
A. Okay.
Q. If you could, please turn to Page 6-1 of Exhibit 6, that's your initial report.

A. Sure.
Q. Page 6-1 of Exhibit 6 has the heading "Conclusions"; is that right?
A. Correct.
Q. And there's a list of five categories of conclusions on this page; is that right?
A. Correct.
Q. Is this a complete list of all the conclusions from your report?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: These are the conclusions from our report, yes.
Q. BY MR. ANTONUCCI: Are there any conclusions from your initial report, Exhibit 6, that are not contained in this list?
A. No.
Q. Am I correct in understanding that this is not a complete list of all the opinions you will render in this case?
A. It's a -- given the context of what we're asked to do, this is a complete list of the -- of the opinions relative to

this. And I've not been asked to formally submit any additional opinions at this time.

Q. Okay. Does any part of this list need to be updated?

A. Not --

MS. BAUGHMAN: Other than with the rebuttal? I mean, I object to the form.

THE WITNESS: No.

Q. BY MR. ANTONUCCI: Okay. And now as we've already discussed, you've provided a rebuttal report which modified some of the conclusions from Exhibit 6; is that right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: No, I don't believe it modified the conclusions of this report. I wouldn't state it that way.

Q. BY MR. ANTONUCCI: Okay. There were errors in Exhibit 6 that you corrected in Exhibit 7; is that correct?

A. That's correct.

Q. Okay.

A. But I don't think any of those errors were significant enough to change the opinions rendered in the initial report.
Q. I understand.
So aside from those errors, are -- is there anything else in Exhibit 6, your initial report, sitting here today that is incorrect?
A. Not that I can think of.
Q. Okay. All right. Now if you could please flip to Page 1-1 of Exhibit 7, that's the rebuttal report.
A. Sure.
Q. All right. Page 1-1 of Exhibit 7, your rebuttal report, has the heading "Summary of Opinions"; is that right?
A. Correct.
Q. And there's a list of six opinions on Page 1-1 of Exhibit 6; right?
A. Correct.
Q. Is this a complete list of all the opinions from your rebuttal report, Exhibit 7?
MS. BAUGHMAN: Objection.
Form.

THE WITNESS: Yes.
Q. BY MR. ANTONUCCI: Do you have any opinions regarding the content of ATSDR's groundwater modeling efforts at Camp Lejeune that are not contained in this list?
MS. BAUGHMAN: Objection. Form. Asked and answered.
THE WITNESS: I don't think I have any opinions that are inconsistent with this list, no.
Q. BY MR. ANTONUCCI: All right. Now, this is from the rebuttal report which includes the corrections to your initial report; is that right?
A. Say that again.
Q. We're looking at your rebuttal report right now, and this --
A. Yes.
Q. -- report includes corrections to your initial report; is that right?
A. Correct.
Q. Does any part of this report need to be corrected?
A. Not that I can think of.
Q. Is any part of this report

incorrect?

A. Not that I can think of.

Q. Is there any part of this report that needs to be updated?

A. No.

Q. You provided, I believe, three lists of materials considered in this case; is that right?

A. What are you referring to?

Q. So my understanding is that you provided a list of materials considered with your initial report, then an updated list of materials considered with that same initial report, and finally a list of materials considered with your rebuttal report; is that correct?

A. That sounds correct.

Q. Okay. Does that materials considered list include all of the facts, data, and information you considered in rendering your opinions?

A. I believe so, yes.

Q. Did you review any facts, data, or information not listed on your materials considered lists in rendering these opinions?

A. Not that I recall.
Q. Okay. Did you review any academic texts when preparing these opinions?
MS. BAUGHMAN: Objection. Form.
You mean other than what's on the lists?
Object to the form.
THE WITNESS: I don't recall.
Q. BY MR. ANTONUCCI: Are you not sure if there's an academic text you've referenced that aren't on your materials considered list --
MS. BAUGHMAN: Objection.
Q. BY MR. ANTONUCCI: -- or in your report?
A. I don't recall any other references specifically considered that were not cited in our report.
Q. Okay. Did you review any course books or peer-reviewed articles in rendering these opinions?
MS. BAUGHMAN: Object to the form.
You mean other than what's

already referenced?

THE WITNESS: I -- in the process of conducting the post-audit and writing the review, I cited -- I believe we cited all of the materials that were directly referenced as part of that process.

Now, were there other books and articles through my career that I've read that influenced this? Probably. Things we specifically cited in terms of writing this that were specifically relevant, I believe we cited those.

Q. BY MR. ANTONUCCI: Can you think of any books or articles you've read through the course of your career that may have influenced your opinions?

A. Oh, yeah, I would say I have 34 years of experience in groundwater and contaminant transport modeling, and I've read countless articles and books that form my basis of knowledge and expertise in this area.

Q. Is there any that stand out?

A. Not particularly.

Q. Okay. Have you reviewed or otherwise considered any other expert reports in this case?
A. Related to the case? I -- I've reviewed the -- several other -- I've reviewed the expert reports by Morris Maslia, Mustafa Aral, Leonard Konikow, I believe Sabatini is his name, the professor at Oklahoma.
Those are the ones I recall off the top of my head. And then of course the -- the DOJ reports that were submitted.
Q. By "the DOJ reports that were submitted," are you referring to the expert report of Dr. Spiliotopoulos?
A. Correct.
Q. And the expert report of Dr. Remy Hennet?
A. Yes.
Q. And the expert report of Dr. Jay Brigham?
A. Yes.
Q. So you reviewed all three of those?
A. Yes.

Q. You mentioned reviewing the expert report of Morris Maslia; is that correct?
A. Yes.
Q. Morris Maslia submitted two reports in this case. Did you review both of those?
A. Yes.
Q. Beginning with his initial report, that was the report disclosed October 25th of 2024. Do you agree with all of the opinions in Mr. Maslia's report?
MS. BAUGHMAN: Object to the form.
THE WITNESS: As far as I can recall.
Q. BY MR. ANTONUCCI: And with regard to Mr. Maslia's rebuttal report, that was the report disclosed January 14th of 2025. Do you agree with all of the opinions in that report?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Yes.
Q. BY MR. ANTONUCCI: What's your

opinion of Mr. Maslia?
A. I think he's a -- a very competent and experienced expert in the field of groundwater flow and transport modeling.
Q. What's his reputation in the field of groundwater flow and transport modeling?
A. As far as I know, he's respected.
Q. Turning to the expert report of Dr. Mustafa Aral, October 25, 2024, do you agree with all of the opinions in that report?
MS. BAUGHMAN: Object. Form.
THE WITNESS: I believe so. I can't think of anything specific that I would disagree with.
Q. BY MR. ANTONUCCI: What's your opinion of Dr. Aral?
A. He's a very accomplished and widely respected expert in this field.
Q. And do you agree with all of the opinions in Dr. Sabatini's report?
MS. BAUGHMAN: Objection. Form.

THE WITNESS: Yes.
Q. BY MR. ANTONUCCI: What is your opinion of Dr. Sabatini?
A. I don't know him very well.
Q. Do you know his reputation in the field of groundwater modeling?
A. Not independent of this project. I reviewed his resum? and his experience and it seems very impressive.
Q. And did you -- did you agree with the opinions stated in the expert report of Dr. -- Dr. Leonard Konikow?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Yes.
Q. BY MR. ANTONUCCI: And what's your opinion of Dr. Konikow?
A. Well, he's -- he's one of the most widely respected experts in groundwater modeling.
Q. Okay. So would you say he has a generally good reputation in the field of groundwater modeling?
A. He has an exceptional reputation.

Q. Okay. I'd appreciate if you could turn back to Exhibit 7, and I'd like for you to look at the materials considered list that's at the end of Exhibit 7.
A. Sure.
Q. So I understand that there's a sort of intermediate materials considered list for your initial report. However, this is your rebuttal report; right?
A. Correct.
Q. Is this the final materials considered list for your rebuttal report?
A. These are the materials that we cited specifically in writing the report.
Q. Does it also include the materials you considered in review -- in rendering your opinions?
A. No, not necessarily. For example, this -- this doesn't include the -- the specific list at the back doesn't include the DOJ reports.
Q. Okay. Other than the DOJ reports, are there any other materials you considered in rendering your opinion that's not included on this list?

A. Not that I can think of.
Q. Okay. So according to this list, you considered ATSDR's Tarawa Terrace Chapters A, F, and C; is that correct?
A. Correct.
Q. Did you review any other chapters of ATSDR's Tarawa Terrace reports?
A. I skimmed through some of the others, but not in the same detail that I read Chapters A, C, and F.
Q. Do you remember which others you skimmed?
A. I don't recall.
Q. Do you remember the subject matter of the other reports that you skimmed?
A. The -- I believe it may have included a more detailed dive into the uncertainty analysis, but I -- I can't -- I couldn't specifically tell you which one. I just know I looked through the others.
Q. Okay. You remember discussion of the uncertainty analysis in the other reports. Do you remember the subject matter of any others?
A. I'm not positive on that, but I

believe that's the topic of one of the others. I -- I couldn't specifically cite the topics of the others, yes.

Q. Did you review others or just the uncertainty analysis chapter?

A. Like I say, I believe I skimmed through all of them, but -- just to see what was there, but I -- I did not do a -- as thorough a reading of those chapters as I did of A, C, and F.

Q. Okay. So you didn't thoroughly review Chapter B: Geologic Framework of the Castle-Hayne Aquifer System; correct?

A. Correct.

Q. You did not thoroughly review Chapter E: Occurrence of Contaminants in Groundwater; is that right?

A. Correct.

Q. You didn't thoroughly review Chapter G: Simulation of Three-Dimensional Multispecies Multiphase Mass Transport of Tetrachloroethylene (PCE) and Associated Degradation Byproducts; is that right?

A. Correct.

Q. You didn't closely review

Chapter H: Effective Groundwater Pumping Schedule Variation on Arrival of Tetrachloroethylene (PCE) at Water Supply Wells and Water Treatment Plants; is that correct?

A. Correct.

Q. And you didn't thoroughly consider or thoroughly review Chapter I: Parameter Sensitivity, Uncertainty, and Variability Associated With Model Simulations of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water; is that right?

A. I -- I believe I may have read that a little more carefully than the others, but certainly not to the same depth of analysis as I did to the other chapters.

Also, Chapter A is kind of a comprehensive summary, as I understand it, of all of the work that was done, including what was put in those other chapters. And so I felt like I had a reasonably good exposure to the overall methods and processes that were used and then described in more detail in those chapters.

But for the purpose of the post-audit which we were hired to do, certainly the most important chapters would be A, C, and F.

Q. Why are A, C, and F the most important chapters for the post-audit you were hired to do?

A. Because A is a -- is a comprehensive summary, a detailed summary of the entire modeling project. It was very helpful in getting an overview of all of the work that was done.

Chapter C provided a very detailed description of the construction and calibration of the MODFLOW flow model.

And Chapter F was a very detailed description of the construction and calibration, uncertainty analysis associated with the contaminant transport model.

And we were asked to, in -- in conducting the post-audit, to -- to perform simulations using both the flow and transport model. So they were clearly the most relevant chapters for our work.

Q. So you weren't asked to review

all of the Tarawa Terrace chapters?
A. They were provided to us and, you know, we -- we were -- we quickly determined which chapters would be most relevant. And it's a matter of, you know, where you focus your time and effort.
Q. Were you provided with ATSDR's reports on their water modeling efforts at Hadnot Point and Holcomb Boulevard?
A. Yes.
Q. Did you review any of those?
A. Yes.
Q. Is there a particular reason none of them are on your materials considered list?
A. Because our primary focus was Tarawa Terrace in terms of the -- what we were asked to do with the -- with the post-audit.
Q. Did you perform as close of a reading on the Hadnot Point/Holcomb Boulevard chapters as you did with Tarawa Terrace Chapters A, C, and F?
A. I wouldn't say it was as equally careful because it was less relevant,

but I did, as I recall, read the entire report on the Hadnot Point/Holcomb Boulevard report --

Q. Did you --

A. -- just to be familiar with the overall project.

Q. And you said that you read those. Did you skim through them or did you read them carefully?

A. I read them completely.

Q. Is there a reason that you skimmed through the Tarawa Terrace reports but not the Hadnot Point reports?

MS. BAUGHMAN: Objection to form.

THE WITNESS: I read through the portions of the -- carefully the Tarawa Terrace reports that I felt were most critical for the work we were asked to do.

Q. BY MR. ANTONUCCI: What about the Hadnot Point reports was critical for your Tarawa Terrace post-audit?

A. I -- I wouldn't classify it as critical. I partially read that out of interest. Curious to -- to kind of see and compare the work that was done there versus the work that was done at Tarawa Terrace.

Q. Do you have any opinions on the Hadnot Point or Holcomb Boulevard chapters that ATSDR published?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: A general opinion that the work that was done there seemed to be rigorous and followed what I would consider good -- good practices, sound practices.

Q. BY MR. ANTONUCCI: And -- I'm sorry, go ahead.

A. I can't think of anything more specific than that, I would say.

Q. What is that opinion based on?

A. Just my reading the document and my experience and the processes they appeared to follow.

Q. Do you have any other opinions about ATSDR's Hadnot Point/Holcomb Boulevard modeling efforts other than that they were rigorous and followed good practices?

A. Not that I can think of at the moment.
Q. So you provided a post-audit for the Tarawa Terrace models; is that right?
A. Correct.
Q. You did not provide a post-audit for the Hadnot Point/Holcomb Boulevard model; is that right?
A. That's correct.
Q. Why did you not provide a post-audit for Hadnot Point or Holcomb Boulevard?
A. We were not asked to do so.
Q. Okay. Have -- are you familiar with the text Modeling Groundwater Flow and Contaminant Transport by Jacob Bear and Alexander H.-D. Cheng?
A. I've heard of it.
Q. Have you ever reviewed it?
A. Not carefully, no.
Q. Do you have any opinion on the reputation of Dr. Bear or Dr. Cheng?
A. I know Dr. Bear is a well-known, widely respected groundwater expert. I'm not as familiar with the other

author.

Q. Do you consider Modeling Groundwater Flow and Contaminant Transport to be a reliable authority in the field of groundwater modeling?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: What do you mean by "authority"?

Q. BY MR. ANTONUCCI: How would you define "authority"?

MS. BAUGHMAN: Objection. Form. He's asked you to clarify your question.

THE WITNESS: I would just say it's a -- it's a book in the field of groundwater I'm familiar with, written by a well-known groundwater expert.

Q. BY MR. ANTONUCCI: Do you consider it to be a reliable book?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I -- like I say, I -- I don't -- I haven't read it. I may have skimmed it earlier in my career, so I -- I don't -- I'm not comfortable rendering an opinion on the book.

Q. BY MR. ANTONUCCI: Okay. Are you familiar with the text Applied Groundwater Modeling Simulation of Flow and Advective Transport by Mary Anderson, William Woessner and Randall Hunt?

A. Yes.

Q. My understanding is that there are two editions of that text; is that right?

A. That's correct.

Q. 1992 and 2015?

A. Correct.

Q. Have you reviewed both editions of that text?

A. Yes.

Q. Did you consult that text in rendering the opinions in your reports?

A. Only in the basis that those texts, along with hundreds if not thousands of other documents, have formed my general background and expertise in groundwater modeling. Not -- not specifically to the point where I would feel it needs to be

cited, that I can recall.
Q. Sure. So you consider the Anderson, Woessner, and Hunt text to be a reliable authority in the field of groundwater modeling?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: I believe it's a -- a -- a valuable and informative book in the area of groundwater modeling.
Q. BY MR. ANTONUCCI: What do you mean by "valuable and informative"?
A. Meaning it has useful content that is helpful in forming understanding of groundwater modeling principles.
Q. Okay. In your experience as a professor, have you ever used that text?
A. I teach a graduate course on groundwater modeling, and I believe there were times in the past where I listed Anderson, Woessner as a -- as an optional textbook that -- but I haven't used it as a required textbook ever.
Q. Okay.

A. That I recall.

Q. Would you make an optional text -- would you list an optional text on your syllabus if it -- you considered it unreliable?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I'm not sure what you mean by "unreliable." I think it's a valuable and instructive book on the general concepts of groundwater modeling.

Q. BY MR. ANTONUCCI: Okay. Other than listing it on your syllabus as an optional text for your students, have you used it in any other capacity as a professor?

A. One of the things that -- there's a -- early in the book there's, I believe, a chapter on the groundwater modeling process, talks about forming conceptual models or the different steps in a modeling project, and if I ever refer to that text I often reference that as a -- as a good overview of the groundwater modeling process in general.

When I -- when I teach my course, I present it in a similar fashion.

Q. Okay. And that's because it's valuable, informative, and instructive; right?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: It's -- it's an instructive textbook, yes.

Q. BY MR. ANTONUCCI: Is it valuable?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I'd consider it valuable, yeah.

Q. BY MR. ANTONUCCI: Is it instructive?

A. It's instructive.

MR. ANTONUCCI: All right. I am going to mark for identification Exhibit 8.

(Exhibit 8 was marked for identification.)

Q. BY MR. ANTONUCCI: All right, Dr. Jones, do you recognize this?

A. Yes, I do.

Q. What is it?
A. These are lecture notes used in my graduate course on a Groundwater Modeling CE 547.
Q. Okay. Did you create -- it looks like this is a PowerPoint presentation; is that right?
A. Correct.
Q. Did you create this yourself?
A. I did.
Q. Okay. And is this a fair and accurate copy of your lecture notes from your graduate course in groundwater modeling?
A. It appears to be, yes.
Q. Okay. I'd like for you to turn to Page 2 and Slide 3.
A. Yes.
Q. I think this might be what you were referencing earlier with regard to the model development protocol from Anderson and Woessner; is that correct?
A. Woessner.
Q. Excuse me. Thank you.
A. Yeah.
Q. So --

A. Excuse me. Yes, this is precisely what I was discussing earlier.
Q. Okay. So you use the Anderson and Woessner text to discuss the model development protocol; is that right?
A. Yes.
Q. Okay. Did you adapt this flow chart from the Anderson and Woessner -- Woessner text?
A. Yes.
Q. Okay. And then sort of flipping through the other sections of this PowerPoint, it looks like you continue to use it throughout the lecture; is that right?
A. Well, the purpose of this lecture is to provide an overview of the model development protocol, and so the different slides here are explaining each of the different steps involved in the model development process, and thus it relates to the different items on that -- on that flow diagram.
Q. Is that a yes?
A. Yes.
Q. Okay. Are you familiar with

the text Guidelines for Evaluating Groundwater Flow Models by Thomas Reilly and Arlen Harbaugh?

A. I'm aware of that, yes.

Q. Do you consider that text to be a reliable authority in the field of groundwater modeling?

A. Again, I -- I --

MS. BAUGHMAN: Object to the form.

THE WITNESS: I think it's a helpful book.

Q. BY MR. ANTONUCCI: Okay. How about the text Calibration and Uncertainty Analysis For Complex Environmental Models by John Doherty; are you familiar with that?

A. Yes.

Q. And John Doherty is the individual who developed the PEST code; is that right?

A. That's correct.

Q. Do you consider Calibration Uncertainty Analysis For Complex Environmental Models to be a reliable authority in groundwater modeling?

MS. BAUGHMAN: Object to the form.
THE WITNESS: I think it's a -- it's a good reference for calibration.
Q. BY MR. ANTONUCCI: Okay. And earlier you -- you mentioned working with Dr. Prabhaker Clement on a grant or some -- the project at the University of Alabama; is that right?
A. That's correct.
Q. Dr. Clement is the principal investigator of that project?
A. That's correct.
Q. What's your opinion of Dr. Clement?
A. Dr. Clement and I have worked together professionally since the earliest days of my career. I consider him a very good researcher and also a close personal friend. And he and I are also currently co-investigators on a NOAA-funded research grant.
Q. All right. I'm going to sort of refocus attention on the ATSDR reports which you were asked to provide opinions

about.

That's correct, that you were asked to provide opinions on ATSDR's Tarawa Terrace reports; right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I'm not sure I would phrase it that way. We were asked to conduct a post-audit and render opinions relative to that post-audit, and -- and that involved -- I'm going to take that back.

Yes, we did render opinions on these reports.

Q. BY MR. ANTONUCCI: Okay. These reports deal with, at a very basic level, groundwater models; right?

A. What do you mean by "a very basic level"?

Q. I don't mean to say that the reports themselves are basic. I guess I should say, like, essentially they deal with groundwater models; is that correct?

A. That's correct.

Q. Okay. Groundwater models are simplified versions of reality; right?
A. That's correct.
Q. And we should never expect a groundwater model to perfectly reproduce subsurface conditions; is that correct?
MS. BAUGHMAN: Object to the form.
THE WITNESS: That's correct. I would not expect any model to perfectly replicate the real-world system that it is meant to simulate.
Q. BY MR. ANTONUCCI: Okay. If you could please turn your attention back to Exhibit 8. That's the PowerPoint.
A. Sure.
Q. I'd like you to turn to Slide 14.
A. Yes.
Q. Okay. There are two quotes on this slide; right?
A. Correct.
Q. The first one says "One of the most insidious and nefarious properties of scientific models is their tendency to take

over, and sometimes supplant, reality." That quote is attributed to Erwin Chargaff?

A. That's correct.

Q. Did I read that correctly?

A. Uh-huh.

Q. And that was quoted in J.J. Zuckerman, The Coming Renaissance of Descriptive Chemistry, Journal of Chemical Education in 1986?

THE REPORTER: In what year?

MR. ANTONUCCI: 1986.

Q. Is that correct?

A. Yes.

Q. The next quote on the page says, quote, "... all models are approximations. Essentially, all models are wrong, but some are useful." And that quote is attributed to George E.P. Box.

Did I read that correctly?

A. Correct.

Q. And that's from George E.P. Box and Norman R. Draper, Empirical Model-Building and Response Surfaces 2007; is that right?

A. Correct.

Q. This is the last slide of your lecture.

A. That's correct.

Q. Why did you choose to end your lecture with these quotes?

A. Because it's a -- it's a fun launching pad for a discussion in the class. I read these quotes and I ask the students, What do you think of these statements? If models are wrong, why are you taking this class?

And that leads to a -- typically to a very constructive discussion of what's kind of captured in Box's quote there that, yeah, you should never expect a model to be a perfect replication of reality; however, models are extremely valuable as an -- as an interpretive tool, a historical reconstruction tool, and in many cases they're the best and only tool we have.

And so, again, it's meant to stimulate a discussion where I then talk about the benefits of modeling, I talk about all the different cases in -- in groundwater management and analysis where models are critical.

Q. You agree that all models are approximations?

A. Yes.

Q. You agree that all models are wrong?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Wrong in the sense that they're all simplifications of reality. That's the context of his statement here.

Q. BY MR. ANTONUCCI: So we can't expect a model to be a perfect representation of reality; right?

A. That's correct.

Q. You can put Exhibit 8 aside now.

So I understand that you were asked to provide a post-audit of ATSDR's Tarawa Terrace groundwater flow and transport model; is that correct?

A. Correct.

Q. Were you asked to do any other evaluation of ATSDR's Tarawa Terrace flow and transport model?

MS. BAUGHMAN: Object to the form.

THE WITNESS: What do you mean by "evaluation"?

Q. BY MR. ANTONUCCI: Did you do anything -- strike that.

Were you asked to do anything other than the post-audit?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Jeff and I were asked to perform some additional simulations using the models to -- with respect to how the model output varies as a function of retardation factor.

The -- the beginning simulation time or the -- excuse me -- the -- when the contaminants were released. And both of those, the results of that were included in Morris Maslia's rebuttal report.

In other words, we were asked to run the models and post process the results and generate some of the graphics that Morris then relied on in his report, and then we were -- most recently we -- we did an analysis where we varied the reaction rate and determined how sensitive the model was to the reaction rate.

Q. BY MR. ANTONUCCI: Is reaction rate a synonym for biodegradation rate?

A. It includes the biodegradation rate, yeah.

Q. Are there other -- so is it correct that reaction rate and biodegradation rate are not the same thing?

A. In general, the -- the reaction rate can include any kind of decay of the contaminant. Most commonly that's a result of biodegradation.

But, you know, in the grand scope of transport modeling, for example, if you're simulating a radioactive contaminant then it would simulate the half-life and decay of the contaminant.

Q. So you performed a sensitivity analysis varying the --

A. The reaction --
Q. -- reaction rate; is that right?
A. Correct.
Q. You did not vary the biodegradation rate?
A. Well, the reaction rate is inclusive of the biodegradation rate in this case.
Q. Does it include anything else?
A. I -- I believe that's predominantly what it's meant to represent in this case.
Q. Okay. And when were you asked to perform that sensitivity analysis?
A. Couple of weeks ago, maybe.
Q. Was it more than a month ago?
A. No.
Q. Was that after you had disclosed your rebuttal report?
A. Yes.
Q. Other than the figures that you created for Mr. Maslia's rebuttal report and the sensitivity analysis that we've already discussed, were you asked to do any other

evaluation of ATSDR's Tarawa Terrace groundwater flow and transport model?

A. No.

Q. Did you review the data mining techniques that ATSDR employed to generate their groundwater flow and transport model?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I recall reading about what Morris referred -- or what was referred to as the data mining process, but I'm not sure I could recall specific details.

Q. BY MR. ANTONUCCI: So is it fair to say you didn't thoroughly evaluate the data mining process that ATSDR undertook?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I -- I reviewed what was in, I believe, Chapter A -- A, C, and F.

Q. BY MR. ANTONUCCI: Okay. Did you review the conceptual model for the Tarawa Terrace groundwater flow and transport model that ATSDR created?

A. Yes.
Q. Can you describe that review, please.
A. Well, the -- the conceptual model was described in the Chapters A, C, and F, and I reviewed it as I -- in that context.
Q. Did you undertake any other review of the conceptual model, apart from your review of the reports?
A. No.
Q. Did you note any flaws in the conceptual model?
A. I don't recall anything that stood out to me as being flawed or a bad assumption, no.
Q. Okay. If you had noted any flaws, would you have included that in your report?
A. Depending on the magnitude of the flaw, I suppose, yes.
Q. How big would a flaw have to be to be included in your report?
A. Well, one of the opinions in our report was the -- the methods that they followed were sound and followed good

scientific and engineering practices and, yeah, I just -- I did not find anything that -- that I was -- would consider to be an error in their process.

Q. If you had noted a flaw in ATSDR's conceptual model, do you believe that recalibration of the models using the post-audit data would have yielded substantive changes in ATSDR's original results?

MS. BAUGHMAN: Object to the form. Incomplete hypothetical.

THE WITNESS: Can you say that again.

Q. BY MR. ANTONUCCI: Sure.

Suppose you had noted a flaw in ATSDR's conceptual model. Do you believe that recalibration of the ATSDR models using your post-audit data would have yielded substantive changes in ATSDR's original results and conclusions?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I think their conceptual model was -- was sound and consistent with the hydrogeologic conditions at Tarawa Terrace, and I think the model was well calibrated.

Q. BY MR. ANTONUCCI: Do you have any opinion about whether or not a -- Mr. Maslia or Dr. Aral should have reran the model using your post-audit data?

A. Yes.

Q. What is that opinion?

A. So the -- the objective of the post-audit was to take the original MODFLOW and MT3D models and evaluate the performance of the model with additional data which was not available to them at the time they built the model.

And when they built the model, they had two sets of data. They had PCE -- well, they had a large set of head and flow data that they used to build a well-calibrated flow model, which is the foundation of the transport model.

To calibrate the transport model, they had a set of PCE concentrations, I believe there were 36 at -- at different points in time at monitoring well locations.

And then they had some concentrations of water at the water -- Tarawa Terrace water treatment plant.

The objective, as I understand it, the original study was to do historical reconstruction of the concentration of the water at the water treatment plant based on the -- the migration of the plume through the Tarawa Terrace aquifer.

And when they did their calibration, the -- if you look specifically at the PCE -- measured PCE -- observed PCE concentrations at the observation wells, there was a high bias for observed concentrations in the lower range, but where there was high, observed concentrations, the simulated concentrations matched quite closely.

That's significant because that means that in the center of the plume where the concentrations are the greatest, the model did a good job predicting the concentrations.

Now, that happens to correspond to Well TT-26, which as the model showed was the primary contributor of contaminated water to the Tarawa Terrace water treatment plant.

After they did their initial calibration --

INTERCOM SYSTEM: Hi everyone. Trina and her dog are in her office. If you want to go over there and say hi to -- to the dog and also to Trina if you want, please head over there. Thank you.

THE WITNESS: The -- they -- they -- the -- the model simulated concentrations at the water treatment plant matched the observed concentrations at the water treatment plant extremely well.

So when we did our post-audit work, we had an additional 318 measured concentrations, observed concentrations. A much richer set that they didn't have in the original case.

So -- but what we didn't have is, you know, additional concentrations at the water treatment plant, of course, because they stopped pumping due to the contamination.

So when we did our post-audit, we found that the -- if you look at the simulated versus observed concentrations from the extended simulation we constructed in the post-audit, there's a significant amount of variance in the observed concentrations.

And that variance caused some -- some high fluctuations in the area -- in the error. However, the errors seemed to be well balanced, meaning the model did a good job at simulating the primary trajectory of the plume.

In fact, if you look at the bias, the bias we got from the extended simulation with the additional data was -- was smaller than the bias they had with the initial concentrations at the observation wells, which I believe strengthens the evidence supporting

the accuracy of the additional model.
And, therefore, I -- there's no reason for me to believe, based on the results of the post-audit, that the initial model was wrong, especially when it comes to the concentrations at the water treatment plant.
It did an excellent job and there's nothing in the post-audit that would warrant, I believe, that would be strong evidence to say, hey, there's something wrong with the original model.
Q. BY MR. ANTONUCCI: Well, thank you, Dr. Jones, I appreciate that. But my question was whether they should have reran the model using the newly available data?
MS. BAUGHMAN: Object to the form. Asked and answered.
THE WITNESS: We did rerun the model. That's part of the -- that's what we did in the post-audit, is we ran the model.
Are you asking me if they should have recalibrated it or if they

should have rerun the model?

Q. BY MR. ANTONUCCI: Should they have recalibrate the model using newly available data?

A. We -- well, before you recalibrate it, you would do an analysis precisely in the fashion that we did. You would test the original model using the new data.

And if in that process there was some evidence that there was a major flaw with the original model or that you would get significantly different answer, then that may warrant a reevaluation. But we did not find any evidence to that.

MR. ANTONUCCI: Okay. I'd like to clarify for the record. In my previous question I used the term "they." I was referring to Morris Maslia and Dr. Aral and their expert reports.

All right. I would -- I would like to discuss a new document, so I am going to mark for identification Exhibit 9.

(Exhibit 9 was marked for identification.)
Q. BY MR. ANTONUCCI: All right. Dr. Jones, Exhibit 9 is the document titled "Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Chapter A: Summary of Findings."
And for the record, this document has the Bates range beginning CLJA_WATERMODELING_09-0000615638 and ends with the Bates number ending in 615753.
And when I say "Bates number," Dr. Jones, do you know what I'm referring to?
A. My understanding is it's a -- it's a systematic way of referring to content that's been submitted in litigation.
Q. Right. It's the numbers at the bottom; right?
A. Right.
Q. Okay. So I would appreciate if you could turn to Page A48 of Exhibit 9, and that page ends in Bates Number 615699.

Okay. So the caption underneath the figure on Page A48 says "Figure A21. Sensitivity of tetrachloroethylene concentration in finished water at the water treatment plant to variation in water-supply well operations, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina. [PCE, tetrachloroethylene; see text for discussion of points A-I]."

You're familiar with this figure; right, Dr. Jones?

A. Yeah, I've seen it before.

Q. This is one of the figures you had tabbed in your copy of the report; right?

A. No, it was not.

Q. Okay. Well, this is a graph from ATSDR's sensitivity analysis of the Tarawa Terrace model; isn't that right?

A. Correct.

Q. And this shows the change in PCE concentrations in finished water based on different well pumping schedules; is that right?

A. Correct.

Q. And, Dr. Jones, you're aware that ATSDR used the pumping and schedule optimization system tool to simulate otherwise unknown supply well pumping rates; right?
A. Yes.
Q. And in this graph, all of the simulations assumed a constant mass loading rate of 1,200 grams per day; is that right?
A. Yes, I assume so.
Q. And that constant rate of 1,200 grams per day is the same mass loading rate that you used when conducting the post-audit; right?
A. Correct, we did not change the model.
Q. Okay. So looking at Figure A21 on Page A48 of Exhibit 9, we see that all of these use a mass loading start date of January 1953; is that correct?
A. Where are you reading that?
Q. Strike that.
All of the -- ATSDR's model assumed a PCE mass loading start date of January 1953; is that right?

A. As far as I know, yes.
Q. Okay. And that's the same mass loading start date that you used in your post-audit?
A. Correct.
Q. Okay. So on Figure A21, that blue line that's -- it's labeled A.
Do you see that?
A. Yes.
Q. This blue line shows the earliest arrival of PCE at the water treatment plant under the maximum pumping schedule; right?
A. Correct.
Q. Okay. And so that blue line shows a concentration of 0.001 micrograms per liter of PCE starting just before January 1955; is that right?
A. That looks correct, yes.
Q. Okay. Now, there's also a red line here, and that one is labeled B.
Do you see that?
A. Yes.
Q. And that is the calibrated model; right?

A. Correct.
Q. Okay. That's the same -- that model used the same parameters that you used in your post-audit; is that right?
A. Yes.
Q. So that red line, the calibrated model, shows a concentration of 0.001 micrograms per liter of PCE starting on or about January 1955; right?
A. Correct.
Q. Okay. Next I'd ask that you look at the black line. That one is labeled C.
A. Yes.
Q. So this shows the late arrival of PCE at the water treatment plant under the Minimum Schedule Number 2; is that right?
A. That looks correct.
Q. Okay. And under the Minimum Schedule 2, TT-26 is operated at at least 25 percent capacity; right?
A. Yes.
Q. And that black line that's line -- letter C shows a concentration of 0.001 micrograms per liter of PCE starting

sometime after January 1955; right?
A. Yes.
Q. All right. Now, finally there's the green line, and that one is, I believe, split into D and G.
Do you see what I'm referring to?
A. Yes -- well, let's see. The black -- oh, yes, the -- Well TT-26 not operated January '62 to February 1976, hence there's a gap, yes.
Q. Okay. So that green line, that shows the arrival -- excuse me -- it shows the latest arrival of PCE at the water treatment plant under Minimum Schedule 1; right?
A. That's -- that looks correct, yeah.
Q. Okay. And minimum -- Minimum Schedule 1 is where Well TT-26 is not operated between January of 1962 and February of 1976?
A. That's correct.
Q. Okay. So that green line shows a concentration above 0.001 micrograms per

liter of PCE starting sometime between
January 1955 and January of 1960; right?
A. Starting, yes.
Q. Okay. And then there's sort of a gap where the green line is not represented on the figure, and then it restarts again sometime between January 1970 and January 1975; is that right?
A. Yes.
Q. Okay. So in general, that blue line, that shows the highest PCE concentrations over time; right?
A. Yes.
Q. Then that red line there, that shows the next highest PCE concentrations over time; right?
A. Yes.
Q. Then the black line shows the next highest PCE concentrations over time?
A. Yeah, I think that's fair.
Q. Okay. And, finally, that green line shows the lowest PCE concentrations over time; right?
A. Correct.
Q. Okay. So the arrival of PCE at

the water treatment plant is dependent on when PCE contamination arrived at the supply wells; right?

A. Can you say that again.

Q. Of course.

The arrival of PCE at the water treatment plant is dependent on when PCE contamination arrived at the supply wells; right?

A. Correct.

Q. The concentration of PCE simulated by the model is dependent on when PCE contamination arrived at the supply wells; right?

A. The concentration at the treatment plant. You said -- I'm sorry, can you state that one more time.

Q. Of course.

The concentration of PCE simulated by the model is dependent on when PCE contamination arrived at the supply wells; right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Yeah, I -- I

think you're not clear in how you
formulated that question. Do you mean
the concentration at the water
treatment plant?
Q. BY MR. ANTONUCCI: As opposed to?
A. You just said "the concentration."
Q. Sure. Yes. Let's say -- I'll rephrase the question.
A. Okay.
Q. The concentration of PCE simulated by the model at the water treatment plant is dependent on when PCE contamination arrived at the supply wells; right?
A. Correct.
Q. Okay. And to be clear, the contamination at the water treatment plant was assumed to be the same level at the tap in consumer's homes; right?
A. Would you state that again.
Q. Sure.
The ATSDR assumed that contaminations of PCE at the water treatment plant were the same as those after the water

had gone through the water distribution system and was at the point of use by the consumer; is that right?

A. Yeah, I'm not sure on that.

Q. Do you know if -- I mean, should there be a different contamination concentration at the water treatment plant versus at the tap?

A. I know that one of the areas that's been debated in the -- in the rebuttals and the expert report is how much the concentration changes through the water treatment process, and I know that was reviewed by the expert panel and others.

I'm generally familiar with that discussion that that volatilization issue was addressed by Sabatini. That is not my area of expertise.

I will say that what the model simulates is the water that would be pumped, the concentration of the water as it's pumped out of the aquifer, that's what -- the model does not inherently explicitly include the treatment process as part of the model.

Q. Okay.

A. It's simply how the contaminants move through the aquifer through the wells.

Q. Do you agree that there would be losses of contamination to volatilization during the treatment process?

MS. BAUGHMAN: Object to the form.

THE WITNESS: That is not my area of expertise.

Q. BY MR. ANTONUCCI: Okay. However, the model -- the model doesn't take that into account --

MS. BAUGHMAN: Object to the form.

Q. BY MR. ANTONUCCI: -- correct?

A. The model does not explicitly simulate volatilization.

Q. Does the model implicitly simulate volatilization?

A. It potentially could.

Q. Can you please elaborate.

A. Sure. Suppose that the concentrations used to calibrate the model were concentrations taken from treated water.

If the model is then calibrated to predict accurate concentrations at the water treatment plant based on observed concentrations of treated water, then you could argue that it implicitly includes the effects of any volatilization.

Q. Did the model calibrate to treated water samples?

A. I know some of the samples -- from what I've read, it's believed some of the samples may have been post-treated water, and -- but I don't know if there's any conclusion on the majority of the samples.

Q. Okay. Well, it's fair to say that concentrations of PCE at the water treatment plant that's simulated by the model is dependent on when PCE contamination began entering the aquifer; right?

A. Yeah.

Q. Based on your review of the reports, is it your understanding that ATSDR assumed PCE contaminants started leaking when ABC Cleaner started operating in 1953?

A. Yes.

Q. Hypothetically, if ABC Cleaners

opened later than 1953, would that impact the arrival time of contaminants at the water treatment well?
A. It would --
MS. BAUGHMAN: Object to the form. Incomplete hypothetical.
Go ahead.
THE WITNESS: It makes a small difference in the concentrations at the water treatment plant.
Q. BY MR. ANTONUCCI: Okay. So let's say that the --
MS. BAUGHMAN: Were you finished answering?
THE WITNESS: Let me clarify.
I know some different dates have been proposed, argued by the DOJ experts as a more accurate start date.
Having run the model at both start dates, I -- I believe that the differing start dates as proposed by the DOJ experts does not make a substantial difference in the concentrations that are simulated at the water treatment plant.

Q. BY MR. ANTONUCCI: Okay. So it doesn't make a substantial difference; right?
A. No, that was part of Morris Maslia's rebuttal report.
Q. Is that a yes?
A. Yes.
Q. Okay. Does it make any difference?
A. It makes some difference.
Q. Okay. Hypothetically, let's ignore the start dates proposed by differing experts.
A. Okay.
Q. Let's say that the contamination began in 1970. How big of a difference would that make?
MS. BAUGHMAN: Object to the form.
THE WITNESS: If the contamination started in 1970 --
Q. BY MR. ANTONUCCI: Let's say -- what would the impact on 1981 data be?
MS. BAUGHMAN: Object to the form. Are you asking in terms -- wait, in 1981?

Are you asking in terms of the concentration or the arrival time? I object to the form. I don't understand the question.

THE WITNESS: So if --

MS. BAUGHMAN: It's also outside the scope.

THE WITNESS: If the contamination was not released until 1970, and that was simulated in the model, yeah, I would suspect that would lead to a much more significant difference in the results.

Q. BY MR. ANTONUCCI: Okay. If you were to -- to dispose of dry cleaning solvents improperly -- which I know you never would -- they would be -- you would -- let's assume you would dump them on the ground.

Do you understand where my hypothetical is so far?

A. Okay, yeah, sure.

Q. If you were to just pour dry cleaning solvents on the ground outside, would the PCE from that solvent enter the aquifer immediately?

MS. BAUGHMAN: Object to the form. Incomplete hypothetical. Foundation.
THE WITNESS: Immediately, no.
Q. BY MR. ANTONUCCI: Okay. Can you elaborate?
A. Well, if you -- for example, if you had a really high water table, the water table's close to the surface, it would enter it very rapidly. Or if you had highly permeable materials between the ground surface and the aquifer, that contamination, again, could happen very rapidly, so it's -- depends on the context.
Q. Sure. I guess is the inverse true? If you had a low water table or low permeability materials?
MS. BAUGHMAN: Object to the form.
THE WITNESS: There are conditions where it would take longer to get to the groundwater, yes, if it's starting at the ground surface.
Q. BY MR. ANTONUCCI: Okay. So from the ground surface to the aquifer it has

to travel through something; right?
A. Yeah.
Q. And that takes time, depending on different conditions; right?
A. Yeah, another factor is the precipitation. How -- and snow melt, precipitation, how much water is -- is traveling through -- we call that the vadose zone between the ground surface and the water table.
And, you know, there are conditions that are a variety of conditions that would impact the -- the -- the rate of transport from the ground surface to the aquifer.
Q. Okay. Does MT3DMS model contaminant transport through the vadose zone?
A. No.
Q. Does TechFlowMP?
A. I believe it does, yes.
Q. And then for my own understanding, the vadose zone and the unsaturated zone, are those the same concept?
A. Yeah, same thing.

Q. If -- if the DOJ experts are correct, would you agree that it makes a substantial difference for calculating exposure to someone at Tarawa Terrace prior to DOJ's start but after ATSDR's mass loading start?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I don't understand the question.

Q. BY MR. ANTONUCCI: Not sure I do either.

So say the true start date of contaminant mass loading at Tarawa Terrace is sometime between when ATSDR said it started and when DOJ said it started.

You on board?

A. So January '53 is when ATSDR said it started. To my understanding the DOJ said maybe June '54 or July '54? Does that sound right?

Q. Sounds about right.

A. Okay.

Q. Sometime in between there.

A. Okay.

Q. If that was when mass loading started, would it make a substantial difference for calculating exposure for someone who was at Tarawa Terrace?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Your question is not -- you said "if that is when." We just talked about two different dates or -- can you restate the question?

Q. BY MR. ANTONUCCI: Sure.

Let's say contaminant mass loading started in December 1953. Would --

A. One year later, roughly, yeah.

Q. Would that make a substantial difference for calculating exposure to someone at Tarawa Terrace?

MS. BAUGHMAN: Object to the form.

THE WITNESS: No, I think one of the dates that we simulated may have been January 1954, which is one month off from that, and kind of between the January '53 and July '54 dates and, no, none of those changes in the date made a substantial difference in the concentration of the water at Well TT-26 or in the concentration of the water at the Tarawa Terrace water treatment plant over the majority of the time frame.

Q. BY MR. ANTONUCCI: Okay. How far apart were the simulated concentrations from this experiment that you did for Mr. Maslia's report?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Well, if -- if you have the copy of the Maslia rebuttal I could -- we could look at the graph.

MR. ANTONUCCI: Okay.

THE WITNESS: It -- in my opinion, there -- there was a minor difference through a majority of the simulation period.

Q. BY MR. ANTONUCCI: Were there major differences at any time in the simulation period?

MS. BAUGHMAN: Object to the

form.

THE WITNESS: Not that I would consider significant. There was -- if you -- during the very early years, there was maybe a larger gap between the curves, but that is where the concentrations are really low.

And once the -- you get a few years later where the concentrations are higher, those curves -- the distance between those curves narrowed significantly and through most of the period from, you know, '60s, '70s, through the '80s, there's very little difference.

Q. BY MR. ANTONUCCI: Do you recall the magnitude of the difference at any time?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Numerical magnitude, no.

Q. BY MR. ANTONUCCI: What numerical magnitude would you consider significant?

MS. BAUGHMAN: Object to the form.

THE WITNESS: That depends on the context.

Q. BY MR. ANTONUCCI: What -- what numerical difference would you consider minor?

A. Depends on the context.

Q. What would impact your consideration there?

A. Well, for example, in this case for the majority of the range the -- the concentrations are at a very high rate well over the MCL level of five.

And qualitatively looking at that, it seemed like the model was highly insensitive or relatively insensitive to the -- to the start date given the start dates that were considered.

Q. Okay. And earlier you mentioned that the model is perhaps better at calculating concentrations at TT-26 than over the wider area. Am I -- is that correct?

MS. BAUGHMAN: Object to the form.

THE WITNESS: That's not how I would characterize what I said.

Q. BY MR. ANTONUCCI: Can you please repeat it for me.

A. Sure.

MS. BAUGHMAN: Object to the form.

What's the question? I don't -- let's make sure there's a question.

THE WITNESS: Do you want me to restate what I said earlier relative to simulated concentrations at observation wells versus -- sure.

As I mentioned earlier, I believe the concentration data used to calibrate and evaluate the performance of the original flow and transport model consisted of two types of data.

One of which was PCE concentrations that were sampled at observation wells; and the other is a -- was a series of measured concentrations at the water treatment plant.

When you have an individual sample taken at an observation well, it's a small amount of water from a very small part of the aquifer, a specific point location, and -- and it has -- it's more susceptible to sampling errors and -- and the impact of local scale heterogeneities.

And when they -- when they calibrated to that, they had a good match where the simulated observed concentrations were high, and a bias where the observed concentrations were low.

The concentrations that were measured -- or that were observed at the water treatment plant are different because that involves the collection of water from a variety of wells over a period of time, and the water pumped through those wells comes from a -- a much broader part of the aquifer than when you take a simple sample.

And those -- the contaminant is

then brought in and it's mixed and averaged. And so it has much less variation and sampling error than you'd get with the individual error.

So I would consider that to be, I would say, the gold standard of -- of data for calibrating the original model. And it matched, in my opinion, the model-simulated results matched those observed concentrations at the water treatment plant quite well.

Q. BY MR. ANTONUCCI: Okay. Before this deposition began, when speaking to counsel, you used the phrase "dilution is the solution to pollution"; right?

A. Yeah.

Q. That's kind of what we're talking about here, isn't it?

MS. BAUGHMAN: Object to the form.

Q. BY MR. ANTONUCCI: There were multiple wells, some were presumably pumping clean water, some were presumably pumping contaminated water, mixing and diluting at the water treatment plant; right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Yeah -- well, the context are a little different. We were talking about dirty air being blown out of the valley.

But when you calculate the -- the concentration of water at the water treatment plant, you have to consider the -- the pumping rate for each of the supply wells to the water treatment plant, and then the concentration of the water coming in.

So there's a mixing process that's represented in the equation we use to come up with those concentrations.

It weights the -- the overall concentration by the product of the individual concentrations and the individual pumping rates.

So there's a mixing and, yeah, there's a dilution process. For example, the -- the water coming in in Well TT-26 has a higher concentration than the water you measure at the water treatment plant because it's mixed with water from other supply wells that have generally a lower concentration.

Q. BY MR. ANTONUCCI: Okay. So -- all right. Thank you for answering that.

If you could turn to Page A2 of Exhibit 9. I think this will maybe tie up what we were discussing earlier. And that is the page ending in Bates Number 615653.

So the footnote on this page, Footnote 6 says "For this study, finished drinking water is defined as groundwater that has undergone treatment at a water treatment plant and is delivered to a person's home. The concentration of contaminants in treated water at the water treatment plant is considered the same as the concentrations in the water delivered to a person's home. This assumption is tested and verified in the Chapter J report (Sautner et al. in press 2007). Hereinafter, the term 'finished water' will be used."

Did I read that correctly?

A. Yes.
Q. So I will represent to you that Chapter J was never published. However, a draft of Chapter J was produced in this litigation with the Bates Number CLJA_WATERMODELING_05-22 -- excuse me -- 212246 through 212309.
Have you reviewed the draft of Chapter J?
A. No.
Q. Do you know whether any testing was done to compare the concentrations of contaminants delivered to the water treatment system with the concentrations of contaminants delivered to a person's home?
A. Not that I'm aware of.
Q. Okay. Please turn to Page A13 of Exhibit 9. That's the page ending in Bates Number 615664.
A. Got it.
Q. Okay. So there's a sort of list of paragraphs on this page. One of them starts with the Number 4.
Do you see that?
A. Yes.

Q. So this says "The monthly concentrations of PCE assigned to finished water at the Tarawa Terrace WTP were determined using a materials mass balance model (simple mixing) to compute the flow-weighted average concentration of PCE. The model is based on the principles of continuity and conservation of mass (Masters 1998).
Did I read that correctly?
A. Yes.
Q. Do you know what a materials mass balance model is?
A. I know what they're describing here, yes.
Q. So you agree that simple mixing flow-weighted average has no calculation simulating processes where contaminants are lost during storage, treatment, or distribution?
A. That's correct. It's simply taking the -- the pumping rates and concentrations of the supply wells to determine what the resulting concentration of the mixed water would be at the water

treatment plant.
Q. So a simple mixing flow-weighted average wouldn't explicitly take into account something like sorption or volatilization?
MS. BAUGHMAN: Object to the form.
THE WITNESS: That's not what it's meant to do, no.
Q. BY MR. ANTONUCCI: It's true that ATSDR's Tarawa Terrace model did not include a calculation simulating contaminant losses during storage, treatment, or distribution; right?
A. Not that I'm aware of.
Q. You agree that ATSDR's Tarawa Terrace model simulated PCE concentrations as equivalent to the mixture of water straight out of the wells?
A. Yes.
Q. And ATSDR assumed continuity and conservation of mass in its simple mixing model; right?
A. Yes.
Q. Do you agree that some losses

during treatment, storage, and distribution are inevitable?

MS. BAUGHMAN: Object to the form. Outside the scope.

THE WITNESS: That is not my area of expertise. I don't have an opinion on that.

MR. ANTONUCCI: Okay. I'd like to break for lunch now.

THE WITNESS: Great.

THE VIDEOGRAPHER: We're off the record. The time is 12:10.

(The lunch break was taken from 12:10 p.m. until 1:13 p.m.)

THE VIDEOGRAPHER: We're back on the record. The time is 1:13. This is Media Number 3.

Counsel may proceed.

Q. BY MR. ANTONUCCI: All right. Dr. Jones, I remind you that you are still under oath.

Have you discussed the substance of your testimony with anyone during the break?

A. Only superficially.

Q. Can you describe what you mean by that, please.
A. Hey, Norm, you're doing a good job.
Q. Okay. Did you discuss it -- did you discuss it any further?
A. No.
Q. All right. A couple of things I want to circle back on from before the break. First is going to be this document, which I will mark as Exhibit 10.
(Exhibit 10 was marked for identification.)
THE WITNESS: Okay.
Q. BY MR. ANTONUCCI: All right. Dr. Jones, do you know what this is?
A. Yes.
Q. What is it?
A. It appears to be the model simulation results based on varying the reaction coefficient over three different values, and it shows the resulting concentrations at the water treatment plant and at Well TT-26.
Q. Okay. What are the three different values that you used to perform

this analysis?
A. One of which was the -- the -- the middle line. The red line is the .005, which was what was used in the original ATSDR model. And one of those, as I understand, was a .004 value that was suggested or used by Faye. And then another one was a .006 value, which was suggested by -- by Dr. Aral.
Q. Okay. And for all of those values, those are different values of reaction rates; is that right?
A. Yeah, so the only thing that was changed in the model was the reaction rate, and then we looked at what impact that had on the simulated concentrations for these two outputs.
Q. Okay. And when did you perform this analysis?
A. A week or two ago.
Q. Okay. So there are two graphs here. I want to make sure we're looking at the same one. There's one that has a caption that says "MT3DMS," "Calibrated," and "TechFlowMP" in the top right. Then there's one that has the sort of legend in the middle

of the page; is that right?

A. Top left, yeah.

Q. Excuse me, thank you.

A. Yep.

Q. So what you just described, was that the version of the document with the legend in the center of the page or the left?

A. So the one with the legend in the center is the simulated concentrations at the Tarawa Terrace water treatment plant, and the one with the legend in the upper left corner is the simulated concentrations at Well TT-26.

Q. Understood.

And are the reaction rates the same for the different categories in both graphs?

A. Yes. Yeah, they're both based on the same model results, yeah.

Q. And then you also in front of you should have a series of spreadsheets.

Do you see those?

A. Yes.

Q. What -- what do these show?

A. So the first column are the

monthly dates through the simulation period, and then for each month the second column would be the -- the concentrations at -- resulting from -- well, let me back up a little bit.

This -- I believe this spreadsheet represents the concentrations at the water treatment plant.

Q. Dr. Jones, when you say "this spreadsheet," are you referring to the one with the Bates number ending in 302 or document name ending in 302 up at the top?

A. 299.

Q. 299, okay.

All right. I'm on the Page 1 of the spreadsheet with the title CL_PLJ-EXPERT_DAVIS_0000000299.xlsx. Is that where you are?

A. Yes.

Q. And this is what you were describing in your last answer?

A. Yeah, so the first column or the simulated concentrations resulting from -- or excuse me -- the first column after the date it says r00004_orig, that would be the concentrations resulting from the simulation featuring a reaction rate of .004.

Likewise, the next column would be the results featuring a reaction rate labeled as -- or corresponding to .0005. And the last column would be the results with a simulation with a reaction rate of .0006.

In other words, it's the actual numbers used to generate the plots.

Q. Okay. I will ask you to take a look through CL_PLJ-PLG-EXPERT_DAVIS_299 and ask if you're familiar with the data contained in this spreadsheet?

A. Yes, I am. I generated it.

Q. Okay. I'm interested in the difference between the values in the three columns, the Robert Faye column, the ATSDR column, and the Dr. Aral column.

If I refer to them that way, do you understand what I mean?

A. Yeah.

Q. Okay. What -- where is the smallest discrepancy between the three data points? At what time?

A. The beginning.
Q. Okay. Is that because they all simulate a concentration of 0 micrograms per liter?
A. That's partly why.
Q. Okay. Where is the largest discrepancy between any two columns on this spreadsheet?
A. On the spreadsheet, I -- I'm not sure. If I had the spreadsheet in front of me I could use an Excel function to find that, but looking at the graphs, it appears that the -- the -- the spread between the curves increases until roughly late '60s and then it stays relatively constant after that in terms of the log-log plot.
Overall, they're -- in my opinion, they're really close. In terms of a model result, this is what I would call the models being highly insensitive to changes in the reaction rate.
Q. Did you just use the phrase "log-log plot"?
A. A log plot. So that means the vertical axis is based on the log of the

concentrations.

Q. Okay. And both of these graphs use a logarithmic scale for the Y axis; is that right?

A. That's correct.

Q. You I think stated that the concentrations, the spread between the concentrations seems to stabilize around the late '60s; is that what you said?

A. Well, there's -- there's actually a reason for that.

Q. Okay.

A. Well, there's a reason why the curves are closer together in the early years, and that's because, for example, the TT-26 plot, this is the model simulated concentrations at Well TT-26, and the source of the contaminants at the ABC Cleaners is some distance away from Well TT-26.

And so it takes time for the results to get down that far. And it's -- you're looking at -- there is a -- an early arrival, but it's at a really small concentration as a function of the dispersion coefficients used in the model.

So just the fact -- and then the Tarawa Terrace water treatment plant concentrations, those are a function of supply wells which are all downgradient.

The point being, it takes time for the contaminants to reach those wells after it leaves the source and, therefore, there's not much spread.

And you can see the same narrowing of the band in the -- in the probabilistic -- or excuse me -- the uncertainty analysis results, which is results from the same phenomenon I'm describing.

Q. Okay. If you could please turn to Page 5 of that same spreadsheet, which has the title ending in 299.xlsx. I'm just sort of looking at the bottom row. The date is February 1, 1967.

Do you see that?

A. Yeah.

Q. So it looks like under the point I think 004 reaction rate, the PCE concentration in micrograms per liter is 67.16, and then many further digits; is that

right?

A. Correct.

Q. Okay. And for the ATSDR value, that's the 0.005, it's 60.37; is that right?

A. Correct.

Q. And for the Aral value, and that's the .006, it's 54.3; right?

A. Correct.

Q. By my math, that's a -- in terms of percentages, it's a pretty widespread, don't you think?

MS. BAUGHMAN: Object to the form.

THE WITNESS: In terms of contaminant concentrations which are log normally distributed, I would consider that a relatively small chance spread of values.

Q. BY MR. ANTONUCCI: Okay. What do you mean by contaminant concentrations are log normally distributed?

A. Sure. That means there's a -- a statistical analysis you can run on data. When a parameter is log normally distributed means the values cover a very broad range of values over several orders of magnitude.

And if you refer to the rebuttal report, Exhibit 7, this is where I can -- let's see. Give me a second to find the page I'm looking at.

MS. BAUGHMAN: You can use these, too, if that helps.

THE WITNESS: Okay, I got it right -- okay. Figure 3 of the rebuttal report. In this case I took the 318 observed PCE concentrations and ran a statistical analysis to generate a histogram. And if a parameter is log normally distributed, you see that classic bell-shaped curve.

And so this clearly indicates that the PCE values are log normally distributed, which is very typical of concentration data, and, therefore -- that's one of the reasons why people almost always show when they plot concentration data, use a log scale for the concentrations.

Q. BY MR. ANTONUCCI: When you

plot concentrations on a logarithmic scale like you've done here --

A. Yeah.

Q. -- numbers that are -- what's the benefit of using a logarithmic scale? Can you explain that to me?

A. It captures -- given that there's a high variability in concentration data and the fact that they are log normally distributed, it is considered to be the proper way to -- to show them.

And so, yeah, it will -- it also allows you to -- one of the benefits is it doesn't compress the lower part of the plot. So it allows you to get a level of detail on the very small concentrations that you wouldn't get in a -- in a -- in a non -- in a normal arithmetic scale.

Q. At the higher concentrations, would the lines be further apart if you had used an arithmetic scale here?

A. Yes.

MR. ANTONUCCI: All right. I'm going to ask that you please mark Exhibit 11 for identification.

(Exhibit 11 was marked for identification.)

Q. BY MR. ANTONUCCI: Okay. Dr. Jones, this is ATSDR's Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Chapter F: Simulation of Fate and Transport of Tetrachloroethylene (PCE).

Have you seen this before?

A. Yes.

Q. And for the record, this document has the Bates range CLJA_WATERMODELING_01-0000093047 through 93114.

Dr. Jones, could you please turn to Page F28 of this report. That's the page with Bates number ending in 93086.

A. Sure.

Q. Thanks very much.

All right. So I am reading on the last full paragraph of Page F28. This says "The PCE concentrations at water-supply Well TT-26 on September 25, 1985, and

July 11, 1991, were 1,100 and 350 micrograms per liter, respectively, and the elapsed time was 2,151 days (Table F2). Applying these data to Equation 3 yields a degradation rate of 0.00053 per day. Potentiometric levels shown on Figure F7 and F8 indicate that Well TT-26 is located on a direct advective pathway from ABC One-Hour Cleaners. Thus, PCE mass migrates downgradient toward and away from Well TT-26. To the extent migration of PCE mass toward and away from Well TT-26 occurred at about equal rates from 1985 to 1991, the compound degradation rate of 0.00053 per day approximates a long-term average degradation rate. On the other hand, if a significant quantity of the PCE degraded in the vicinity of Well TT-26 was replaced by advection, then a degradation rate computed using Equation 3 is probably a minimum rate.

"Half-lives of PCE reported in the literature range from about 360 to 720 days (Lucius and others 1990). Applying these half-lives to Equation 3 yields first-order degradation rates ranging between .001 and .002 per day, about twice to four times the rate computed using concentrations at water-supply Well TT-26. An initial first-order degradation rate of 0.00053 per day was applied to the MT3DMS model uniformly to every layer for all stress periods. The final calibrated degradation rate was 0.00050 per day, similarly applied."

Did I read that correctly?

A. Yes.

Q. So it seems that Robert Faye, the author of this report, is saying that a higher degradation rate here could be warranted; is that right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: It looks to me like he's -- if that's who wrote this, explaining the logic that was used to calculate the degradation rate that was used in the model, .0005.

Q. BY MR. ANTONUCCI: Is there a reason that you did not calculate -- or perform sensitivity analysis using the values from this portion of Chapter F?

MS. BAUGHMAN: Object to the

form.

THE WITNESS: We were asked to perform an evaluation using the three values specified.

Q. BY MR. ANTONUCCI: Who asked you to do that?

A. The legal team.

Q. All right. You can put that to the side. Thanks, Dr. Jones.

All right. Dr. Jones, did you review the model parameters that ATSDR subjected to probabilistic analysis?

A. Yes, I read a summary of their probabilistic analysis. I'm not sure I remember all the details, but I did review that.

Q. Beyond reading the summary, did you -- beyond reading the summary, did you otherwise evaluate the model parameters ATSDR subjected to probabilistic analysis?

MS. BAUGHMAN: Object to the form.

THE WITNESS: No.

Q. BY MR. ANTONUCCI: You used all the same model parameters in your post-audit

that ATSDR used in the calibrated model; is that right?
A. Correct.
Q. Did you perform any independent evaluation of the appropriateness of those parameters?
A. No.
Q. Okay. Dr. Jones, are you aware of any critiques of ATSDR's Tarawa Terrace model?
A. Yes.
Q. Okay. Well, first, which critiques are -- are you aware of?
A. The critiques first and foremost by the Department of Justice experts we reviewed earlier.
Q. Are you aware of any other critiques of ATSDR's Tarawa Terrace model?
A. I know that there was a review by an NRC panel. There was a review by a -- a peer review by a panel of experts. I'm not sure I would call those critiques, but they're reviews. And I'm aware of -- of a paper published by Prabhaker Clement in The Groundwater Journal.

Q. Are you familiar with critiques that the Department of the Navy has made of ATSDR's Tarawa Terrace model?
A. Yes, I've seen reference to those as well.
Q. Okay. Are you aware of any other critiques of ATSDR's Tarawa Terrace model?
A. Not that I can think of at the moment.
MR. ANTONUCCI: All right. I am going to mark for exhibit -- for identification Exhibit 12.
(Exhibit 12 was marked for identification.)
Q. BY MR. ANTONUCCI: For the record, this document has the Bates range CLJA_HEALTHEFFECTS-0000000479 through 517.
Can you look up at me, Dr. Jones, after you've finished looking through that.
A. Sure.
MS. BAUGHMAN: Did you want him to read it or just flip through it?
Q. BY MR. ANTONUCCI: Dr. Jones, you've mentioned you're aware of the NRC

critique of -- or the NRC's review of the Camp Lejeune modeling done by ATSDR; is that right?

A. That's correct.

Q. Have you read this before?

A. I have skimmed through it, and I can't say I've read every part of it, no.

Q. You cited to this in your rebuttal report, didn't you?

A. Yes.

Q. How did you decide which portions to read carefully and which portions to skim?

A. I -- there were in the -- I remember reading in the documents somewhere a rebuttal to this from Morris Maslia, and so I -- I read -- I was aware with -- of some of the concepts in -- in this document and in the rebuttal.

And in the context of the -- of the post-audit that we did, there were some sections that seemed relevant to things we were discussing.

Q. Okay. Dr. Jones, you agree that the basis used for setting the values of calibration targets was unclear for ATSDR's TT model?

A. Yes.

Q. I ask that you turn to Page 49 of the Exhibit 12.

A. Okay.

Q. I am looking at the one, two, three, fourth bullet point from the top.

Do you see that? The sentence starting with "The PSOpS."

A. Uh-huh.

Q. This says "The PSOpS modeling study is based on the premise that an optimization model can be used to evaluate pumping stresses. Without site-specific pumping data and water-quality data, the results will be nonunique and uncertain."

Did I read that correctly?

A. Yes.

Q. That's a correct statement, isn't it?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I'm not familiar enough with the context to say with

certainty whether that's a correct
statement or not.
Q. BY MR. ANTONUCCI: Okay. Is this one of the sections that you skimmed or one of the sections you reviewed carefully?
A. I don't -- I don't recall reading this specific bullet point.
Q. Okay. On the next bullet point down the last sentence says "The difference indicates that the real system is highly transient and that the model did not account for temporal and spatial averaging effects."
That's a correct statement, Dr. Jones, isn't it?
MS. BAUGHMAN: Object to the form.
THE WITNESS: I'm not willing to say whether or not that's correct or not.
Q. BY MR. ANTONUCCI: Why not?
A. You just read one sentence at the end of a paragraph, so I'm --
Q. Okay.
A. Asking me whether to say whether it's true or not, I would need to

explore the full context of what they're describing before I could have an opinion as to whether or not that's a true statement.

Q. Sure. I'll start from the beginning of that bullet point there. That's the fifth from the top.

It says "Review of water quality monitoring data indicates substantial temporal variability even at a single well."

You agree with that statement, don't you, Dr. Jones?

A. Yes.

Q. Okay. "For example, the seven measurements taken on Well TT-26 from January to September 1985 indicates that the concentrations at this well varied from 3.8 to 1,580 micrograms per liter (see Table 2-8). The model predictions for the same time frame range from 732 to 804 micrograms per liter."

Did I read that correctly?

A. Yes.

Q. "The difference indicates that the real system is highly transient and that the model did not account for temporal and

spatial averaging effects."
Did I read that correctly?
A. Yes.
Q. Now that you've seen the full paragraph, are you willing to offer an opinion about the validity of the last sentence?
MS. BAUGHMAN: Object to the form.
THE WITNESS: I'm not sure what they mean by "temporal and spatial averaging effects." The fact that the simulated concentrations differ from the observed concentrations which vary quite significantly is a phenomenon that we've discussed at length in our -- both our post-audit report and our rebuttal document.
There's a -- there are very good reasons why one wouldn't expect an exact match between the simulated and observed values and why there would be much greater variance in the observed values versus the simulated values.

Q. BY MR. ANTONUCCI: Okay. We'll get into all of those reasons a little bit later. I'd like to continue reading. This is the second-to-last bullet point on Page 49 of Exhibit 12.

It says "Reporting absolute predicted concentrations of PCE and its biodegradation byproducts in finished water delivered by the Tarawa Terrace water-supply system with a precision of up to five significant figures without any error bounds (for example, Jang and Aral [2008] report concentrations of PCE at 102.10 micrograms per liter, TCE at 4.33 micrograms per liter, DCE at 13.75 micrograms per liter, and vinyl chloride at 7.50 micrograms per liter) provides an unwarranted sense of certainty. Such reporting can contribute to misconceptions by the public and the epidemiology-research community such that water-modeling efforts can produce a specific value for contaminant concentration. Posting such precise point estimates for PCE, TCE, DCE, and vinyl chloride concentrations on public web pages (www.atsdr.cdc.gov/sites/

lejeune) and encouraging former Camp Lejeune marines and their families to find the estimated exposure concentrations of these contaminants leads to a misleading perception that reactive transport models can make accurate predictions."

Dr. Jones, is it your opinion that providing numbers such as the ones mentioned in this paragraph without error bars can provide an unwarranted sense of certainty?

MS. BAUGHMAN: Object to the form. Outside the scope.

THE WITNESS: I think that depends on the context.

Q. BY MR. ANTONUCCI: Okay. The last bullet point on this page, that's Page 49 of Exhibit 12, says "In the absence of data, historical reconstruction efforts that use groundwater models can only provide a general conceptual framework for what happened at the site and why. At best, such models may be used only to estimate a range of possible concentrations. Without historical geochemical data, the uncertainty associated with many of the input parameters (such as the biodegradation parameters) could be very high. In addition, current understanding of subsurface reactive transport processes is inadequate, so" reactive -- excuse me -- "so transport models cannot be expected to provide definitive concentration estimates especially for biodegradation by products."

Did I read that correctly?

A. Yes.

Q. Okay. That's a true statement, isn't it, Dr. Jones?

MS. BAUGHMAN: Object to the form. That's about five statements, it's not one.

THE WITNESS: Yeah, well, I think this, as is the case with some of the reviews, may tend to overestimate, overstate the absence of data. I think they did have quite a bit of data to use to build the flow and transport model. Certainly enough to make it a reasonable and valuable model.

And I think they did a reasonable job of simulating or estimating the uncertainty in the model through their Monte Carlo analysis and presenting that to the public in their reports.

Q. BY MR. ANTONUCCI: Do you agree that in the absence of data, historical reconstruction efforts that use groundwater models can only provide a general conceptual framework for what happened at the site and why?

MS. BAUGHMAN: Object to the form.

THE WITNESS: No, I don't agree with that.

Q. BY MR. ANTONUCCI: Why not?

A. I think it -- it's -- I -- where's the part you read again?

Q. That's the first sentence of the last bullet point on --

A. Okay.

Q. -- Page 49 of Exhibit 12.

A. I think they can go beyond providing a general conceptual framework, as was done in the case here.

I think what they did with the historical reconstruction is a perfectly valid application of groundwater and contaminant transport model.

Q. What's your understanding of what the NRC is?

MS. BAUGHMAN: Object to the form.

THE WITNESS: National Research Council. It's a -- it's part of the National Academy of Sciences.

Q. BY MR. ANTONUCCI: Is the NRC a well respected institution?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Generally it -- they -- they use experts in their work.

Q. BY MR. ANTONUCCI: Are you aware that Dr. Clement served as a reviewer for this report?

A. Yes.

Q. Earlier you mentioned you're familiar with a critique of ATSDR's water modeling efforts from -- by Dr. Clement; is that right?

A. That's correct.

Q. Do you have any opinions on that article?

A. I do.

Q. Okay. What are they?

A. Well, as I mentioned, Professor Clement is a good friend of mine and he has a habit of writing thought -- thought-provoking issue papers. And he has a number of these over the years that are meant to push buttons and stimulate conversations.

He typically asks me to review his draft manuscripts of his issue papers and we have a lot of fun discussing the issues, and he enjoys getting reactions and getting people to talk about things.

I did not review this particular article when he published it, nor have we had extensive conversations about it, but it certainly follows the pattern. And if you read his response to Morris' response, in the opening paragraphs he does indicate that one of his objectives was to stimulate conversation with that.

That being said, when I read the paper, it seemed that a lot of his critiques were -- were directed at the TechFlow -- use of the TechFlowMP model in the modeling study. And in fact he -- I recall he suggested that a better approach would be to stick perhaps with MODFLOW and MT3DMS, which is what we've done in this study and what I think the -- you know, certainly what's documented in Chapters C and F.

And I also think he made some fundamental logical errors in his critique of the -- of the modeling effort.

For example, he stated that with a hindcasting model, the farther you go back in time, the greater the uncertainty. And I -- I do not agree with that, because probably the most certain state of this model is 1953 when it started. That's a point in time when you have a definitive representation of what the model should look like.

So they -- they had

concentration data at the water treatment plant in the -- in the mid '80s. They had concentrations at the wells. And so you could argue that there's -- there's less uncertain -- there's data at that point.

So you're going to from a state -- a known state to another known state. And so there's uncertainty along that path, but you're simulating between two relatively precise states.

Another issue I had with the model with his analysis is he pointed to the -- the uncertainty band of the simulated concentrations at well -- at the Tarawa Terrace water treatment plant, and he looked at the -- the narrow band of uncertainty in the early years of the results as we were discussing a little bit earlier in this deposition.

And he said this is wrong because it implies that -- that there's no -- there's very little uncertainty at that point in time, which is wrong. And I believe Spiliotopoulos made the same critique about the narrow band there.

And as I explained earlier, there's a very important reason why the band is narrow. The -- the -- that plot shows the concentrations at the water treatment plant, which is derived from concentrations at supply wells that are a significant distance away from the source.

So no matter what -- no matter what perturbations or variation you had in the model in those early stages, you would get very small concentrations downgradient during the first few years.

So it has -- has nothing to do with falsely representing the uncertainty. That -- the fact that that band is narrow is a natural mathematical byproduct of the -- of the geometry and the -- and the physics at the site.

Q. Okay. Do you have any other fundamental logical errors that you'd like to point out?

A. No.

Q. All right. When was the last time you reviewed the Clement article?

A. I -- a couple of weeks ago,

maybe.
Q. And you said that you haven't discussed it with Dr. Clement; is that right?
A. That's correct.
Q. Why not?
A. I figured it would be best as I'm serving as an expert on this case and knowing his past involvement to -- to not have that conversation. Save it for a later time.
Q. You don't think he'd want to engage with you in a controversial discussion?
A. Oh, I'm sure he would. But I don't want that to -- my personal relationship with him to impact my -- my -- my work and my conclusions on this.
Q. You mentioned that many of Dr. Clement's critiques were directed at the use of TechFlowMP; is that correct?
A. In my reading of the article, that's the -- that's the sense I got. For example, he -- one of his critiques was we shouldn't use cutting-edge research -- we should be careful or reluctant to use

cutting-edge research models developed in academic institutions that haven't been thoroughly vetted. That certainly would not apply to -- to MODFLOW and MT3D.

Q. Understood.

But is it -- is it your opinion that TechFlowMP has not been thoroughly vetted?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I don't -- I don't -- I don't think it's been vetted to the same degree as MODFLOW or MT3D. That doesn't mean it's not a -- a -- an accurate and valuable model.

Q. BY MR. ANTONUCCI: Do you have any opinion on the accuracy and validity of results generated using TechFlowMP?

A. No.

Q. You have no opinion either way?

A. I haven't studied the TechFlowMP results. We focused mainly on the MODFLOW and MT3DS -- MS as -- within the context of the work were asked to do. Was not asked to evaluate TechFlowMP or study it.

Q. Okay. It's my understanding that TechFlowMP was generated at the Georgia Institute of Technology by Dr. Aral?

A. That's correct.

Q. Okay. And that was done for the purpose of the Camp Lejeune study; right?

MS. BAUGHMAN: Object to the form. Foundation.

THE WITNESS: I'm not sure what it was -- if that's why it was developed or not. I'm just not -- I'm not aware.

Q. BY MR. ANTONUCCI: Okay. How many other groundwater modeling projects have you evaluated that use TechFlowMP?

A. I don't recall seeing any other.

Q. This is the only one you've evaluated that's used TechFlowMP?

A. That's correct.

Q. Okay. How about published studies, things you've reviewed in the literature. Have you seen TechFlowMP used anywhere else?

A. Not that I recall.
Q. Okay. All right. I would like to discuss hindcasting.
When I say the word "hindcasting," what does that mean to you?
A. Using a model to look back in time and characterize what happened in the past in an aquifer.
Q. Okay. ATSDR's groundwater flow and transport models are hindcasting models; right?
A. That's what they were primarily developed for, yes, to do a historical reconstruction is another term for hindcasting.
Q. So the -- would you consider those terms, "historical reconstruction" and "hindcasting" to be synonyms?
A. Yeah.
Q. Have you ever constructed a historical reconstruction or hindcasting model?
A. Yes.
Q. Okay. I think we discussed a few of those at the beginning of the

deposition; is that right?
A. Correct.
Q. Are there any others that we didn't already mention?
A. Yeah. One in particular, you may or may not be familiar with the -- with the Woburn case near Boston, Massachusetts.
Early in my career I became interested in that case after reading the book A Civil Action and learning about the -- at that site they had PCE contamination in the groundwater, which then traveled to some municipal supply wells resulting in a cluster of childhood leukemia and other things, I believe, in the -- in the Woburn neighborhood.
And I became very interested in the case and I read up on it and I contacted a lot of -- I knew some of the experts who had been involved in the study, such as George Pinder, and I contacted a number of the people who were involved and asked if they had any data they could share with me.
And so I collected a wide variety of data on the site, which I then put

into a website, Woburn hydrogeologic data, or something I think I called it.

And then as I was teaching a graduate course on contaminant -- on groundwater modeling, I ended up developing a series of exercises where each time I teach the class, we study the case and I have the students build groundwater models, and then take opposing sides in the case and critique each other's models and -- and estimate the -- whether or not the contaminant would have reached the wells within a certain time frame and answer questions like that.

I was able to travel to a symposium at Harvard Law School on the case and interact with a lot of the people involved with it, and over the years a number of other university courses have adapted this same set of exercises and materials and content that I developed for this particular model.

MR. ANTONUCCI: I'm showing you what I will have marked for identification as Exhibit 19.

THE REPORTER: 19?

MR. ANTONUCCI: Excuse me, 13.
Thank you.
(Exhibit 13 was marked for identification.)
Q. BY MR. ANTONUCCI: Dr. Jones, do you recognize this?
A. Yes, I do.
Q. How do you recognize this?
A. This is a part of the Woburn case study that I just described to you. This is one of the pieces of information that I provide to my students.
Q. Is this a page from the CE 547 website?
A. Yes, it is.
Q. Did you -- did you create this web page?
A. Yes, I did.
Q. Okay. And have you visited it in the past?
A. Yes.
Q. Okay. Have you read the contents of this web page before?
A. Yeah, I wrote this web page.
Q. Okay. And do you currently remember the contents of this web page?

A. Yes.

Q. Okay. I'd like for you to look at the italicized text in the center which starts with the word "First"?

A. Yes.

Q. This says "First: Had the plaintiffs established by a preponderance of the evidence that any of the following chemicals - TCE, perc, and 1,2 transdichloroethylene - were disposed on the Beatrice land after August 27, 1968 (in the case of W.R. Grace, after October 1, 1964, and the date Well G had opened), and had these chemicals substantially contributed to the contamination of the wells before May 22, 1979?"

Did I read that correctly?

A. Yes.

Q. That appears to be from the jury instructions from Judge Skinner; is that right?

A. Yes. And I took this from the book A Civil Action published in 1995 by Harr.

Q. Okay. So the question posed to

the groundwater modeling experts at Woburn was whether or not contaminants could have reached the pumping wells through the groundwater flow within a certain time frame; is that right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Can you state that again.

Q. BY MR. ANTONUCCI: The question posed to the groundwater modeling experts at Woburn was whether or not contaminants could have reached the pumping wells through groundwater flow in a certain time frame; right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: Yeah, I think that's accurate.

Q. BY MR. ANTONUCCI: Okay. Were the groundwater modelers at Woburn asked to determine the concentrations of contaminants in the wells at different points in time for determining an individual's potential exposure to contaminants?

MS. BAUGHMAN: Objection.
Form. Foundation.
THE WITNESS: I don't recall.
Q. BY MR. ANTONUCCI: You don't know if the groundwater modelers generated a list of contaminant exposure doses?
A. As part of this initial case, I -- I'm not sure.
Q. Okay.
A. I know that this -- after this -- this civil action was concluded, there was an extensive study by the -- by the USGS, there was a model built. It also became a Superfund site and, you know, there were a lot of different kinds of analyses that were performed.
I also became friends with a professor at Ohio State University who studied this extensively and did a number of simulations, including calculating the concentrations at the wells and then putting those concentrations into a water distribution model to simulate the resulting -- the concentrations of water delivered to different neighborhoods in

Woburn, and then he compared that to incidents of leukemia in the children in those neighborhoods who were in -- in utero when they -- their mothers drank the water, and found a really strong correlation. And that study was then published in Nature, the journal Nature and got a lot of recognition.

So my point is there -- there are a lot of different modeling efforts and analyses associated with this case. It's been very highly studied.

Q. Okay. Specifically for the question you ask your students --

A. Yes.

Q. -- the project you ask them to recreate --

A. Yes.

Q. -- are they determining specific concentrations of contaminants at wells?

A. No. I have them focus purely on travel time and whether or not the contaminants -- it's more likely than not that the contaminants would have reached Wells G and H within the time frame

associated with this case.
Part of my objective is to -- is to frame a -- you know, the case study around an amount of work that could reasonably be done in the course of a university semester.
Q. Sure. The other studies you were discussing, the I think USGS and others --
A. Yeah.
Q. -- those use a EPA net water distribution system modeling software to estimate the movement of contaminants through the water distribution system; right?
A. I don't know about the USGS. I know the study that was done at Ohio State University did that.
Q. Okay. The -- the USGS study -- or what's -- how would you describe your level of familiarity with that study?
A. I know that they -- they built a groundwater model. I have copies of the model. I've looked at the model and the outputs. I looked at the boundary conditions they found, the -- the conceptual model they

used and -- and that -- the manner in which they built that model informed the guidelines that I give my students to -- to recreate the model each semester I -- I teach it. We use the same basic conceptual model and boundary conditions used by the USGS. And I believe we may calibrate to the same data that they had.

Q. The USGS study did not determine specific concentrations of contaminants individuals in Woburn were exposed to; right?

A. I'm not sure. I don't recall.

Q. The USGS study bifurcated into two parts; right?

A. The USGS? I'm -- not that I'm aware of.

Q. The USGS study first looked at whether contaminants could have possibly reached the wells, then whether contamination from the wells would have reached certain neighbors in different proportions.

Does that sound like your understanding of the USGS study?

MS. BAUGHMAN: Object to form

and foundation.

THE WITNESS: I think you may be conflating some different things here. But the -- the description in this Exhibit 13 was based on the evidence presented at the original trial, and in that case there were modeling -- a modeling expert for the plaintiffs, another modeling expert to defense. They had different models and argued for the merits of each, and that's the -- that was bifurcated as described in this -- in this issue.

Now, the -- the other study I was talking about at Ohio State, that was purely, to my knowledge, an academic study. He had a PhD student that worked on that, and like me, he became interested in the case and did that more extensive analysis.

You know, one of the questions in this case -- this was the late '80s, early '90s at a time when our understanding of chlorinated solvents and their impact on health and how they migrate and degrade in an aquifer was not as well understood as it is now, and so there -- that was one of the -- that was one of the issues in the case.

And -- and so, again, one of the questions was does -- do these contaminants cause the illnesses that were reported in Woburn.

And so one of the objectives of the Ohio State study was he was able to take the -- recreate through the model simulation the concentrations that were reaching the supply wells, and then the next question is once they're in the supply wells, where did they go, right?

Because -- and so the EPA net model -- I believe he used EPA net -- it was a water distribution model similar to EPA net, then simulated where -- which specific neighbors and houses that would go to. And then they did statistical analysis of the correlation between that water delivery and the incidents of childhood leukemia and found a very strong statistical correlation.

Q. Understood.

You mentioned that your students use the same calibration data that was available to USGS; is that right?

A. That's -- I believe so. I collected my calibration -- I was also in contact with some of the original experts who were involved in the litigation, and so I -- whether my calibration data came from the USGS model or theirs, I'm not positive.

Q. Okay. Regardless of where it came from --

A. Yeah.

Q. -- can you describe that data to me?

A. Yeah. It -- it is measured water levels at a number of observation wells in the Woburn area, and also there's a -- there's a river or a stream that flows through the -- the valley and the -- there were some measure -- and I believe this one was USGS data -- measured the change in flow across that -- between a gauge at the top of where the model is and a gauge at the bottom to determine how much water in this case was gained. There's water flowing from the aquifer to the river, and the magnitude of that was measured.

So the students calibrate the MODFLOW model to the water levels at the observation wells and to the stream discharges. The discharges to the streams -- stream.

Q. Can you use the discharges to the stream to determine the recharge rate of the aquifer?

A. Yes, it's actually really helpful because based on the -- the closed nature of the -- of the site, there's only one source of water to the aquifer, and that's through recharge.

And then the water leaves the aquifer by being pumped out through the wells that are active at the specific point in time, and also through discharge to the stream.

So, in fact, I instruct my

students you can actually back calculate the recharge in a spreadsheet using a simple water balance method using that data.

Q. What time frame did the water level data cover that you just discussed?

A. I don't recall. I would have to go back and look and see. But we build a steady-state model. We don't build a -- actually, I take that back. I have them build both a steady-state model and then they have the option to make a transient model, but the calibration is the steady-state conditions.

Q. Is that because you don't have well pumping data?

A. No -- well, it's partly because it's -- I don't believe we had water-level data over a long period of time. And, again, I have to construct the case study, it's something that a set of students who are brand new to groundwater modeling can do over the course of a semester, so it's -- it's -- it's a small aquifer. It's a contained system.

Q. Sure. Do you -- do you know if

that data is available, the well pumping data?

A. Oh, so we have -- we use some pumping data in -- in the case, yeah. There are four wells; there are two industrial wells and then Wells G and H and the pumping data's described somewhere in my website.

Q. Do your students calibrate the model to any contamination concentrations?

A. No.

Q. Were contaminant concentrations available to the water modelers in the lawsuit?

A. Yes, I believe so.

Q. Do you know roughly what time period that data spanned?

A. I don't recall. I know once they -- similar to the Camp Lejeune case, once the chlorinated solvents were discovered in the municipal wells, they -- they shut down the wells and stopped pumping.

Q. Okay. So there wouldn't be -- strike that.

I'm sorry, were you going to continue?

A. Well, that -- there are two types of concentrations data. There's the concentration of the water coming out of the well, which I know they measured that. But then I think at a later point in time they went in and started sampling water at monitoring wells throughout the Aberjona aquifer and collected a set of concentration data from that, which was then used to build the models that were used in the court case.
Q. Okay. Maybe zooming out from Woburn --
A. Sure.
Q. -- talking about groundwater modeling in general.
A. Sure.
Q. What are the types of data that are required to create a historical reconstruction groundwater model?
A. That depends on the context.
Q. Sure. Would you ideally have precipitation data for use in creating a hindcasting model?
A. Ideally, yes.
Q. Okay. And that would help you

determine the recharge rate; is that correct?
A. That does inform the recharge rate, typically, yes.
Q. To calibrate the groundwater flow model, would you say that you need water level data?
A. Yes.
Q. And for the flow and transport model, would you say that pumping schedules and pumping rates are helpful in creating a hindcasting model?
MS. BAUGHMAN: Object to the form.
THE WITNESS: I would say, yeah, any of the major, significant what we call stresses, sources and sinks of water you'd want to characterize as best you can based on the data that are available to you.
Q. BY MR. ANTONUCCI: How about the properties of the aquifer, like porosity or other parameters similar to that, would that be helpful in generating a groundwater model?
A. Yes.

MS. BAUGHMAN: Object to the form.

Q. BY MR. ANTONUCCI: Ideally, where do you get information about the aquifer properties from?

MS. BAUGHMAN: Object to the form.

THE WITNESS: It depends on the aquifer properties that you're talking about. One of the ways in which we get hydraulic conductively, for example, is you can go to the site and perform pump tests where you either inject water or pump water out of the aquifer and watch the -- the response of the aquifer, and from that you can back calculate or infer the hydraulic conductivity in the region surrounding the well.

And -- but in some cases we start with our -- our best estimate using scientific and engineering judgment and experience on the parameters, and then use the feedback from the calibration data to help inform those results.

For example, recharge is hard to quantify, but once you start running the model, if your recharge rate is too high, the whole aquifer floods and you know that's not realistic; where if your recharge rate is too low, your aquifer gets dewatered.

So there are things that you can do as part of the modeling exercise to help narrow down a reasonable range of parameters in your model.

Q. BY MR. ANTONUCCI: Okay. I would appreciate if you could please turn to Exhibit 9, Page A27.

A. Okay.

Q. All right. Page A27 of Exhibit 9, the title of the table is "Summary of model-derived values and observed data of tetrachloroethylene at water-supply wells, Tarawa Terrace U.S. Marine Corps Base Camp Lejeune, North Carolina; is that right?

A. That's correct.

Q. And it looks like this graph shows the model-derived values versus the observed data at Tarawa Terrace; is that correct?
A. Correct.
Q. Is it your understanding that this is all of the water supply well data that ATSDR had available?
A. I would assume so.
Q. Okay. And this is 36 data points; right?
A. Yes.
Q. Okay. And it looks like they were taken in 1985 and 1991; correct?
A. Correct.
Q. Okay. Now I'd appreciate if you could turn to Exhibit 6, that's your initial report.
A. Okay.
Q. And if you could please look at Page 7 in Roman Numerals vii, it's the Executive Summary.
A. This is Exhibit 6?
Q. Yes.
A. Oh, sorry, I thought you said

7-I. Okay. Got it.

Q. Okay. I'm reading from the top of Page 7, the sentence starting with the word "Despite."

A. Yes.

Q. It says "Despite the inherent challenges in simulating complex subsurface conditions and dealing with incomplete data, the model effectively simulates long-term trends in contaminant migration."

Did I read that correctly?

A. Yes.

Q. What did you mean by "the inherent challenges in simulating complex subsurface conditions"?

A. I think I would probably use this sentence to describe just about any groundwater modeling project that I've been familiar with over the course of my career.

When we're looking at groundwater models, we always have -- we're dealing with something that's underground, that you can't directly touch and measure, and so the whole process is based on building the model as best you can from the available data that you have and overcoming, in a reasonable fashion, the -- the lack of more continuous data.

Q. Okay. And what did you mean by "dealing with incomplete data"?

A. What I just described. I -- there -- I've never in my 34 years in this -- in this profession and my career encountered a case where someone built a model and said, By golly, we had all the data we needed for this project, right?

You're always dealing with incomplete data. But there are standard, established procedures on how to do that and how to assess uncertainty in those cases and how to -- again, I -- I previously -- I mentioned that recharge, which is very hard to measure directly.

And so we use indirect methods to -- to pin down the -- the level of recharge. That process is used in multiple ways in building models.

MR. ANTONUCCI: Is this Exhibit 14?

THE REPORTER: Yes.

MR. ANTONUCCI: Okay. I'm handing you Exhibit 14.

(Exhibit 14 was marked for identification.)

Q. BY MR. ANTONUCCI: Dr. Jones, have you seen this before?

A. It certainly looks familiar, yes.

Q. Where have you seen this before?

A. That would appear to be a poster. I believe I presented this at the American Geophysical Union meeting, annual meeting.

Q. Could you please turn to the --

THE VIDEOGRAPHER: Sorry, can you...

Q. BY MR. ANTONUCCI: Could you please turn to the page with the title "Augmenting Sparse Groundwater Level Data With Earth Observations via Machine Learning" with the multiple text box -- text boxes on it.

A. Sure.

Q. I believe that's the second page.

A. Oh, okay, yeah.
Q. If you could look at the box entitled "Data Gaps"?
A. Yes.
Q. Here this says "Monitoring wells are often samples at irregular or sporadic intervals. It is not uncommon for monitoring wells to be abandoned, or to have quite brief periods of record. We may have only one or two years of information from the well. How can we use machine learning to best make use of what little data we have?"
Did I read that correctly?
A. Yes.
Q. So according to this poster, one or two years of information from a well is a brief period of record; right?
MS. BAUGHMAN: Object to the form.
THE WITNESS: Depending on the context.
Q. BY MR. ANTONUCCI: Okay. Are you currently researching ways to address the issue of sparse groundwater level data and groundwater modeling by using machine

learning?

A. Yes, although I would characterize it as the -- the primary objective of the research we're doing here with this algorithm is to help scientists and water managers accurately determine how their groundwater storage is changing over time so that they can determine if their groundwater resources are being used sustainably.

And one of the challenges in -- in generating a time history of aquifer storage change is we have to work with water levels measured at wells, and some wells have a -- a -- a relatively complete record over a long period of time.

Other wells have -- may go years between measurements or have measurements that only cover a short time span. And we're exploring machine learning algorithms that combine the data you do have with satellite data, earth observations to -- to intelligently infer the missing data so that you can more accurately build an aquifer storage versus time curve that can be used by water managers to address aquifer

sustainability.
Q. Okay. And to be totally clear, machine learning is not something that was applied to ATSDR's Tarawa Terrace groundwater flow or transport model; right?
A. Not to my knowledge.
Q. You can put that exhibit aside. Thanks, Dr. Jones.
A. Sure.
Q. Is it fair to say that a modeler's goal might be to keep a model simple enough to be manageable yet complex enough to be useful?
A. That's a -- that's a common expression we use, yes.
Q. Okay. And would you agree with the phrase that one should start simple and build in complexity only as needed?
A. Yes, in general.
Q. Okay. That's sort of the theory underpinning model parsimony; right?
MS. BAUGHMAN: Object to the form.
THE WITNESS: Yeah, that's -- that -- model parsimony is having the

right level of -- the level of complexity in your model warranted by the purpose of the model and what it's going to be used for and the -- the nature of the site that you're modeling.

Q. BY MR. ANTONUCCI: Theoretically, it's true to say that there are an infinite number of combinations of model parameters that will calibrate the same model; right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: It depends on the context. Not in -- there are certain circumstances where that could apply, but it's not true as a general statement.

Q. BY MR. ANTONUCCI: Okay. What is the problem of nonuniqueness in the context of groundwater modeling?

A. Depending on how a model is built, if -- if you have -- for example, let me refer back to the -- earlier I mentioned that we can use stream flow data to pin down our recharge value.

Suppose you have an aquifer where all you have are water level measurements and no -- no -- no estimates on discharge, and that -- that could become a little more problematic in pinning down your recharge value.

And so there are certain conditions where if a -- if the conceptual model is overly simplistic or your boundary conditions are not well posed, you can achieve a mathematical situation where, for example, you could plug in any value of hydraulic conductivity and get the same heads out of it.

So it's something that modelers need to be aware of. It's something that I teach in my groundwater modeling class. But it -- it's -- I certainly would never say that for any given model there are an infinite number of parameters that would reasonably calibrate it.

Q. It is fair to say, though, that multiple sets of model input parameters could calibrate to a single set of observed data;

right?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I -- again, it depends on the context. I wouldn't say that as a general statement.

MR. ANTONUCCI: I'm going to introduce Exhibit 15.

(Exhibit 15 was marked for identification.)

Q. BY MR. ANTONUCCI: Dr. Jones, you've seen this before, haven't you?

A. It looks like one of my exams, yes.

Q. Okay. I'll represent to you that I pulled this off the website for your groundwater modeling class.

Are you familiar with the content of this exam?

A. Yes, I am.

Q. Okay. You've seen it before?

A. Yes.

Q. And you currently know what the information on this exam is; right?

A. Yes.

Q. Okay. I'd like you to look at

Question 4, please.
A. Yes.
Q. It reads "(calibration) Model non-uniqueness occurs when:" Answer: "b. Multiple sets of model input parameters will calibrate to a single set of observed data."
Did I read that correctly?
A. That's correct.
Q. Okay. That means there could be more than one calibrated model that fits a given data set; right?
A. You notice the way that's phrased, "model uniqueness occurs when." That -- basically there are certain conditions, depending on how the model was built, where the model can end up being nonunique. That doesn't mean that all models are nonunique.
Q. So with regard to the ATSDR model, theoretically a model that sits outside the uncertainty range of their model could still be a good fit to the post-audit data; right?
MS. BAUGHMAN: Object to the form.

THE WITNESS: Say that again.
Q. BY MR. ANTONUCCI: Theoretically, there could be a model that sits outside the uncertainty range of the ATSDR model that is still a good fit to the post-audit data set; right?
MS. BAUGHMAN: Object to the form.
THE WITNESS: I'm sorry, one more time. I got to make sure I get the correct answer here.
Q. BY MR. ANTONUCCI: Theoretically, there could be a model that sits outside the uncertainty range of the ATSDR model that is still a good fit to the post-audit data set; right?
MS. BAUGHMAN: Objection. Form.
THE WITNESS: Not necessarily.
Q. BY MR. ANTONUCCI: Dr. Jones, is a non- --
MS. BAUGHMAN: Wait. Were you finished answering?
THE WITNESS: Well -- no. So from my understanding of what they did

is they calibrated the model and got a set of parameters which best fit the -- the observed heads and concentrations, and then in the uncertainty analysis, they perturbed those over a wide range of values and looked at the effect on the -- on the outcome, the concentrations. That means they explored a broad range of models.

Now, whether outside of that range there could be models that -- that would adequately calibrate, I can't say.

Q. BY MR. ANTONUCCI: Okay. Is it your opinion that the post-audit calibrated model is the only model that could fit the data ATSDR had?

A. Well, the -- the post-audit was not a calibration exercise.

Q. Excuse me. I'll re-ask my question.

Is it your opinion that ATSDR's calibrated model is the only model that could fit the data ATSDR had?

MS. BAUGHMAN: Object to the
form.
THE WITNESS: I think it's a
model that reasonably and accurately
fits the data that they had.
Q. BY MR. ANTONUCCI: Is it the
only one that reasonably and accurately fits
the data they had?
MS. BAUGHMAN: Object to the
form.
THE WITNESS: I can't say.
Q. BY MR. ANTONUCCI: Why not?
A. I think it's an overly
restrictive question.
Q. Can you explain what would need
to change for you to be able to answer your
question?
MS. BAUGHMAN: Object to the
form.
THE WITNESS: Well, I would
need you to explain more what you
mean. What are the circumstances that
you're talking about? If you could --
it's a general statement. That's why
I'm nervous about giving a definitive

answer.

Q. BY MR. ANTONUCCI: Dr. Jones, is a nonunique model a useful predictive tool?

MS. BAUGHMAN: Object to the form.

THE WITNESS: A model that is -- it depends on the level of nonuniqueness. I would say with every model there's -- there's some variability in the calibration, right?

It's not a yes-or-no question whether or not a model is unique. There are levels of uniqueness. In fact, there are actual numerical analyses that you can do to analyze uniqueness.

When I teach the calibration section of my groundwater class, we use the PEST model. And one of the outputs from the PEST model is a number, it's a set of eigenvalues and you can look at that number and determine its -- it's a measure of the level of uniqueness.

So if that number is within a certain range, you say there's good evidence that the model is relatively unique. If it's beyond a certain range, then it's evidence that there's nonuniqueness at play.

But it's not -- that's why I'm not comfortable with your question, is it's not a -- it's not a black and white boundary between unique and nonunique models. It's a spectrum.

Q. BY MR. ANTONUCCI: Sure. Did you evaluate the ratio of eigenvalues that the calibrated model ATSDR made?

A. No, I did not.

Q. Why not?

A. That would have required running a PEST simulation. It was -- it was not within the scope of work that we were asked to do.

Q. Okay. How can a modeler make a model more unique?

A. More data. And it's not just the amount of data, it's the types of data that you have. For example, with the ATSDR model, the -- they had -- from what I, in my judgment, was a pretty rich data set to -- to calibrate the flow model.

Then for the transport model, you know, the initial condition was zero contaminants represents, you know, one bound. And on the other end they had a combination of -- of water levels -- or excuse me -- concentrations at the wells plus the water treatment data.

The combination of the concentrations at the water treatment plant plus the concentrations simulated at the observation wells, in my opinion, makes the model more unique.

Now, I would also argue that at this point in time we have another 318 point observations at monitoring wells at a later date, which I believe the model does a -- does a good job of simulating; therefore, providing additional evidence for the -- for the accuracy and uniqueness of the model.

Q. Dr. Jones, you agree that it's impossible to fully characterize and incorporate all parameters and complexities of a real aquifer system into a discretized computer model; right?

A. Correct.

Q. Okay. ATSDR had no site-specific data for estimating the distribution coefficient; right?

MS. BAUGHMAN: Object to the form and foundation.

THE WITNESS: I'm not -- I don't know. Not that I'm aware of.

Q. BY MR. ANTONUCCI: Would reviewing Chapter F help you remember?

A. It could.

Q. Okay. I'd like you to turn to Page F27.

A. Let's see, exhibit -- I'm getting a stack here.

Q. Chapter F is Exhibit 11.

A. Okay. Okay.

Q. Okay. I am looking at the last full paragraph on Page F27, starting with the word "Estimates."

A. Yes.

Q. This says "Estimates of retardation factors and distribution coefficients for PCE migration within the Tarawa Terrace aquifer or Castle Hayne aquifer are unknown, and initial estimates applied to the MT3DMS model were based on literature sources."

Did I read that correctly?

A. Yep.

Q. That help you remember whether they had data for the distribution coefficient?

A. Yes.

MS. BAUGHMAN: Object.

Q. BY MR. ANTONUCCI: Okay. Did they have site-specific data to estimate the distribution coefficient for the ATSDR TT model?

A. No.

Q. Okay. Instead, ATSDR reviewed literature sources; right?

A. Correct.

MR. ANTONUCCI: All right. I'd like to take a break now.

THE VIDEOGRAPHER: We're off the record. The time is 2:42.

(There was a break taken.)

THE VIDEOGRAPHER: We're back on the record. The time is 2:56. This is Media Number 4.
Counsel may proceed.
Q. BY MR. ANTONUCCI: Dr. Jones, what is your understanding of how the data from ATSDR's Tarawa Terrace model was to be used?
MS. BAUGHMAN: Objection. Form. Foundation.
THE WITNESS: So are we through with this discussion on the --
MR. ANTONUCCI: Yep, you can put that to the side.
THE WITNESS: Okay. All right.
MR. ANTONUCCI: I'll ask again.
Q. What is your understanding of how the data from ATSDR's Tarawa Terrace model was to be used?
MS. BAUGHMAN: Objection. Form and foundation.
THE WITNESS: From my understanding, the primary objective was to do a historical reconstruction of the PCE concentrations at the

Tarawa Terrace water treatment plant between 1953 and when the plant was shut down.

Q. BY MR. ANTONUCCI: Okay. I'd ask that you turn to Exhibit 9. That's TT Chapter A Page A1.

A. Exhibit 2?

Q. Exhibit 9.

A. Did you say Chapter A?

Q. Yes. Exhibit 9 is also a copy of Chapter A.

A. I'm sorry. Let me grab your copy. What page again?

Q. A1. That's the page ending in Bates Number 615652.

A. Okay.

Q. All right. In the column underneath the word "Abstract," I'm reading the third sentence starting with the word "Because."

"Because scientific data related to the harmful effects of VOCs on a child or fetus are limited, the Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Department of

Health and Human Services, is conducting an epidemiological study to evaluate potential associations between in utero and infant (up to one year of age) exposures to VOCs in contaminated drinking water at Camp Lejeune and specific birth defects and childhood cancers. The study includes births occurring during the period 1968 to 1985 to women who are pregnant while they resided in family housing at Camp Lejeune. Because limited measurements of contaminant and exposure data are available to support the epidemiological study, ATSDR is using modeling techniques to reconstruct historical conditions of groundwater flow, contaminant fate and transport, and the distribution of drinking water contaminated with VOCs delivered to family housing areas."

Did I read that correctly?

A. Yes.

Q. Please turn to Page A98. That page ends in Page Number 615749.

A. Okay.

Q. All right. I am looking at the last paragraph on this page. It looks like it's a question and answer section. Here the question reads "ATSDR's historical reconstruction analysis documents that Tarawa Terrace drinking water was contaminated with PCE that exceeded the current maximum contaminant level (MCL) of 5 micrograms per liter during 1957 and reached a maximum value of 183 micrograms per liter. What does this mean in terms of my family's health?"

Did I read that correctly?

A. Oh, hang on, I was looking at the wrong paragraph.

MS. BAUGHMAN: Where -- just tell him -- where are you reading from?

THE WITNESS: The blue paragraph on the left. I think you might be on the wrong page. It's A98.

MS. BAUGHMAN: I thought he said 97, okay.

THE WITNESS: Okay, yes, I -- I believe you read that correctly.

Q. BY MR. ANTONUCCI: Okay. Now I'm looking at the paragraph in black text on the right next to what I just read.

Do you see that?

A. Yeah.

Q. It reads "ATSDR's exposure assessment cannot be used to determine whether you, or your family, suffered any health effects as a result of past exposure to PCE-contaminated drinking water at Camp Lejeune."

Did I read that correctly?

A. Yes.

Q. It goes on to say "The study will help determine if there is an association between certain births defects and childhood cancers among children whose mothers used this water during pregnancy."

Did I read that correctly?

A. Yes.

MR. ANTONUCCI: Okay. I am now going to hand you what will be marked for identification as Exhibit 16.

(Exhibit 16 was marked for identification.)

Q. BY MR. ANTONUCCI: Okay. For the record, Exhibit 16 has the Bates range CLJA_WATERMODELING_01-09_0000033263 through 33326.

Dr. Jones, this document has the title "Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Response to the Department of the Navy's letter on: Assessment of ATSDR Water Modeling for Tarawa Terrace."

Dr. Jones, have you seen this before?

A. Yes, I have.

Q. Okay. I'm going to ask you to turn to the page ending in Bates Number 33272.

A. Okay.

Q. All right. Looking at the last full paragraph on that page, this says "To address the issue of the intended use of the water-modeling results by the current ATSDR epidemiological study" --

A. Excuse me, I think I might be on the wrong page. What -- what was the page number? Is it 33272?

Q. Yes, sir.
A. And which paragraph are you -- oh, the last paragraph. Okay, I gotcha.
Q. So the last paragraph on Page 33272 of Exhibit 16 states "To address the issue of the intended use of water-modeling results by the current ATSDR epidemiological study, the DON should be advised that a successful epidemiological study places little emphasis on the actual (absolute) estimate of concentration and, rather, emphasizes the relative level of exposure. That is, exposed individuals are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to be 'true' (measured) PCE concentration."
Did I read that correctly?
A. Yes.
Q. Okay. So, Dr. Jones, the paragraph I just read states that a successful epidemiological study places little emphasis on the actual absolute estimates of concentration; right?

A. Yes.
Q. Okay. In your report you opine that the model remains a reliable tool for understanding general trends of contaminant migration in the Tarawa Terrace region, and that you can find no significant evidence that would invalidate the analysis performed by ATSDR with the original model; right?
A. Correct.
Q. However, you're not offering an opinion that the Tarawa Terrace model is a sufficiently reliable model for determining quantitative levels of contaminant exposure for an individual; right?
MS. BAUGHMAN: Object to the form. Foundation. Outside the scope.
THE WITNESS: I am not an expert in epidemiology, so I don't feel qualified to render an opinion on that question.
Q. BY MR. ANTONUCCI: Okay. So you're not offering the opinion that the Tarawa Terrace model can be used to determine quantitative levels of contaminant exposure for individuals?

MS. BAUGHMAN: Object to the form.

THE WITNESS: I don't believe I've -- again, my answer's the same. I'm not an epidemiological expert so I can't comment on that.

Q. BY MR. ANTONUCCI: Can I have a yes or a no?

MS. BAUGHMAN: No -- objection. You do not have to answer yes or no.

Q. BY MR. ANTONUCCI: Are you offering the opinion or not?

MS. BAUGHMAN: Object to the form. Asked and answered.

THE WITNESS: Could you restate the question.

Q. BY MR. ANTONUCCI: You're not offering the opinion that the Tarawa Terrace model is a sufficiently reliable model for determining quantitative levels of contaminant exposure for an individual; right?

MS. BAUGHMAN: Objection; form. Objection; Foundation.

THE WITNESS: The -- the opinions we've rendered on the model was that in terms of the -- how the model simulates concentrations at the water treatment plant, it -- it is a reasonably accurate model developed using sound scientific and engineering principles.

How that -- concentrations resulting from that are then incorporated in an epidemiological study is outside my scope of expertise -- expertise.

Q. BY MR. ANTONUCCI: So that is not an opinion you're offering?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: No, that's not an opinion I'm offering.

Q. BY MR. ANTONUCCI: Had you done a post-audit prior to the Tarawa Terrace post-audit?

MS. BAUGHMAN: Objection to form.

THE WITNESS: In the sense of

running a model simulation and
comparing its output to field observed
values, I have done that countless
times.
Q. BY MR. ANTONUCCI: You just described calibration, didn't you?
A. In a -- no. Calibration is when you then take the results of that and go back and change the input parameters.
But I would say what I just described is a subset of what you do for calibration. But simply comparing model outputs to field observed values is -- is a really simple and very common thing that I've done countless times.
Q. Have you ever published a post-audit before?
A. No.
Q. How long did it take you to perform the Tarawa Terrace post-audit?
A. The initial post-audit we started in, I believe, early September and submitted it in late October of 2024.
Q. So roughly a month?
MS. BAUGHMAN: Objection to

form.

THE WITNESS: A little over a month.

Q. BY MR. ANTONUCCI: And you did both a qualitative and quantitative assessment as part of your post-audit; is that right?

A. That's correct.

Q. Are quantitative and qualitative assessments terms of art applied to post-audits?

A. Excuse me? Terms of art?

Q. Are those -- do those terms have any special significance in the modeling community?

A. Yeah, I would say it's a relatively standard practice. For example, one of the most common ways to assess the -- the results of a model calibration is to visually examine a simulated versus observed plot and see how close the points plot to the -- to the -- the line of agreement, which is what I would call a qualitative assessment of the goodness of fit.

Q. Okay. There are also

quantitative assessment of goods of fit; right?

A. Yes.

Q. That would include summary statistics like mean error and mean absolute error; right?

A. And -- yes, and geometric bias is one of those, yes.

Q. Okay. I'd like to discuss those error metrics in more detail, but first you issued two reports in this case; right?

A. Correct.

Q. One was an initial report and the other was a rebuttal; right?

A. Yes.

Q. In your rebuttal report you corrected errors highlighted by Dr. Spiliotopoulos in his expert report; right?

A. Yes.

Q. That included truncation errors, incorrect mass loading end date, and an incorrect pumping rate for well RWC2; right?

A. That's correct.

Q. After Dr. Spiliotopoulos identified errors in your post-audit, did you go back and confirm that the rest of the post-audit had been done correctly?
A. We had -- I'm not aware of any other reason to believe there were errors in the initial post-audit.
Q. After Dr. Spiliotopoulos identified errors, did you go back and check for any others?
A. No.
Q. So you only corrected errors that Dr. Spiliotopoulos pointed out?
A. That's correct.
Q. Are you aware of any other model input errors in your post-audit?
A. No.
Q. Are you now confident that you've found and resolved all model input errors in your post-audit?
A. I believe so.
Q. Could there be more model input errors in your post-audit?
MS. BAUGHMAN: Objection. Form.

THE WITNESS: It's possible.
Q. BY MR. ANTONUCCI: Okay. Please turn to your initial report, that's Exhibit 6. Page 5-1.
A. Okay.
Q. All right. Are you looking at the page that has the heading "Results"?
A. Oh, sorry. 5-1 did you say?
Q. Yes.
A. I have it now.
Q. Okay. I'm looking at the last sentence of the first paragraph. It reads "Before presenting the results, it is helpful to remember that when simulating the migration of a PCE contaminant plume using MODFLOW and MT3DMS, achieving a close match between simulated and observed concentrations can be challenging for several reasons."
Did I read that correctly?
A. That's correct. And what I was talk- -- what we were talking about in this case is looking at individual observed concentrations and expectations regarding how well the model will reproduce those concentrations in the simulation on a

point-by-point basis.
Q. Okay. With all due respect, Dr. Jones, my question was did I read that correctly. I need you to limit your answers to my questions, okay?
A. Sorry. Will do.
Q. Thank you.
You go on to list reasons why it's helpful to remember that achieving a close match between simulated and observed concentrations can be challenging; right?
A. Correct.
Q. Those four reasons include complex subsurface conditions, temporal variability, limitations in model resolution, and measurement variability; right?
A. Correct.
Q. Okay. Under the subheading "Complex Subsurface Conditions," that's Number 1.
A. Yes.
Q. You wrote that "The subsurface environment is inherently complex, with variations in soil heterogeneity, permeability, porosity, and hydraulic

conductivity. These properties vary spatially in ways that are not fully captured in the model, affecting how the contaminant plume moves through the groundwater system."
Did I read that correctly?
A. That's correct.
Q. Next Number 2, "Temporal Variability," you wrote "The concentration of contaminants can change over time due to factors like seasonal variations in groundwater flow, biodegradation, chemical reactions. Simulating these dynamic processes accurately over the entire simulation period is challenging."
Is that correct?
A. Correct.
Q. Okay. Number 3 says "Limitations in Model Resolution: MODFLOW and MT3DMS rely on discretizing the subsurface into numerical grids consisting of cells that represent a subset of the aquifer. The resolution of these grids can limit the model's ability to capture fine-scale variations in plume behavior, particularly in areas with sharp concentration gradients,

small-scale heterogeneities, or preferential pathways."
Did I read that correctly?
A. Yes.
Q. Number 4 says "Measurement Variability: The observed concentrations at observation wells may contain some degree of measurement error or uncertainty. Field data collection is subject to variability, which adds another layer of complexity with trying to match it closely with model outputs. As outlined above in Section 4.2, extreme variations were observed in some of the measured concentrations used in this post-audit."
Did I read that correctly?
A. Yes.
Q. Okay. I'd like for you to turn to your rebuttal report, Page 3-12. That's going to be Exhibit 7.
A. What was the page again?
Q. 3-12.
A. 3-12. Okay.
Q. Okay. Dr. Jones, the second paragraph on this page reads "We have also

generated new versions of each of the tables and figures from our original post-audit" reporting -- "report featuring simulated PCE values, using the updated post-audit simulation results, processed at full precision. These results are presented in Appendix A. The differences in the tables and figures relative to the original report are relatively minor overall. The differences are summarized as follows:"

Did I read that correctly?

A. Yes.

Q. Dr. Jones, this section says that the differences between the corrections you made to your post-audit are relatively minor overall; is that right?

A. That's correct.

Q. Okay. And the table below that paragraph summarizes the list of changes to the tables and figures of your report; is that right?

A. That's correct.

Q. Okay. I'd like you to turn back to your original report, Page vi, six in Roman numerals. Again, your original report

is going to be Exhibit 6.
A. Okay.
Q. Are you looking at the Executive Summary?
A. Yes.
Q. All right. I am looking at the third paragraph from the bottom beginning with the sentence -- the phrase "The extended."
Do you see where I am?
A. Yes.
Q. This reads "The extended MT3DMS model was found to perform well in simulating PCE concentrations at monitoring wells across the study area. The errors are remarkably well balanced, indicating a good overall fit between simulated and observed concentrations."
Did I read that correctly?
A. Yes.
Q. Now, Dr. Jones, for the purposes of evaluating fit between simulated and observed concentrations you provided some summary statistics; is that right?
A. Correct.

Q. Okay. What is residual error?
A. At a particular observation well location it's the difference between the model simulated concentration and the observed concentration.
And the way we calculated it, we took the simulated value minus the observed value.
So if the model overestimates the concentration, it would be a positive residual error; if the model underestimated the concentration, it would represent a negative residual error.
Q. Okay. The mean error is the average of the residual errors; right?
A. That's correct.
Q. And mean absolute error is the average of the absolute value of the residuals?
A. That's correct.
Q. The mean error of the initial post-audit was 21 micrograms per liter; correct?
A. That's correct.
Q. The mean absolute error of your

initial post-audit was 334 micrograms per liter; correct?

A. That's correct.

Q. Dr. Jones, a negative mean error indicates that a model under predicts observed values; correct?

A. That's correct.

Q. A positive mean error indicates that a model over predicts observed values; correct?

A. Correct, on average.

Q. Mean absolute error is also a metric that's used to evaluate overall fit between simulated and observed concentrations; correct?

A. It's -- it's a different statistical measure used to fit -- to analyze the calibration results, yes.

Q. Okay. And the mean absolute error cannot be negative; right?

A. That's correct.

Q. For your updated post-audit, the mean error was 48 micrograms per liter; right?

A. Yes.

Q. That's an increase of 27 micrograms per liter from the original post-audit results?
A. That's correct.
Q. Did you calculate the mean absolute error for the updated post-audit?
A. I don't recall.
Q. Your groundwater modeling software, GMS, provides the summary statistics automatically, doesn't it?
A. Yes. But to calculate these errors, we typically just took the -- the simulated versus observed PCE concentrations as shown, for example, in Table A1 of the rebuttal report and did the error analysis using Excel, Microsoft Excel. It's a very simple equation.
Q. Okay. So you -- you did that very simple equation for the initial report but not the rebuttal report; is that right?
A. Well, I'm sure I have a spreadsheet with that number in it. Whether that number was reported in the rebuttal report, I don't recall.
I would expect that number to

be roughly similar to the -- to the value reported in the initial report, certainly along the same scale, which is relatively large considering a large -- indicating a large variability in the PCE concentrations.

Q. But sitting here today, you do not know the mean absolute error of your updated -- or your rebuttal post-audit?

A. That's correct. I couldn't tell it off the top of my head.

Q. Okay. Earlier you mentioned geometric model bias as another summary statistic that could be used to evaluated fit between simulated and observed concentrations; is that right?

A. That is correct.

Q. When a ratio of simulated PCE concentrations is simulated to observed PCE concentrations is less than one, that indicates under-prediction by the model; correct?

A. That's correct.

Q. And when the ratio of simulated PCE concentration to observed PCE concentrations equals one, that indicates

exact agreement; correct?
A. That's correct.
Q. When the ratio of simulated PCE concentrations to observed PCE concentrations is greater than one, that indicates over-prediction by the model; correct?
A. Correct.
Q. The further the geometric model bias is from a value of one, the worse the agreement between simulated and observed concentrations; correct?
A. That's correct.
Q. Okay. I would like to direct your attention to Exhibit 9, Page A26. And Exhibit 9 is the Tarawa Terrace Chapter A report.
A. Okay. A26, got it.
Q. All right. Do you see Table A8 at the top of the page?
A. Yes.
Q. Okay. In the one, two -- third column from the top, in the -- excuse me -- third row from the top in the Resulting Calibration Statistics column, geometric model bias is indicated as being equal to 5.8

backslash or 3.9.
Do you see that?
A. Yes.
Q. Okay. ATSDR calculated two geometric model biases for the Tarawa Terrace calibrated model; correct?
A. That's correct.
Q. One was the geometric model bias that used data for TT-23; is that right?
A. Yes.
Q. And that was the 5.9 value?
A. 5.8. It says 5.8 in this table.
Q. It does.
If you turn to Page A25. At the top of the right-hand column I'm reading the sentence that says "The inclusive geometric model bias, using data for water-supply Well TT-23, was 5.9."
A. Okay.
Q. See that?
A. Sure.
Q. "The selected geometric model bias, omitting data for supply Well TT-23 was 3.9."

A. Yes.
Q. "Both results, however, indicate over-prediction by the model."
Did I read that correctly?
A. Yes.
Q. Dr. Jones, I would like you to turn to Exhibit 7, that's your rebuttal report, Figure A2.
A. Yes.
Q. Okay. And here we're looking at a graph. On the Y axis we have simulated PCE concentrations in micrograms per liter, the X axis we have observed PCE concentrations in micrograms per liter; right?
A. That's correct.
Q. That dashed line in the middle is where the simulated and observed concentrations are equal; right?
A. That's correct.
Q. Okay. Earlier you indicated that a scatter plot like this one can be used for a qualitative assessment of the goodness of fit of a model; is that right?
A. Yes.

Q. And that's because you can visually examine how far the points are from the one to one line; is that right?

A. Yes, and also the clustering and -- and distribution.

Q. Okay. Please turn to Figure 5 of your rebuttal report. And that's Exhibit 7.

A. Okay.

Q. This figure shows the graph that we were just looking at on the right-hand side of the page; is that right?

A. Yes.

Q. And it shows a similar plot from your initial report on the left-hand side of the page; right?

A. Correct.

Q. In your rebuttal report you state that while the numbers indicate a high degree of variance, they're visually more balanced than the results we originally presented in the post-audit report; right?

A. Correct.

Q. Quantitatively the updated post-audit indicates a small increase in the bias compared to the initial post-audit; right?

A. Say that again.

MS. BAUGHMAN: Object to the form.

Q. BY MR. ANTONUCCI: The updated post-audit indicates a small increase in the bias compared to the initial post-audit?

A. Based on the mean error, yes.

Q. I'd like you to turn to Page 3-5 of your rebuttal report. I am looking at the one, two -- third paragraph from the top of the page beginning with "In Section 3.1.2."

Do you see where I am?

A. Yes.

Q. All right. About halfway down the paragraph a sentence starts with "For the original post-audit."

Do you see that?

A. Yes.

Q. "For the original post-audit results we calculated a mean error value equal to 21 micrograms per liter, indicating an extremely balanced fit with only a small high bias. For the updated post-audit results, the mean error equals 48 micrograms per liter, indicating a small increase in the bias, but still relatively well balanced overall."

Is that correct?

A. That's correct. When you -- when you asked that before, I thought maybe you were talking of the post-audit versus the original report, so I apologize for the misunderstanding. Excuse me, versus the original model.

Q. Please turn to Table A2 in your rebuttal report. Again, that's Exhibit 7.

MS. BAUGHMAN: What page did you say?

MR. ANTONUCCI: Table A2.

Q. Are you looking at Table A2, Dr. Jones?

A. Yes.

Q. Okay. So this table shows the monitoring wells, the layer in the model where the well is screened, mean error, mean absolute error, and the mean absolute error category; correct?

A. That's correct.
Q. Okay. Earlier you indicated that the mean absolute error is the absolute value of the mean error; correct?
A. No. It's the -- well, yes, you can calculate it that way, sure.
Q. Okay. I'd like you to take a look at Well C3.
A. Okay.
Q. Here the mean error is indicated as being 98 micrograms per liter and the mean absolute error is indicated as being 124.5 micrograms per liter.
Do you see that?
A. Yes.
Q. Why are those numbers different?
A. That is a great question. I'm not sure.
Q. I'd like you to look at Well C9. Here the mean error is negative 5.9 micrograms per liter, the mean absolute error is 6 micrograms per liter.
A. Yes.
Q. Why are those numbers

different?
A. Because they're displayed using different significant figures.
Q. Okay. I'd like you to look at Well C13.
A. Okay.
Q. Here the mean error is negative 555 micrograms per liter, the mean absolute error is 563.7 micrograms per liter.
A. Yes.
Q. Why are those numbers different?
A. I'm not sure.
Q. Okay. Look at Well C17-D. Here the mean error is negative 0.2, the mean absolute error is 0.4.
Why are those numbers different?
A. I'm not sure.
Q. Okay. If you look at Well RWC-1, the mean error is 251.9, the mean absolute error is 252.6; right?
A. Correct.
Q. Why are those numbers different?

A. I'm not sure.
Q. If you look at Well RWS-3A, the mean error is negative 83.8; correct?
A. Yes.
Q. The mean absolute error is 136.4; right?
A. Correct.
Q. Why are those numbers different?
A. The -- well, you -- when you calculate the mean error, you calculate the average of all of the individual errors. To calculate the mean absolute error, you don't simply take the absolute value of that number.
What you do is you take the absolute value of the individual residuals one by one and then calculate the mean of those values. And I suspect the reason there are some differences here is because of that difference in how they're calculated. It is not simply taking the absolute value of the mean error.
Q. Okay. You did say that earlier, though; right?

A. Excuse me?

Q. You said that the mean absolute error is the absolute value of the mean error?

A. Yes, but on an individual basis. And so I'm -- I -- if -- if I stated that misleadingly, then I'm correcting that now.

Q. Okay. Why don't you take a look at Well S2.

MS. BAUGHMAN: Were you -- were you finished with your answer, Norm?

THE WITNESS: Yeah, I think so.

MS. BAUGHMAN: Okay.

Q. BY MR. ANTONUCCI: All right. Well S2.

A. Uh-huh.

Q. Mean error negative 73.8.

A. Yes.

Q. Mean absolute error 111.6.

A. Right.

Q. Is that a rounding error?

A. No. These -- these are not -- these should not be expected to agree. And let me explain why.

Suppose you had a circumstance where you had a number of positive residual errors and a number of negative residual errors, but somehow they -- they balanced, right?

They -- they -- let's say you had a negative ten, a negative five, and a positive ten and a positive five. If you took the mean of those errors, that would equal zero indicating a perfect balance.

But if you first took the absolute value of those numbers and then took the average of that, you'd be averaging ten, five, ten, and five. And the mean of that would be 7.5.

So, no, the mean absolute error is not simply the absolute value of the mean error.

Q. Okay. When you report the mean absolute error in your -- when you reported that in your initial report, which method of calculating did you use?

A. What I just described. You take the absolute value of the individual residuals, and then calculate the average of that. There are circumstances under which your mean error will match the mean absolute error.

For example, if all of your errors are negative or if all of your errors are positive, then your mean error and your mean absolute error will match, and that's why it matches in some of these cases but not others.

Q. Okay. Okay. Another point of clarification that I'd appreciate, if you look at Table 1 of your initial report, and that's going to be Exhibit 6.

A. Okay.

Q. This table shows various publicly available rainfall data; is that right?

A. Yes.

Q. Okay. And it shows publicly available rainfall data from 1995 to 2009; right?

A. Correct.

Q. At the Wilmington Airport, Wilmington 7N, and New River MCAF stations; is that right?

A. That's correct.
Q. Okay. Okay, I am going to mark for identification Exhibit 17.
(Exhibit 17 was marked for identification.)
MR. ANTONUCCI: For the record, this is the native spreadsheet version of the document produced with Bates Number CL_PLG --
MS. BAUGHMAN: Sorry, did you give me one? I don't have one.
MR. ANTONUCCI: Dash EXPERT_DAVIS_0000000203.XL -- excuse me -- 203. That's the end of the Bates number.
Q. Dr. Jones, are you familiar with this?
A. It looks familiar.
Q. This is the rainfall data you used to calculate the effective rainfall recharge rate for the post-audit; right?
A. I believe so.
Q. Okay. Can you please look at the year 1999.
A. Uh-huh.
Q. Is there data available there?

A. No.
Q. Okay. Can you look back at Table 1 in your initial report.
A. Yes.
Q. Will you please look at the year 1999.
A. Yes.
Q. Is there data available there?
A. Yes.
Q. For New River MCAF?
A. Yes.
Q. Can you explain the discrepancy, please.
A. I cannot.
Q. Okay. How about the year 2000? Can you look at the year 2000 on the spreadsheet that you produced?
A. Yes.
Q. Is there data available there?
A. No.
Q. Okay. Can you look at the year 2000 on Table 1 of your initial report.
A. Yes.
Q. In the New River MCAF column, is there a value there?

A. No -- or excuse me -- yes.
Q. It's 50.4; right?
A. That's correct.
Q. Inches per year?
A. Correct.
Q. Where did you get that data from?
A. I -- I'm not sure why there's a discrepancy here.
Q. Okay.
A. I'd have to investigate it.
MR. ANTONUCCI: I'd like to take another break.
THE VIDEOGRAPHER: We're off the record. The time is 3:47.
(There was a break taken.)
THE VIDEOGRAPHER: We're back on the record. The time is 4:06.
Q. BY MR. ANTONUCCI: Dr. Jones, you stated in your initial report that larger errors tend to be concentrated in the center of the plume where the simulated concentrations are greater; is that right?
A. Yes.
Q. You also said that that's

somewhat expected because comparing larger numbers organically results in larger differences; right?

A. Yes.

Q. Concentrations are generally higher in the center of a plume; right?

A. Yes.

Q. Could you please turn your attention to Rebuttal Figure A9. That's going to be Exhibit 7.

A. Okay.

Q. Please look at the center pane of this figure, Model Layer 3. Are you looking there?

A. Yes.

Q. Do you see model -- excuse me -- do you see Well C5, the plot for Well C5?

A. Yes.

Q. And that is within the simulated PCE plume; right?

A. Correct.

Q. And it's in the portion of the simulated PCE plume where concentrations are greater than 500 to 5,000 micrograms per liter; right?

A. That's correct.

Q. Okay. That's the center of the plume; right?

A. Yes.

Q. I'd like you to turn to Rebuttal Table A1.

A. Okay.

Q. And if you could please look at the first two pages of Table A1 in Exhibit 7.

A. Which page number?

Q. So Page 1. The page number is Page 1 of 7.

A. Okay.

Q. And...

A. I got it.

Q. All right. If you look towards the bottom of Page 1 of 7, Table A1?

A. Yes.

Q. Well C5 is the last four rows of this table; right?

A. Yes.

Q. And this shows observed versus simulated concentrations with the error rate and the absolute error rate; correct?

A. That's correct.
Q. All of the observed PCE concentrations for Well C5 are below the detection limit; isn't that right?
A. That's correct.
Q. Okay. And then continuing on to Page 2 of Table A1, we're still looking at Well C5. That's going to be the first seven rows of this table?
A. Yes.
Q. All of the PCE observed concentrations were below the detection limit here as well; right?
A. That's correct.
Q. The calibrated model and the post-audit both simulated high PCE concentrations at that well, didn't they?
A. Yes.
Q. Still in Exhibit 7, your rebuttal report, I'd like you to turn to Page 3-13.
A. Okay.
Q. All right. Under Section 3.7, Opinion 6 - Post-Audit Robustness. I am looking at the second full paragraph.

Do you see that?

A. Yes.

Q. Okay. The last sentences of that paragraph reads "These findings support our original conclusion that the ATSDR model was developed using a methodology that is scientifically sound and accepted within the scientific community, and it remains a reliable tool for assessing the impacts of PCE contamination at Tarawa Terrace."

Did I read that correctly?

A. Yes.

Q. Okay. Dr. Jones, in the post-audit you used the model input parameters that were provided to you by the legal team; right?

A. Yes.

Q. And you did not independently evaluate the suitability of those parameters; correct?

A. The -- the parameters in the -- you mean as part of the post-audit? Can you restate the question, I'm sorry.

Q. You did not evaluate the appropriateness of the model input parameters; correct?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I wouldn't say that.

Q. BY MR. ANTONUCCI: You used the model input parameters that were provided to you by the legal team; right?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Yes, we did.

Q. BY MR. ANTONUCCI: Okay. Dr. Jones, earlier in the deposition you mentioned that you were present via Zoom for the deposition of Mr. Davis yesterday; is that correct?

A. That's correct.

Q. You mentioned that you weren't present for the entire deposition; is that right?

A. That's right.

Q. At what times were you watching the deposition?

A. From about 9:00 to 9:25 a.m., and then I jumped on again about 10:50 a.m.

and watched the remainder of the deposition.

Q. Do you disagree with any of the opinions that Dr. Jones expressed in his deposition -- excuse me -- that Mr. Davis expressed in his deposition?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I -- I'm not going to say that everything he said was precise or exactly the way I would have said it, but the general statements he gave, I -- I think I would agree with that.

Q. BY MR. ANTONUCCI: Were any of the statements that Mr. Davis gave incorrect?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: I'm not prepared to cite specific examples.

Q. BY MR. ANTONUCCI: Can you think of a single instance where Mr. Davis made an incorrect statement in his deposition?

MS. BAUGHMAN: Objection. Form.

THE WITNESS: Nothing substantive.

Q. BY MR. ANTONUCCI: Can you think of any non-substantive errors in Mr. Davis' deposition testimony?

MS. BAUGHMAN: Objection to form.

THE WITNESS: Not that I could recite off the top of my head.

Q. BY MR. ANTONUCCI: What do you mean by "substantive"?

A. Well, I -- I believe there was one case where he was talking about the -- when we did the post-audit and he talked about the calibration target relative to Well TT-26.

In fact, we did not have any observations at Well TT-26 during the extended simulation period, so that was not a correct statement. That's the one that I can recall, and I believe he may have corrected himself, but...

Q. Dr. Jones, how much have you billed to date in this case?

MS. BAUGHMAN: Objection to

form. We've provided the bills.
THE WITNESS: I've billed the amount shown in the invoices that we submitted.
Q. BY MR. ANTONUCCI: Do you know what that amount is?
MS. BAUGHMAN: Object to form.
THE WITNESS: I think through the end of January it would be roughly $120,000, I believe.
Q. BY MR. ANTONUCCI: Does your payment depend on the outcome of this case?
A. No.
MR. ANTONUCCI: Okay. I am going to show you another exhibit.
This will be Exhibit 18.
(Exhibit 18 was marked for identification.)
Q. BY MR. ANTONUCCI: This document has the title "An overview of current applications, challenges, and future trends in distributed process-based models in hydrology"; is that right?
A. Correct.
Q. There's a list of several authors here, one of them being Norm Jones.

Is that you?

A. That's me.

Q. Okay. Were you an author of this study?

A. I was a co-author.

Q. Okay. Please turn your attention to Page 5 of Exhibit 18.

A. Okay.

Q. I'm looking at the very last sentence on the page starting with the word "Although." It's -- it continues on to Page 6.

A. Oh, okay, sure.

Q. Okay. So this says "Although some of those process-based hydrological models include numerous distinct processes, the degree of complexity and quantity of processes represented varies between models and influences the suitability of a given model for specific applications."

Did I read that correctly?

A. Yes.

Q. You'd agree that a model cannot capture the complexity of aquifer conditions completely; right?

A. Yes.
Q. That they don't necessarily reflect all real-world conditions; right?
A. A model, as we've discussed earlier, is a simplification of reality.
Q. Okay. Would it be possible for you to have performed a post-audit on the Hadnot Point/Holcomb Boulevard model?
A. Yes, I assume it would be possible.
Q. Okay. And you did not do it because you weren't asked to by the legal team; right?
A. That's correct.
Q. Okay. Finally, I'd -- I'd like to turn back to our earlier discussion of the model's ability to predict contaminant concentrations at TT-26 accurately.
Do you remember discussing that?
A. I -- we've discussed that topic quite a few times today. In general, yes, I remember discussing that.
Q. Okay. It's true that the ATSDR used a mass balance model for determining

concentrations at the water treatment plant; right?

A. That's correct.

Q. Okay.

A. Based on the concentrations and pumping rates at the supply wells.

Q. It's also true that you did not have information on the pumping rates for all times during this study period; correct?

MS. BAUGHMAN: Objection. Form.

Q. BY MR. ANTONUCCI: Excuse me.

It's true that ATSDR did not have information on pumping rates during all times of the study period; correct?

MS. BAUGHMAN: Objection. Form and foundation.

THE WITNESS: Yes, that is very standard for groundwater modeling projects.

Q. BY MR. ANTONUCCI: Okay. Would the process of performing a post-audit for Hadnot Point/Holcomb Boulevard be different than performing a post-audit for Tarawa Terrace?

A. The basic process would be the same. It would be extended over a -- the model inputs would be extended over a new period. We would not change anything in the original models, other than extending it, and then run the simulations and compare the predicted results of the extended model with any new field observed value data that were available, is the general process.
Q. The -- the -- ATSDR's calibrated model's geometric model bias was lower when considering Well TT-23; right?
A. That's correct.
Q. That's because the ATSDR's calibrated model demonstrated a worse fit between simulated and observed conditions at that well?
A. I think that's safe to say, yes. Well, actually, the reason why -- I'm not comfortable saying they didn't consider it because it had a worse fit. I would say that the difference in the geometric bias between the two, the fact that it goes down if you don't include it would indicate that it -- it has a high fit at that. But I -- I

recall there were -- there were a couple of reasons why they argued why it may not be considered, but they presented both values for consideration, so...

Q. Okay. So then ATSDR's calibrated model had a sort of variable fit between observed and simulated data at different supply wells; isn't that right?

A. Yes.

Q. Okay. Dr. Jones, I think we're coming up on the end of my questions. Are there any answers you've given to my questions you wish to change before we end this deposition?

A. Not that I can think of.

Q. Is there any information I asked you about that you didn't recall at the time but now remember?

A. No.

Q. Were there questions I asked that you did not understand in which I was unable to clarify?

A. Not that I recall.

Q. Once it's ready, you will be provided with a transcript of this deposition. We ask you carefully read, correct, and sign it.

Do you understand that?

A. Yes.

MR. ANTONUCCI: Well, thank you, Dr. Jones, for your patience in answering my questions today.

I pass the witness.

THE WITNESS: Thank you.

MS. BAUGHMAN: Dr. Jones, I just have a few questions for you.

EXAMINATION

BY MS. BAUGHMAN:

Q. First, let's go to Exhibit 6 of your -- Exhibit 6, which is your original post-audit. And if you could turn to Page 5-1.

A. Sure.

Q. Okay. And I think you may remember earlier that counsel for DOJ asked you some questions about -- or he read parts of Numbers 1 through 4 under your results and asked if he'd read it correctly and if these things were true.

Do you recall that?

A. Yes.
Q. Okay. And so what you have here under Section 5 Results is you wrote "Before presenting the results, it is helpful to remember that when simulating the migration of a PCE contaminant plume using MODFLOW and MT3DMS, achieving a close match between simulated and observed concentrations can be challenging for several reasons:" And you listed four reasons; correct?
A. Yes.
Q. Now, I'm going to ask about each of them individually, but is your observation that when simulating the migration of a PCE contaminant plume using MODFLOW and MT3DMS, when doing that achieving a close match between simulated and observed concentrations can be challenging, is that limited to Camp Lejeune and the ATSDR's modeling efforts?
A. No.
Q. What -- to what extent does that apply to groundwater modeling?
A. The contaminant transport modeling with MT3DMS, there's always -- or

there's typically a very high variability in the observed concentration data. And the -- the model simulates a plume representing average conditions over the grid cells and using some simplifying assumptions.

And so you shouldn't expect it to -- to precisely match the observed concentrations at each instance, rather the overall level of fit is what is most important to analyze.

Q. And that's true whenever you're modeling a plume using MODFLOW and MT3DMS; right?

A. That's correct.

Q. Okay. So if we go to the first factor, you wrote that "The subsurface environment is inherently complex, with variations in soil heterogeneity, permeability, porosity, and hydraulic conductivity. These properties vary spatially in ways that are not fully captured in the model, affecting how the contaminant plume moves throughout the groundwater system."

Is that observation specific to

Camp Lejeune and the ATSDR modeling efforts?
A. No.
Q. Is that statement regarding complex subsurface conditions generally true for groundwater modeling efforts using MODFLOW and MT3DMS?
A. Yes.
Q. Okay. Or using any model?
A. Yes.
Q. Okay. Your second factor listed is "Temporal Variability," and you wrote "The concentration of contaminants can change over time due to factors like seasonal variations in groundwater flow, biodegradation, and chemical reactions. Simulating these dynamic processes accurately over the entire simulation period is challenging."
Is that observation specific or unique to Camp Lejeune and the ATSDR's modeling efforts?
A. It's a -- it's a general statement that would be true of any contaminant transport model.
Q. At any location?

A. Yes.
Q. By any modeler?
A. Yes.
Q. Okay. Your third reason listed is "Limitations in Model Resolution." And you wrote "MODFLOW and MT3DMS rely on discretizing the subsurface into numerical grids consisting of cells that represent a subset of the aquifer. The resolution of these grids can limit the model's ability to capture fine-scale variations in plume behavior, particularly in areas with sharp concentration gradients, small-scale heterogeneities, or preferential pathways."
Is that observation specific to ATSDR's modeling efforts at Camp Lejeune?
A. No, it's a general statement, and I think there's evidence of this specifically at Camp Lejeune.
Q. But the limits in modeling -- limitations of model resolution that you've described here is a limitation that would apply whenever this type of modeling is done with MODFLOW and MT3DMS?
A. Correct.

Q. Okay. And the fourth factor you listed is "Measurement Variability," and you wrote "The observed concentrations at observation wells may contain some degree of measurement error uncertainty. Field data collection is subject to variability, which adds another layer of complexity when trying to match it closely with model outputs."

Is that observation unique to ATSDR's efforts at Camp Lejeune?

A. No.

Q. Is it a general issue on measurement variability that applies in all groundwater modeling efforts?

A. That's correct.

Q. Okay. You were asked, I think, on numerous occasions today by DOJ's counsel for what purpose ATSDR's modeling effort can be used, and I want to ask you this: Can ATSDR's model be used to determine -- let me strike that.

Is ATSDR's model or models used for Camp Lejeune sufficiently reliable to determine the mean monthly concentrations at the water treatment plant at Tarawa Terrace based on the work that you've done in this case?

A. Yes, I believe so.

Q. And was it necessary for you or for the ATSDR modelers to know how those mean monthly concentrations would be used by any health professional, including an epidemiologist or a toxicologist or a medical doctor, in order to conduct the modeling efforts appropriately?

A. I can't think of any circumstances in how they would be used that would alter the modeling process that went about building the model and generating those simulated concentrations at the water treatment plant.

Q. So, in other words, if a MD, PhD, epidemiologist, medical doctor wanted to use the mean monthly concentrations to estimate an individual exposure as opposed to a group exposure, would that change how you or Morris Maslia or anyone else conducts the modeling?

MR. ANTONUCCI: Objection.

THE WITNESS: No.

Q. BY MS. BAUGHMAN: You were asked a number of questions by DOJ counsel regarding -- about geometric bias.
Do you recall that?
A. Yes.
Q. Do you know what the geometric bias was that was calculated for the concentrations at the water treatment plant for Tarawa Terrace?
A. Yes.
Q. What was that?
A. 1.5.
Q. And that's -- what's your opinion of that in terms of, you know, good, bad, accurate, inaccurate, do you have an opinion?
A. I would say in the context of contaminant transport modeling that would be a slight high bias.
Q. Okay. And did you calculate the geometric bias related to your post-audit work?
A. Yes.
Q. And what was that geometric bias?

A. I calculated geometric bias for the 318 observations, and the geometric bias was 2.1, which is substantially lower than the 3.9 to 5.9 range that they got with the original model.

And if you look solely at observation -- observation -- concentrations at observation wells that are greater than 5 micrograms per liter, that bias drops to 1.2.

Q. And remind me, 5 micrograms per liter, why is that number significant?

A. It's the minimum -- it's the MCL.

Q. Maximum contaminant --

A. Maximum contamination level, yes.

Q. Set by the EPA?

A. That's correct.

MS. BAUGHMAN: Okay. I'll pass the witness.

EXAMINATION

BY MR. ANTONUCCI:

Q. Dr. Jones, you just testified that the geometric model bias at the Tarawa

Terrace water treatment plant was 1.5; is that correct?

A. That's correct.

Q. Where did you get that value from?

A. From the modeling reports. ATSDR modeling reports.

Q. Okay. Can you tell me where specifically in the modeling reports you got that value from?

A. Well, earlier this afternoon you had me read from a table, and it was in that table and a discussion of that was in the prior page. I believe it's in -- you can find it in Chapter A, if I recall correctly.

Q. Okay. And you also testified that the geometric model bias of your post-audit was 2.1; is that correct?

A. That's correct.

Q. It's true that you calculated a geometric model bias but not a mean absolute error of your post-audit; is that right?

A. I -- there is a mean absolute error calculated, I just can't remember what it was off the top of my head.

Q. Okay. And it's not in your report; correct?
A. No, we did not put it in the report.
MR. ANTONUCCI: Okay. All right. I pass the witness.

EXAMINATION

BY MS. BAUGHMAN:
Q. The geometric bias, is there -- is there a table or a figure in your report from which one could easily calculate the geometric bias for the post-audit work?
A. Yes. If you take the simulated versus observed PCE concentrations at the 318 well locations, it's -- it's a simple spreadsheet calculation.
Q. And all of the data necessary to do that is in your report?
A. That's correct.
Q. Where? Where?
A. It's the -- well, the most recent and correct version of that would be in table -- Table A1 of the rebuttal report.
MS. BAUGHMAN: Okay. Thank you.

I'll pass the witness.

MR. ANTONUCCI: All right. Thank you, Dr. Jones, no further questions.

THE WITNESS: Okay. Thank you.

MS. BAUGHMAN: I think we're finished. Thank you.

THE VIDEOGRAPHER: We're off the record. The time is 4:34.

(The deposition was concluded at 4:34 p.m.)

-oOo-

Reporter's Certificate

State of Utah)
County of Salt Lake)

I, Vickie Larsen, Certified Court Reporter and Registered Merit Reporter in the State of Utah, do hereby certify:

THAT the foregoing proceedings were taken before me at the time and place set forth herein; that the witness was duly sworn to tell the truth, the whole truth, and nothing but the truth; and that the proceedings were taken down by me in shorthand and thereafter transcribed into typewriting under my direction and supervision;

THAT the foregoing pages contain a true and correct transcription of my said shorthand notes so taken.

IN WITNESS WHEREOF, I have subscribed my name this 19th day of February, 2025.

Vickie Larsen, CCR/RMR
Utah License No. 109887-7801
Nevada License No. 966

In Re: Camp Lejeune Water Litigation
Case No.: 7:23-CV-00897
Date: February 14, 2025
Reporter: Vickie Larsen, CCR/RMR

WITNESS CERTIFICATE

State of Utah)
ss.
County of Salt Lake)

I, NORMAN L. JONES, HEREBY DECLARE: That I am the witness referred to in the foregoing testimony; that I have read the transcript and know the contents thereof; that with these corrections I have noted this transcript truly and accurately reflects my testimony.

PAGE-LINE		CHANGE/CORRECTION	REASON
____	____	______________________	_____
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_____ No corrections were made.

I, NORMAN L. JONES, hereby declare under the penalties of perjury of the laws of the United States of America and the laws of the State of Utah that the foregoing is true and correct.

Dated this ______day of _______________, 2025.

____
NORMAN L. JONES

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EXHIBIT 14

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION
Civil Action No. 7:23-cv-00897

IN RE: CAMP LEJEUNE WATER LITIGATION

THIS DOCUMENT RELATES TO:
ALL CASES

VIDEOTAPED
DEPOSITION OF: MORRIS MASLIA
DATE: March 13, 2025
TIME: 9:14 a.m.
LOCATION: BELL LEGAL GROUP
219 North Ridge Street
Georgetown, SC

TAKEN BY: Counsel for the Defendants
REPORTED BY: Lauren A. Balogh, RPR
____

APPEARANCES OF COUNSEL:

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ALSO PRESENT:
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Leonard Konikow (via videoconference)
Deanna Havai, Motley Rice
(Via videoconference)

Alex Spiliotopoulos
(Via videoconference)
Timothy Thompson
(Via videoconference)

Bill Williams (via videoconference)

(INDEX AT REAR OF TRANSCRIPT)

THE VIDEOGRAPHER: The following will be the videotaped deposition of Morris Maslia in re Camp Lejeune Water Litigation versus United States of America, File No. 7-23-CV-897. Today's date is March 13th, 2025 and the time is 9:14 a.m. We are here today at 219 Ridge Street, Georgetown, South Carolina. The court reporter is Lauren Balogh and the videographer is Jon Landau.

At this time I will ask all attorneys present to please state their names and whom they represent for the record.

MR. DEAN: Good morning. Kevin Dean here on behalf of the PLG and the witness.

MR. BELL: Edward Bell on behalf of the plaintiff.

MR. ANWAR: Haroon Anwar on behalf of the United States.

MS. SILVERSTEIN: Kaylie Silverstein on behalf of the United States.

THE VIDEOGRAPHER: Do you want the people on the Zoom to do it?

MR. DEAN: It's up to you.

MR. ANWAR: The court reporter can take it down. That's fine.

MR. DEAN: Yeah.

THE VIDEOGRAPHER: Okay. All right. You may swear the witness, please.

MORRIS MASLIA

being first duly sworn, testified as follows:

EXAMINATION

BY MR. ANWAR:

Q. Good morning, Mr. Maslia.

A. Good morning.

Q. My name is Haroon Anwar. I am a lawyer at the Department of Justice here on behalf of the United States. We've met before at your prior deposition in fall 2024, correct?

A. September 26th.

Q. September 26th of 2024. Thank you.

A. Yes.

Q. You may remember that experience. I'm just going to go through -- go over a few rules for the deposition just so we're on the same page, but I'm going to ask you a number of questions today. If I ask you a question that's vague or you don't understand, please ask me to clarify. Otherwise, I'm going to assume that you -- you understand my question. Fair enough?

A. Fair enough.

Q. Okay. And the number one most

important rule for the deposition today, same as before, is that you are under the oath to tell the truth as if you were in an actual court of law. Do you understand that?

A. Yes, I do.

Q. Okay. And is there any reason that you'll be -- is there any reason today that you'd be unable to testify truthfully?

A. No, there is not.

Q. The court reporter is transcribing everything that we're taking down, so if we could try not to speak over each other and perhaps give a brief pause in case your lawyer needs to object, it will make for a much cleaner transcript as well as a much happier court reporter. Can we agree to try to do that?

A. Yes.

Q. Okay. We will try to take breaks about every hour. If you need to take a break sooner than that, just let me know.

A. Okay.

Q. I'm happy to accommodate you. The only stipulation I would put on that is if there's a pending question, I would ask that you answer that question and then we -- we can take a break. This is not intended to be sort of a punishment, so to speak.

A. Understood.

Q. So with that I wanted to start by asking you what you did to prepare for today's deposition?

A. I reviewed every single ATSDR Camp Lejeune historical reproduction report that I was involved with both for Tarawa Terrace, Hadnot Point. I've also reviewed my expert report that was submitted to you as well as my rebuttal report, and I also reviewed some published journal articles.

Q. What were the published journal articles that you reviewed?

A. There was a series by -- that appeared in Groundwater journal by Dr. Prabhakar Clement, who I think you may know, and ATSDR exposure dose reconstruction program staff responded to it, and then they responded to -- to ours, so it's three articles in Groundwater. His was 2010 and ours was 2012.

Q. Okay.

A. And then I've also reviewed just some articles on uncertainly analysis. An article that

I published in 2004 on use of -- contained some historical reconstruction of some smaller sites using an analytical contaminant transport system model and also contained the probabilistic uncertainty analyses using Monte Carlo simulation. So reviewed that as well as an article by Dr. Clement in 2000 at Dover Air Force Base, which is identical to Tarawa Terrace and came out with identical values for some of the parameters, and I would, in fact, like to add that to my expert report if I can.

Q. Okay.

A. I've got a copy here, if you would like to see that.

Q. Sure.

MR. DEAN: Yeah, I brought a copy.

MR. ANWAR: Thank you.

MR. DEAN: You're welcome.

BY MR. ANWAR:

Q. Thank you. So this -- we'll note this for the record as an additional material --

A. Okay.

Q. -- on your -- your reliance list.

A. Yes, yes.

Q. For your expert report. Thank you.

Aside from the articles that you -- you mentioned, the ATSDR reports and -- the ATSDR modeling reports for Tarawa Terrace and Hadnot Point, Holcomb Boulevard, and then your expert and rebuttal report, did you review any other documents?

A. Just my deposition from September 26th.

Q. Okay.

A. And the exhibits that you provided.

Q. Oh, okay. During the September 26th --

A. Yes.

Q. -- 2024 deposition?

A. Yes.

Q. Did you review any of the other expert reports in the case?

A. I reviewed Dr. Konikow's report. I reviewed Dr. Sabatini's report. I reviewed Dr. Jones and Mr. Davis's post-audit report and rebuttal. And I also reviewed the defense's expert reports by Dr. Spiliotopoulos, Dr. Hennet, and Dr. Brigham.

Q. Understood. And I understand just from attending the depositions of Dr. Aral, Mustafa Aral, Dr. Davis, Dr. Jones, and then Dr. Konikow about a week or so ago -- did you listen in to all of those depositions as well?

A. Yes.
Q. Okay.
A. With Dr. Konikow I had to step out for a couple of hours.
Q. Okay.
A. To do a medical run with my dad, so -- but I listened, I would say, to a majority of it.
Q. Did you review any of the transcripts from those depositions?
A. I -- I read them. I guess Dr. Konikow's transcript, because I wasn't there for part of it, I read that in its entirety. Okay. The other ones, just spot, you know, spot read because I was watching the entire time.
Q. Understood. Did you do anything else to prepare for today's deposition?
A. Only discuss with the plaintiff's attorney the logistics, again, of, I believe, the first time I was deposed as a fact witness versus an expert witness to them.
Q. Understood. And I'm not asking about the substance of your conversations with --
A. Right.
Q. -- the lawyers, just the circumstances of the meeting. When did you meet with the lawyers

to prepare for the deposition today?
A. Yesterday, most of the day, and on Tuesday afternoon.
Q. Okay. Who did you meet with yesterday?
A. Yesterday I met with Mr. Dean and also Mr. Williams.
Q. Was there anyone else present in that meeting?
A. Mr. Tim Thompson. He works with Mr. Williams, and that's it.
Q. Okay. About how long did that meeting last, the one yesterday?
A. Yesterday, we started about 9:30 and ended about 4:30, 5.
Q. Did you review any documents during yesterday's meeting?
A. Yes, the same ones that I had mentioned to you, and spoke about wanting to place the journal article as an addition to my materials in my expert report.
Q. Understood.
MR. DEAN: Not to interrupt, but you might want to ask him was anybody else in attendance by Zoom. Because you asked in person and he may have forgotten that.

MR. ANWAR: Sure.
BY MR. ANWAR:
Q. Were -- was anyone else in attendance?
A. Yes, another attorney, Laura Baughman.
Q. Okay.
A. With -- was in and out on Zoom.
Q. To the best of your knowledge, during yesterday's meeting, it was only yourself and attorneys for the plaintiffs attending, correct?
A. That's correct.
Q. And then on Tuesday's meeting, who was present for that?
A. I believe that was Mr. Dean and Mr. Williams and Mr. Thompson.
Q. And --
A. I don't recall if anyone was on Zoom or not. I don't believe because I did not get here until three o'clock p.m.
Q. To the best of your knowledge, the only folks in attendance on Tuesday's meeting were yourself and lawyers for the plaintiffs?
A. That is correct.
Q. Prior to yesterday's meeting and Tuesday's meeting, were there any other meetings with the lawyers to prepare for today's deposition?

A. No, no meetings.
Q. Dr. Konikow mentioned during his deposition a meeting that took place. I think he said it was in preparation for his deposition, but you were present as well; is that right?
A. That's -- yes, yes, yes, now that I recall, that was when -- I believe, if I'm not mistaken, that was in February.
Q. Okay.
A. And I think I was supposed to be -- be deposed that Thursday. That got postponed.
Q. Sure.
A. But Dr. Konikow and I were in that meeting, yes.
Q. Aside from yourself and Dr. Konikow, who else attended that meeting?
A. Mr. Dean, Mr. Williams, and I believe Mr. Thompson.
Q. Any -- anyone other than yourself, Dr. Konikow, and the plaintiffs' lawyers attend that meeting?
A. Not that I recall.
Q. Have you -- did you attend any other meetings in preparation for today's deposition?
A. No, I did not.

Q. Did you speak with anyone else in preparation for today's deposition?

A. No, I did not.

Q. Did you speak with anyone from ATSDR in preparation for today's deposition?

A. No.

Q. Now, you -- we have the -- the most recent 2020 article from Clement that you're adding to your -- your reliance list --

A. Yes.

Q. -- and have provided a copy here today. You mentioned a couple of other articles that you reviewed.

A. Right.

Q. And I was just wondering, the Clement article and the other articles that you reviewed, why did you review those articles?

A. Well, the article that I coauthored on the analytical contaminant transport analysis system, the ACT system, I think it was published in 2004, we reviewed that because it had a number of historical reconstruction cases. One was for 20 years, a dry cleaner in New Mexico, and one was -- I want to say it's Otis Air Force Base, EDB contamination, and we did 65 years, and we used an analytical contaminant fate and transport model and conducted two-stage Monte Carlo simulation. So I just wanted to refresh my memory as to what we did and some of the parameters that -- contaminant fate and transport parameters that we used in that.

In the Clement article I reviewed -- and I reviewed that one in specific detail because Dover Air Force Base is very similar to Tarawa Terrace. About the same size, 2.4 square miles. They used a -- was testing out the RT3D model, which is the reactive transport. So they went from PCE to TCE to DCE to vinyl chloride in their analysis, and a number of their parameters are right where the parameter values that we calibrated for Tarawa Terrace, so I thought it was a good comparison article.

Q. The Clement article, I'll look at it during the break.

A. Okay.

Q. But just based on your memory, what -- what did they use that model for?

A. I think the -- the purpose was to -- was it to -- well, there was historical contamination at the Air Force base and they wanted to look at how it advanced in time, and they wanted to test out the RT3D code that Dr. Clement had developed originally when he was at Lawrence Livermore National Labs, and it was hooked in to MT3DMS, and so they were testing that out, and that's what basically I recall. And then when I started reading the details of it, it appeared to me that it was a very, very good comparison article to what we did at Tarawa Terrace.

Q. Just quickly -- and I'll mark this as an exhibit, actually.

A. Okay.

(DFT. EXHIBIT 1, article from Journal of Contaminant Hydrology entitled "Natural Attenuation of Chlorinated Ethene Compounds: Model Development and Field-scale Application at the Dover Site", was marked for identification.)

BY MR. ANWAR:

Q. Let's go ahead and mark this as Exhibit 1, but I'll -- I'll mark it and then I'll hand it to you after I have a chance to read it. The 2020 Clement article on the Dover Air Force Base site, in the abstract it states, "the numerical model developed in this study is a useful engineering tool for integrating field-scale natural attenuation data within a rational modeling framework. The model results can be used for quantifying the relative importance of various simultaneously occurring natural attenuation processes."

Does that sound consistent with your recollection?

A. Yes.

MR. DEAN: Object to the form of the question. I think you misspoke about the data, the article. I think you said 2020. If you said 2000, I apologize, but I thought I heard 2020.

BY MR. ANWAR:

Q. Okay. And I understood you, Doctor, or Dr. Maslia, Mr. Maslia, to state that this article was published in 2020, but I perhaps misunderstood.

A. Okay. Okay. It is a 2000 article.

Q. 2000 article. Okay. So I'll reask my question. This 2000 article -- and it looks like on the first page of the article it actually says it was accepted in October -- into the -- this journal in October of 1999, but let's -- let's call it the 2000 Clement article.

The abstract states, "the numerical model developed in this study is a useful engineering tool for integrating field-scale natural attenuation data within a rational modeling framework. The model results can be used for quantifying the relative importance of various simultaneously occurring natural attenuation processes."

Is that consistent with your recollection of the article?

A. Yes.

Q. To the best of your knowledge, was the model discussed in this 2000 Clement article estimating contaminant concentrations for determining exposure in specific individuals?

A. The article did not go into what the end use was, okay? I took it to mean that this was the first stage or initial stage in developing a model. It did not discuss exposure. In other words, it was not an exposure assessment article.

Q. And to the best of your knowledge, was this -- the model discussed in the 2000 Clement article used for estimating contaminant concentrations for the purpose of -- purpose of determining exposure in individuals?

A. It was used for determining contaminant concentrations.

Q. But as you sit here today, you're not aware of it being used for the purpose of determining exposure in individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: I don't know what the end use was.

BY MR. ANWAR:

Q. With respect to any -- the other articles that you mentioned, were any of those models -- strike that.

With respect to the other articles that you mentioned, were any of the models discussed in those articles used for estimating contaminant concentrations that were used to determine exposure in individuals?

A. The -- or the sites that we summarized or did an analysis for in our 2004 paper, the analytical containment transport analysis system, one of them was at a dry cleaner in New Mexico and the other one was Otis Air Force Base, which was multimedia, meaning groundwater surface water and -- and volatilization, and I know USGS has done some work at Otis Air Force Base. It's been an ongoing thing and I believe there are some components from just the general topic of Otis Air

Force Base that look at exposure. It goes -- there are people living downstream from the river that goes through the Air Force base. I don't know the details of the subsequent analysis of -- on -- on that. I believe ATSDR did use the New Mexico site, I think it's North Avenue Railroad site, if I recall correctly, and I think they did a health assessment there, okay, but I don't know the specifics.

Q. Those other articles, are those included on your -- either in your report or on the reliance list?

A. Yes, the -- the 2004 is already on my reliance list, 2004 by Maslia and Aral.

Q. And that's the one -- 2004 is focused on Otis Air Force Base?

A. And -- and the New Mexico site.

Q. Okay. So it's just one article from 2004?

A. Yes.

Q. Besides that article and this 2000 Clement article, it sounded like you reviewed a couple of other articles, perhaps related to uncertainty analysis.

A. Right.

Q. Did any of those involve using groundwater modeling to estimate contaminant concentrations for the purposes of determining exposure in individuals?

MR. DEAN: Object to the form.

THE WITNESS: Again, most of the articles that I reviewed did not state the end purpose of the -- they said the purpose of the modeling to reconstruct or predict groundwater contaminant concentrations using techniques, different techniques, and also one of the articles went into -- I think it was one of the earlier applications of uncertainty analysis using Monte Carlo simulation.

BY MR. ANWAR:

Q. So as you sit here today, you're not aware of those other articles using models to estimate contaminant concentrations for the purpose of determining exposure in individuals, correct?

MR. DEAN: Object to the form.

THE WITNESS: Again, not having been directly involved with the analysis, it's -- I really can't answer what the results were used for.

BY MR. ANWAR:

Q. Okay.

A. The articles describe the process of developing and/or calibrating models.

MR. DEAN: Object to the form. And also add that if you're going to ask him about what certain conclusions are in certain reports, that the witness is entitled to see those reports, have an opportunity to review them in detail, and then properly respond.

MR. ANWAR: I'm going to mark the 2000 Clement article as Exhibit 1.

BY MR. ANWAR:

Q. Now, earlier we talked about the other experts in the case and you having listened to their depositions and read the deposition transcripts, correct?

A. Right, yes, to -- some more detail than others.

Q. Sure. One of those experts is doctor -- professor -- or Dr. Mustafa Aral, correct?

A. Yes.

Q. Who is -- remind me, who is Mustafa Aral?

A. Well, he was a professor at the Georgia Institute of Technology. He was also director of the multimedia environmental simulations laboratory

within the School of Civil and Environmental Engineering. And he had or he was the principal investigator on a cooperative agreement between ATSDR and Georgia Tech.
Q. And the cooperative agreement between ATSDR and Georgia Tech, was that in relation to the Camp Lejeune water modeling?
A. Not specifically. That was a multiyear-type agreement and it was for any site. For example, the couple of sites that I mentioned in the journal article, ACTS article, we did cooperatively.
Q. Understood. So -- but it did include the Camp Lejeune water modeling, correct?
A. Yes, it did.
Q. And if I understand your testimony before correctly, Dr. Aral was a professor that you had at Georgia Tech, correct?
A. Yes, yes, he was my -- my master's thesis dissertation chair of that -- that committee.
Q. Okay. And you know him personally, correct?
A. I know him professionally. I don't socialize with -- with -- with him, but I've known

him throughout the years professionally.
Q. Understood. What is your opinion of Dr. Aral?
A. He's very qualified. I view him as a mentor.
Q. Okay.
A. And can take his problems and analyze them from a practical standpoint and also address them through computational methods.
Q. Now, you also listened to the depositions of Jeffrey Davis and Norman Jones, correct?
A. Correct.
Q. Who is Jeffrey Davis?
A. I only -- I've never met him in person. I met him, I assume, through Zoom and he's -- to my understanding, he's a consulting engineer and modeler.
Q. You mentioned you have spoken with Mr. Davis on Zoom; is that right?
A. In a meeting, yes, in meetings.
Q. Was that during the course of preparing expert reports in the case?
A. I believe he and Dr. Jones had some questions about the Tarawa Terrace model input

files, and so I think that's where we had discussions over Zoom.

Q. And it was in the context of the -- the litigation, correct?

A. Yes.

Q. Had you met either Jeffrey Davis or Norman Jones prior to being retained by plaintiffs as an expert?

A. I have met Dr. Jones previously.

Q. Okay. You had not met Mr. Davis prior to working -- or that call with him in the context of the litigation, correct?

A. That is correct.

Q. Had you worked with Mr. Davis prior to that Zoom meeting with him?

A. No, I have not.

Q. And it sounds like you don't know him personally or socially, correct?

A. That is correct.

Q. Now, you mentioned having met Dr. Jones in the past?

A. Right.

Q. When have you met Dr. Jones in the past?

A. I served with Dr. Jones on a review of a National Science Foundation grant for the University of Alabama. And so he was the chair of the panel. And I think every year, every other year, they have to have a review status report like that, so that's -- that's where I met him in person.

Q. Around what time frame would that meeting have taken place?

A. 2021, 2022, someplace around there.

Q. Have you met him on any other occasions?

A. Not in person, but I do know of him.

Q. How do you know of him?

A. Early on or as part of the Tarawa Terrace analyses we found out that the -- I believe it was the U.S. Army Corps of Engineers or U.S. Army Corps of -- Hydrologic Center were developing a software platform called GMS. And while they were beta testing it, since we were a federal -- sister federal agency, they wanted people to test it out. So they provided us with a license, and I believe Dr. Jones was one of the original developers of the GMS software and platform.

Q. Do you remember around what time frame that would have been developed?

A. I don't know the start of GMS, but there's probably some letters in my files or e-mails. I'm going to say 2005, '6, somewhere -- maybe 2004, right when we were modeling or -- modeling Tarawa Terrace.

Q. Did Dr. Jones directly work on the model -- ATSDR's Camp Lejeune model for Tarawa Terrace?

A. No.

Q. Okay. You just had the conversation with him in the context of the GMS software?

A. No, I've never had --

Q. Oh, you didn't. Okay.

A. It was just his -- his name as the developer --

Q. Understood. Understood.

A. -- when we were provided the executable code by -- I think it was U.S. Army Corps of Engineers Hydrologic Engineering Center, and so I just saw it -- saw it through there, okay?

Q. Outside of the work with the University of Alabama and then the Zoom meeting that you described for the purpose of this litigation, have you worked with Dr. Jones in any other context?

A. No.

Q. Do you have any opinion about either Mr. Davis or Dr. Jones?
A. Both very well qualified. Very good analysts and they know their way around the GMS modeling platform. And I believe Dr. Jones is the chair of the Brigham Young University School of Civil and Environmental Engineering.
Q. What about David Sabatini, who is Dr. Sabatini?
A. I understand he's a professor -- and I forget the university, whether it's Texas or Oklahoma. Reading his report, he is -- appeared to me to be an expert in volatilization issues, and I, again, only met him over Zoom.
Q. And that was in the context of this litigation, correct?
A. Yes.
Q. Had you met him prior to the Zoom meeting in this litigation?
A. No, I have not.
Q. Do you have any opinion about Dr. -- or David Sabatini?
A. The same as the others, very competent and understands volatilization issues. Was able to assess them both from a scientific engineering

standpoint as well as present them to a layperson who is not as technically knowledgeable.

Q. Thank you.
A. Can I get a drink of water here?
Q. Sure.
(DFT. EXHIBIT 2, deposition of Morris L. Maslia dated June 30, 2010 Bates-stamped CLJA_Healtheffects-00000494487 through 0000049712, was marked for identification.)
BY MR. ANWAR:
Q. I'm handing you what I'm marking as Exhibit 2. Here you go. And I asked you these questions last time around --
A. Okay.
Q. -- in September, but I just want to confirm.
A. Okay. Can I take the rubber band off?
Q. Sure. Actually, that's all -- I actually gave you all the copies.
A. Oh.
Q. Feel free to give one to Kevin.
A. Okay. Who else?
Q. And I can take that one. Exhibit 2 is a transcript from a deposition you gave in 2010 in Laura Jones versus the United States, correct?

A. That is correct.
Q. Okay. And at that time you were employed still with the ATSDR, correct?
A. That is correct.
Q. And you were, I think, in the midst of working on the Hadnot Point/Holcomb Boulevard model, correct?
A. That is correct.
Q. And the Laura Jones versus United States case, that was a prior Camp Lejeune case, correct?
MR. DEAN: Object to the form of the question.
THE WITNESS: It was never explained to me, either by the Office of the General Counsel or DOJ or the plaintiffs' attorney, what -- what exactly the case was for.
BY MR. ANWAR:
Q. The focus of your deposition, was it on your work on the ATSDR water modeling for Camp Lejeune?
MR. DEAN: Object to the form of the question.
THE WITNESS: It was for Tarawa Terrace, my understanding was.

BY MR. ANWAR:
Q. Okay. So the focus of the deposition was the Tarawa Terrace model, correct?
MR. DEAN: Object to the form of the question.
THE WITNESS: That's my --
MR. DEAN: Give me time to -- you can answer.
THE WITNESS: Okay. That -- that was my understanding.
BY MR. ANWAR:
Q. Okay. And you testified under oath during that deposition truthfully, correct?
A. Yes, I did.
Q. And you had an opportunity to -- to review the transcript and make corrections on an errata sheet, correct?
A. That is correct.
Q. And I believe the last page of the transcript is your signed errata sheet. You can take a look.
A. Yes, yes, it is.
Q. Okay. And as you sit here today, do you stand by your prior deposition testimony?
A. I will say I generally do. If there's

a specific item in -- in here that there's a question about, I would have to see what that technical issue is and then I could specifically tell you.

Q. Okay.

A. Okay.

Q. As you sit here today, you don't have any changes that you want to make to that testimony?

MR. DEAN: Object to the -- object to the form.

BY MR. ANWAR:

Q. You didn't come with changes, correct?

A. No, I did not come with changes.

Q. Okay. So I am handing you now what I'm marking as Exhibit 3.

(DFT. EXHIBIT 3, deposition of Morris Maslia dated September 26, 2024, was marked for identification.)

BY MR. ANWAR:

Q. Here you go.

MR. ANWAR: Kevin, here you go, if you would like a copy.

MR. DEAN: All right. Thanks.

BY MR. ANWAR:

Q. I'll represent to you this is a copy of the transcript from your September 26th, 2024 deposition in this case. Would you agree with that?
A. It appears to be, yes.
Q. And this is deposition you gave in this case in your sort of capacity as a fact witness, correct?
A. That is my understanding, yes.
Q. And this deposition took place after you had been retained by the plaintiffs, but before you had disclosed your expert report in the case, correct?
A. Yes, that is correct.
Q. And you gave that deposition testimony under the oath to tell the truth and testify truthfully, correct?
A. That is correct.
Q. And you had an opportunity to review and make corrections on an errata sheet for that deposition transcript as well, correct?
A. Yes, I did.
Q. And I say that deposition transcript. I mean the September 2024 transcript; is that correct?

A. Yes.
Q. Okay.
(DFT. EXHIBIT 4, Acknowledgement of deponent and errata sheets, was marked for identification.)
BY MR. ANWAR:
Q. I'm handing you what I'm marking as Exhibit 4, which I'll represent to you is a copy of your signed errata sheet for the September 2024 deposition transcript. Would you agree with that?
A. Yes, it is.
Q. Aside from the changes on that errata sheet, do you have any changes to your prior deposition testimony?
A. Not that I recall at this time.
Q. Okay. Nothing that you came with to the deposition, correct?
A. Excuse me? I don't understand the question.
Q. You didn't come prepared to make changes or offer changes to your past deposition testimony as you sit here right now, correct?
A. No, I do not.
Q. Okay. I am going to hand you now what I'm marking as Exhibit 5.

(DFT. EXHIBIT 5, Expert Report of Morris L. Maslia, P.E., D.WRE, DEE, Fellow EWRI, was marked for identification.)

BY MR. ANWAR:

Q. Here you go.

MR. ANWAR: Here's a copy for you.

BY MR. ANWAR:

Q. Mr. Maslia, this is a copy of your expert report in this case dated October 25th, 2024, correct?

A. That is -- I'm looking for the date on here. There's no date on this copy.

Q. I think it's at the bottom there in the middle.

A. Oh, there it is, yes. Okay. That is correct.

Q. And to the -- you had an opportunity to sort of look through that. True and accurate copy, to the best of your review?

A. The copy is correct.

Q. And aside from the articles that you -- we discussed this morning already, is the materials-considered list on there complete and accurate?

A. Yes, as far as I know.

Q. Is there anything on -- in that report that you believe needs to be added that's not reflected in the report?
A. No.
Q. I am handing you now what I'm marking as Exhibit 6.
(DFT. EXHIBIT 6, Rebuttal Response to Reports of Alexandros Spiliotopoulos, Remy, J.-C. Hennet & Jay Brigham, was marked for identification.)
BY MR. ANWAR:
Q. Mr. Maslia, is Exhibit 6 a true and accurate copy of your rebuttal expert report submitted in this case?
A. Yes, it is.
Q. And it's dated January 14, 2024?
A. Yes, it is.
Q. And aside from the articles that you mentioned this morning, is there anything missing from the materials-considered list or the references provided with this report?
A. No.
Q. And in this report, as the title indicates, is in response to the reports of DOJ experts Dr. Spiliotopoulos, Dr. Hennet and Brigham?

A. That is correct.
Q. Do you know Dr. Spiliotopoulos, Hennet or Brigham?
A. I do not know any of them and have never met any of them.
Q. Do you know of any of them?
A. I know of Dr. Spiliotopoulos. I believe his name appeared in -- as an observer at at least one of the ATSDR expert panel meetings.
Q. Okay.
A. But I could not tell you exactly which one, okay?
Q. Have you ever met Dr. Spiliotopoulos?
A. No.
Q. Have you -- so fair to assume if you haven't met him, you've never worked with him, correct?
A. That is correct.
Q. And same with Dr. Hennet?
A. That is correct.
Q. And I assume same with Dr. Brigham?
A. That is correct.
Q. Do you have any opinion about Dr. Spiliotopoulos, Hennet or Brigham?
A. Not other than they are the DOJ's

expert witnesses.

Q. Okay. In your -- either your primary expert report or the rebuttal report, is there anything that you believe is incorrect?

A. I would -- in my expert report there was -- and there was discussion during my deposition about model bias and geometric biases. And I believe that we -- or I went back and -- because there were a number of duplicate samples. And because our model was only on a monthly time frame, it really is not correct to try to match daily or even weekly samples within monthly model output.

So if you take the average within the month of the actual sample data, you get a much closer geometric bias to 1 -- 1.5. So we overstated both in the ATSDR report, and I'm talking about Tarawa Terrace, as well as my expert report, which came from -- had that overstated or provided a higher geometric bias both for the supply wells and the water treatment plant than I believe should actually be there.

Q. Is that currently reflected in your expert report?

A. No, it's not.

Q. And it's not reflected in the ATSDR reports, correct?
A. No, no.
Q. When --
A. I'm sorry.
Q. No, go ahead.
A. My expert report reflects or copies exactly the tables out of the ATSDR reports specifically for Tarawa Terrace with that.
Q. When did you do this analysis about the geometric bias? And this is specifically for Tarawa Terrace?
A. Yes, I would say within -- as I was preparing my rebuttal report to the DOJ experts and within last month sometime, I started just reading more about nondetection of sample data and multiple samples within a month, which we had at Tarawa Terrace, Hadnot Point, and then realizing that our model results -- we only had one result per month because they were monthly time steps. So the implication was that the model could reproduce those daily or multiple monthly sampling, and they -- it really can't if you only have a one-month time step.
Q. Does it follow, then, the -- the model

certainly -- because the model produced monthly estimated concentrations, correct?
A. That is correct.
Q. And the model was not intended to produce daily estimated concentrations, correct?
A. Not the groundwater flow and contaminant transport. It was produced -- we had monthly time steps, so that would be 31, 30, 28 or 29 days, depending on which month it was, and our assumption was that represented the last day of each month, like January 31st, February 28th, and so on, but that it was equally likely to occur on any day of the month.
Q. So is it your opinion because you used daily samples, but the model was producing monthly simulated contaminant concentration estimates, that you overestimated the geometric bias?
A. Yes.
MR. DEAN: Object to the form.
THE WITNESS: We computed a geometric bias that was higher than if you had a one-to-one correspondence, one -- one sample and one model result for each month.
BY MR. ANWAR:
Q. Have you actually done the calculations

on that?
A. Yes, I have.
Q. I guess, based on the opinion that you're offering now, what is -- what is, in your opinion, the geometric bias for the Tarawa Terrace model?
A. For the supply wells, I believe it comes down to somewhere below 1.5 and recalling a value of 1.0 would be an exact match, okay? And at the water treatment plant, I believe it comes down to almost 1.0.
Q. Do you -- when you said you did the calculations, is that reflected in writing anywhere?
A. I've got notes, but not with me.
Q. Okay. If we requested those notes to be produced, would you be agreeable?
MR. DEAN: Object -- object to the form of the question. I'll let you finish. I'm not sure if you were finished.
BY MR. ANWAR:
Q. Well, we will request the notes from your lawyer and the lawyers will work it out, but if your lawyers ask you for the notes, would you be agreeable to giving it to them?

A. Yes.

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. And outside of those notes, this opinion that you're offering now, it's not reflected in either your current expert report or rebuttal report or the ATSDR reports themselves?

A. That is correct.

Q. And sort of my general high-level understanding of sort of the thrust of your main expert report at least is, is that the -- the ATSDR models for Tarawa Terrace and the model for Hadnot Point and Holcomb Boulevard are sufficiently reliable and accurate to -- in estimating contaminant levels for purposes of using them to make exposure determinations in this case; is that right?

A. I would say that the models produce reliable results on a monthly basis, the groundwater flow and contaminant transport models for both Tarawa Terrace and Hadnot Point, and that we met one of the objectives that we were required to meet by the study epidemiologists of providing mean monthly concentrations.

Q. You're serving as an expert in this case, correct?
A. That is correct.
Q. On behalf of the plaintiffs, correct?
A. That is correct.
Q. And do you understand that the plaintiffs are offering the model for purposes of estimating exposure in individual plaintiffs in the litigation?
MR. DEAN: Object to the form of the question.
THE WITNESS: When we did the model, I was not aware of the end use of it. I was concerned with and what I have presented to the plaintiffs is that it's reliable to provide monthly mean concentrations. I'm not involved in, nor have I ever been involved in, any use post-modeling results.
BY MR. ANWAR:
Q. You understand the -- and if not, I'm telling you now, the plaintiffs' lawyers are offering the model as a way to estimate exposure -- estimated exposures in individual plaintiffs. Do you understand that?
MR. DEAN: Object to the form of the

question.

THE WITNESS: I understand what you have just said, yes.

BY MR. ANWAR:

Q. Okay. And do you believe the model is sufficiently reliable and accurate for that purpose?

A. The model is sufficiently reliable and accurate for the monthly mean concentrations in groundwater and in drinking water. I don't know what analyses they are conducting with those -- with those values, nor I have ever known, even when I was at ATSDR, what the epidemiologists or how they were planning on -- on using them other than in a general framework. But the epidemiologists at ATSDR believe the model results were reliable and accurate for their use.

Q. Sort of at a high level I understood the purpose of your report as -- to be supporting the use of the model in the litigation. Would you agree with that?

MR. DEAN: Object to the form of the question.

THE WITNESS: Could you clarify which report you're speaking of?

BY MR. ANWAR:

Q. Sure. I understood the purpose of your expert report that you submitted as a litigation expert in the case for which you're consulting with the plaintiffs on as advocating for or supporting the use of ATSDR's Tarawa Terrace and Hadnot Point/Holcomb Boulevard models in the litigation.

MR. DEAN: I'm sorry.

BY MR. ANWAR:

Q. Do I understand -- am I -- would you agree with that?

MR. DEAN: Object to the form of the question. You're asking him if he understands the same thing you understand? That's...

THE WITNESS: My understanding was --

MR. DEAN: For the record, I do not know, nor has Mr. Anwar provided sufficient information about what his understanding is to get in his head in order to be able to have anyone properly be able to respond to that question, so I object to the form.

MR. ANWAR: And I appreciate your objections, Kevin. I would appreciate if you also limit your objections to form within the rules and limit your speaking objections. Mr. Maslia is the one here to testify. This isn't your deposition.

MR. DEAN: You're familiar with the rules of the road and the rules of depositions, and if you follow those rules, then I will certainly follow them as well.

MR. ANWAR: And I am sort of raising this now because if this continues to be a problem, we intend to take that to the Court, so...

BY MR. ANWAR:

Q. Mr. Maslia, I will ask you the question again. So you submitted an expert report in this case?

A. Yes.

Q. And you submitted an expert report as a paid litigation expert, correct?

A. That is correct.

Q. And you did so on behalf of the plaintiffs, correct?

A. That is correct.

Q. Did you do so with the understanding that the plaintiffs are offering the model or the -- and when I say "the model", I mean ATSDR's Tarawa Terrace model and ATSDR's Hadnot Point/Holcomb Boulevard model -- for use in the litigation?

MR. DEAN: Object to the form.
THE WITNESS: I did so as the expert and the person who oversaw the development of the ATSDR models to any technical or scientific questions pertaining specifically to the model, model assumptions, model results that the plaintiffs' attorneys may have.
BY MR. ANWAR:
Q. Okay. I just want to make sure I'm crystal clear on this because as of now the Court intends to hold a hearing on -- or the -- there's discussion of a potential hearing being held on issues related to water contamination in the case. And I imagine if the Court does hold a hearing, you'll be called to testify. And if you're asked by a lawyer or one of the judges that -- whether or not the Court should use the model for making exposure determinations for individual plaintiffs in the case, what would your answer be?
MR. DEAN: Object to the form of the question.
THE WITNESS: My response would be, from my standpoint, my professional and expert standpoint, that the model results are reliable based on our assessment of model calibration, model

results, and that the -- as long as the models are sufficiently calibrated, in my mind, anyone can use them for whatever purpose they want to use them for. In other words, we did not calibrate the models with the end result of exposure assessment. Again, we were, at ATSDR, blinded to anything with the epidemiology in terms of cases, controls, people, anything like that, other than the five objectives that I believe I listed in my expert report as to what the epidemiologists requested us to meet.

BY MR. ANWAR:

Q. Okay. Now, Appendix A, which is page 120 of your initial expert report.

A. 2020. Yes, I'm there.

Q. Is that a true and accurate copy of your curriculum vitae?

A. Yes, it is.

Q. To the best of your knowledge, as you sit here today, is it complete?

A. Yes, it is.

Q. And there's not anything that needs to be updated as far as you're aware on that curriculum --

A. Not that I'm aware of.

MR. DEAN: So there's someone who has just joined with an area code 202 number. You're not muted. Would you mind muting your phone, please. Thank you.
BY MR. ANWAR:
Q. And on page 17 of your report it states that "I'm being compensated an hourly rate of 400 for my work for preparing this report. My rate for depositions and trial testimony is 2,000 per day." Did I read that correctly?
A. Yes, you read that correctly.
Q. And is that what you're being compensated in the case?
A. Yes, as it states right here.
Q. I'm handing you what is being marked as Exhibit 7.
(DFT. EXHIBIT 7, M.L. Maslia Consulting Engineer invoices Bates-stamped CL_PLG-Expert_Maslia_0000000609 through 0000000680, was marked for identification.)
BY MR. ANWAR:
Q. These are invoices that were produced to us in response to a document, subpoena, accompanying your -- your deposition notice.
A. Okay.

Q. Are these the invoices for the -- for your expert work performed on behalf of the plaintiffs in the case?

A. I haven't gone through all of them, but they appear to be with my signature and the billable hours and expenses that I submitted, yes.

Q. Okay. Do you have an estimate on how much you've billed to date in the case?

A. No, I just submit it on a monthly basis.

Q. Sure.

A. And you would have to ask the -- whoever the accountant is for the plaintiffs or my CPA who is filing my taxes.

Q. Well, so I went through the invoices.

A. Right.

Q. According to my calculation and let's -- let's call this rough, it looks like you've billed a little over 1100 hours in the amount of about $346,000, just under $347,000, for your work in this case and that's for professional services. Does that sound about right to you?

MR. DEAN: Object to the form.

THE WITNESS: It sounds high to me, but, again, you'll have to add these up. If you're

basing them on -- on these, that's all --
Q. Okay.
A. It does sound high. The 300 number sounds high.
Q. Okay. But if it's -- if that's what the invoices add up to, you wouldn't dispute it?
A. No, I would not.
Q. And I noticed your invoices were separated out for professional services and then you had travel and related expenses, correct?
A. That is correct.
Q. Okay. And so the hours and the numbers I read to you just now were what I calculated for professional services. For travel and related expenses, again, roughly I calculated 82.5 hours in the amount of about $16,000. Does that sound about right to you?
A. It would be hard for me to answer that right at this instant of time without going through them and adding them up.
Q. Okay. If that's what they add up to in the invoices, do you have any reason to dispute that?
A. No, I do not.
Q. We've been going for about an hour.

Would you like to take a break or --
A. Sure. That would be good.
Q. Okay. Let's do that.
THE VIDEOGRAPHER: Okay. We're going off record. The time is 10:14 a.m.
(A recess transpired.)
THE VIDEOGRAPHER: Okay. We're going back on the record. The time is 10:25 a.m.
BY MR. ANWAR:
Q. We are back on the record from a short break, Mr. Maslia. Are you okay to continue?
A. Yes, I am.
Q. Did you speak with your lawyers during the break?
A. No, I did not.
Q. Okay.
A. There is one thing I would like to clarify.
Q. Sure.
A. If I could do that. When we were speaking about the improved and reanalysis of the geometric biases, I got the original thought reading Dr. Konikow's expert report where he had mentioned about duplicate values in his report.
Q. Okay.

A. So I just wanted to give credit for the initial thought about that.
Q. No, I appreciate that. You actually anticipated my question. I was going to ask you sort of as a follow-up when you decided to do that analysis and it sounds like it was in the last month or two; is that right?
A. That is correct.
Q. Okay. And it was in the context of reading Dr. Konikow's report?
A. Yes.
Q. Okay. Would that have been after he had disclosed his report?
A. Yes, yes, it was the -- I mean, what was submitted to DOJ.
Q. Okay. And was there any particular reason you decided to do the analysis or it was just the thought popped up in reading his report?
A. Well, he mentioned that -- specifically I believe it was in reference to well TT26 at Tarawa Terrace where there were, like, five samples within a short time period, like within a day or week.
Q. Yeah.
A. And that the models could not really

reproduce that, okay, on a monthly basis. And so that's when I looked at our tables that we had published in the Tarawa Terrace Chapter A report where we computed the model biases and the geometric biases, and I went back and took that suggestion and did the analysis.

Q. Okay. And you indicated you have some notes about that, right?

A. That is correct.

Q. Okay.

MR. ANWAR: We will -- we will formally request those notes be produced. We will just formally on the record request that those notes be produced and reserve the right to reopen the deposition depending on what's in the notes.

MR. DEAN: That's right. And we reserve all of our objections and -- but we will take a look at it and provide a response back to you.

MR. ANWAR: Okay. Sounds good. Thanks, Kevin.

MR. DEAN: I don't have what he's referring to here either, so...

MR. ANWAR: Okay. Understood.

BY MR. ANWAR:

Q. And then I wanted to ask you, Mr. Maslia, when we were talking about expert reports that you had reviewed, did you review Dr. Longley's report as well?
A. No, I did not.
Q. Okay. Did you review it at any point?
A. I don't know who Dr. Longley is.
Q. Okay. I wanted to ask you a few questions about the invoices. There were a couple of references to discussions with -- with Robert Faye. And it looks like you spoke with Robert Faye in August of 2024. I'll call him Bob Faye. Everyone calls him Bob Faye, it appears. And one of the notes is -- provide Robert Faye, Bob Faye, with verbiage on the use of probabilistic analysis for Tarawa Terrace models, compose table listing, ATSDR data discovery activities, and then review so -- review 2005 expert report panel. And I can direct you to where in the invoices that is if you would like to take a look at it, but --
A. Yeah, if you could, please.
Q. Sure. It's the page ending 626.
A. 626. Okay. Ah, okay. Sure. What date in particular?
Q. It's August 24.

A. Okay.
Q. Why did you speak to Robert Faye there? What was that about?
A. Well, Bob Faye and I have known each other professionally probably for 40 years.
Q. Four or 40?
A. 40. 40. 40 years, more or less. And he was the person responsible for developing the Tarawa Terrace groundwater flow and contaminant fate and transport models as well as analyzing all the hydrogeologic data. And so I had found out, maybe through Bob, that he had been retained by the plaintiffs' attorneys and I think there was a question on -- on his part as to how to properly -- or how to word something containing probabilistic analyses, which is what I did at ATSDR. Not only did that, but I was familiar with -- with that on numerous occasions of doing that, and so I think that's what the discussion was about.
Q. Do you know when Bob Faye was retained?
A. I don't know the date.
Q. But as of this day, August 24th, 2024, you spoke with him and he was retained; is that right?
A. That is my understanding.

Q. Okay. And on that same page there is an entry phone call with R. Faye about review of ABC One Cleaners site data 2007 to 2012. Do you remember what that conversation was about?
A. I think the question came up in some of the production that DOJ provided to the -- the plaintiffs about what documents we may have had at ATSDR and what documents either the Department of Navy provided us --
Q. Sure.
A. -- in conducting the Tarawa Terrace reports. And so that ABC Weston 2007 report came up.
Q. Okay. And then if you turn the page to the page ending 640.
A. Okay.
Q. There are a couple of entries for December 28th and 29.
A. Right.
Q. The 29th entry is, review R. Faye rebuttal report, call with R. Faye. Do you recall that conversation?
A. On the 28th?
Q. 29th.
A. 29th. I'm sorry. I don't specifically

recall that -- that phone call. I mean, I don't know what exactly I was reviewing in his report. He may have asked me my opinion of something he was writing and being that he was retained and I was retained, I probably provided an opinion.

Q. Okay. We have not received a rebuttal report from Bob Faye. One has not been disclosed. I'm just wondering if you knew why that was?

MR. DEAN: Object to the form of the question. It's confidential attorney work product and I would instruct the witness not to answer the question.

BY MR. ANWAR:

Q. Do you know if Bob Faye intends to testify in this case?

A. I've -- I'm not involved in that part of being retained as to who does and does not testify, so I do not know.

Q. Okay. Other than sort of what's reflected on these invoices, have you spoken with Bob Faye about any other aspect of your work on this case?

A. Well, just in reviewing the original ATSDR reports where he was the primary author, making sure I understood what he was writing about

or what his intent was.
Q. Sure.
A. For example, the Chapter F, fate and transport model, I wanted to clarify, you know, technically clarify something.
Q. When would that have taken -- conversation taken place?
A. Last week sometime.
Q. I also noticed from some of the entries on your invoices that you exchanged some e-mails with Jerry Ensminger; is that right?
A. If you could -- can you point me to exactly where they -- they are?
Q. I don't -- I don't -- I can look during one of the breaks --
A. Okay. Okay.
Q. -- and point you directly, but do you recall exchanging e-mails with Jerry Ensminger or talking with him during the course of your work on this case?
A. He has called me a couple of times.
Q. Okay.
MR. DEAN: I think you might have marked some of that in the first depo, if I remember correctly, just for what it's worth to

help him remember. I think you might have marked a couple that were produced.

BY MR. ANWAR:

Q. When is the last time you spoke with Mr. Ensminger?

A. Sometime this past month he called me.

Q. What was that conversation about?

A. He wanted to know my opinion of the ATSDR models. He did mention geometric bias specifically, but whether the models were, you know, accurate, did they overpredict, underpredict.

Q. Do you know why he called you in the last month about that, about whether the models were accurate?

A. No, he never provides a reason why he calls. He just calls me. I mean, in that sense.

Q. You know, just in reviewing the documents in the case, it seems like -- and you should correct me if I'm wrong -- throughout the years Mr. Ensminger has had a number of conversations with you and others on the ATSDR side about work that was being performed related to the models and the epi studies. Is that consistent with your recollection?

A. Well, Mr. Ensminger was a member of the

Camp Lejeune camp.

Q. Yeah.

A. And he probably called or talked to me in that capacity because when I was at ATSDR -- and I don't know what the situation is now -- they would have quarterly CAP meetings, okay, and it's mostly when -- if I was going to present some information or whatever, I called in his capacity as the -- as a CAP member. That's what I recall.

Q. Okay. I was just wondering if you had any insight on why he called you now. Because it seems like he probably has a pretty good understanding of the models just from the years of working with you-all. If you have any insight on why he decided to call in the last month.

MR. DEAN: Object to the form of the question.

THE WITNESS: No, I do not know why -- why he would call me, because I had not heard from him in a while. I mean...

BY MR. ANWAR:

Q. Sure. And did you-all specifically discuss geometric bias during that call?

A. Not -- not that specific verbiage, but the concept and what it means.

Q. Okay. Now --
A. Those were the values -- I need to clarify. Those were the values relating specifically to the report, not anything additional that I had done.
Q. Understood. Have you had any other conversations with Mr. Ensminger during the course of your work in this case?
A. I believe there's one e-mail where he wanted to know if I had an award certificate where we were awarded the grand prize in research from the American Academy of Environmental Engineers and Science in 2015, and I believe I did provide him with a couple of images.
Q. Sure. And if my understanding -- if my recollection from your prior deposition is correct, Mr. Ensminger is a Camp Lejeune activist, right?
MR. DEAN: Object to the form.
THE WITNESS: I assume there's different definitions for activist. I have always known him as a member of the CAP and a -- I'll just leave it at that. That's where I first met him and that's -- even when he calls today, I still think of him in terms of the Camp Lejeune CAP.
BY MR. ANWAR:

Q. And are you aware that he's a plaintiff in the lawsuit as well?
A. No, I'm not aware of anyone who's a -- who's in the lawsuit.
Q. Is Mr. Ensminger a water modeler?
A. No, he is not.
Q. Is he an epidemiologist?
A. No, he's not. Let me qualify that, to my knowledge, I guess.
Q. Sure. I also noticed in the invoices at some point during the course of your work as a retained expert, you spoke with Chris Portier. Do you recall that?
A. I don't ever recall speaking with Dr. Portier once I was retained here.
Q. Okay.
A. I spoke to him -- or he spoke to me when I was at ATSDR. That's the last -- last time, actually, I recall speaking to Dr. Portier.
Q. Who is Chris Portier?
A. Dr. Portier is a former director of the Agency for Toxic Substances and Disease Registry. I'm not sure when he started. Maybe 2010, perhaps, and retired, my understanding is, in 2013.
Q. Okay. And then I noticed on the

invoices there were some e-mails or conversations that took place with Walter Grayman; is that right?
A. That is correct.
Q. First off, let me ask you, who is Walter Grayman?
A. Walter Grayman I would consider a mentor in water distribution system modeling and probably one of the godfathers of water distribution system modeling using computational methods.
Q. And why did you speak with Walter Grayman?
A. In my capacity here or -- I don't understand --
Q. Sure.
A. -- the question.
Q. During the course of your retention --
A. Right.
Q. -- as a -- for the plaintiffs in the litigation as an expert. I noticed his name on some of the invoices. Why did you speak with him during the course of the litigation?
A. My understanding is that he was also retained as an expert witness.
Q. Okay.

A. But he is no longer that. But that was my initial understanding. So he had some questions about the water distribution system modeling because he had assisted us in conducting field studies and using the -- the model, and so that's probably why I spoke with him, about that.

Q. Do you recall any other conversations that you've had with Walter Grayman during the course of the litigation?

A. No, no.

Q. I wanted to -- we talked -- some of this is going to overlap with our discussion during the last deposition. I'm trying --

A. Okay.

Q. -- my best not to duplicate too much. We talked about, in your prior deposition, sort of when you started working on the Camp Lejeune water modeling at ATSDR and when it concluded. And I noticed in Dr. Aral's report submitted in this case, he makes a statement that over the 15-year period from 2000 to 2015, I had my team members work with essentially EDRP at ATSDR -- and, for the record, the EDRP is exposure dose reconstruction program. The statement is "from 2000 to 2015, I and my team members worked with other team members at EDRP at ATSDR to perform analysis of Tarawa Terrace, Holcomb Boulevard, Hadnot Point studies related to Camp Lejeune."

Does that time period, 2000 to 2015, is that right in terms of the work for the water modeling?

A. For Camp Lejeune?

Q. Correct.

A. No, that is not correct. We had a -- as I indicated previously, we had the cooperative agreement that ran every five years, and Georgia Tech was the cooperative agreement university partner. And so on other sites, for example, I mentioned the journal article that was published in 2004, so we would work on other sites. We did not begin working in earnest until 2003 on Camp -- Camp Lejeune, at which point, if they were still part of the cooperative agreement, which they were, that's when they would have started or we would have started to have discussions about Camp Lejeune and the approaches we should be taking and things of that nature.

Q. And that's helpful in terms of the start date. And then the end date he had in his report as 2015. I noted that the -- I think the

last Hadnot Point/Holcomb Boulevard report was published in 2013. Is that consistent with your understanding?
A. The last report series was released in March 2013.
Q. Did -- did the work related to the Hadnot Point/Holcomb Boulevard modeling at ATSDR, did it conclude in March 2013 or did it go on another year until 2015?
A. The actual modeling activities and data analysis activities and report publishing concluded March 2013. I may have been asked by the epidemiologists to forward them the final modeling results after March of 2013, but I don't recall the exact date.
Q. Were you doing any work on the modeling in the ATSDR, I guess, either Tarawa Terrace or Hadnot Point/Holcomb Boulevard models, in 2015?
A. No, I was not.
Q. Okay. So the -- the time frame is just slightly off a little bit in his report, it sounds like?
A. That is correct.
Q. Okay. I just wanted to clarify that.
So you -- you worked on the ATSDR

models for Tarawa Terrace and Holcomb Boulevard/Hadnot Point -- Hadnot Point/Holcomb Boulevard for just over a decade; is that right?

A. Yes, that would be correct, although the initial work plan development probably was in early 2003 or maybe 2002, internal, internal work plan.

Q. Understood. You said 2002, 2003?

A. Yes.

Q. Okay. 11, 12-year time frame?

A. That is correct.

Q. For the 11, 12-year time frame for the work that you and your colleagues at ATSDR did related to the Tarawa Terrace and the Hadnot Point/Holcomb Boulevard models, correct?

A. That is correct.

Q. Okay. And during that period of time, you were ATSDR's project officer for the exposure dose reconstruction program, correct?

A. That is correct. I was the project officer from the beginning of the exposure dose reconstruction program, which was probably 2004 or '5.

Q. Okay. And then you were also the -- the lead or the project manager for ATSDR's water

models on Camp Lejeune, correct?
A. That is correct.
Q. Okay. Now, when you were employed during this period of time by ATSDR working on the Camp Lejeune modeling, you were a federal government employee, correct?
A. That is correct.
Q. Do you remember what grade you were sort of in the GS system in terms of employed?
A. It changed over time because I was classified under the Office of Personnel Management's research grade evaluation system.
Q. Sure.
A. So I was promoted twice from a GS-13, which is where I came into ATSDR, applied to be reclassified as -- under the research grade, and then was promoted to a GS-14 and a GS-15.
Q. When were you promoted to a GS-15?
A. I would have to look at my electronic personnel file.
Q. Sure. Were you a GS-15 by the time you were working on the Camp Lejeune water models at ATSDR?
A. Somewhere in there. Not necessarily at the beginning.

Q. Okay. I am going to hand you what I'm marking as Exhibit 8.

(DFT. EXHIBIT 8, Federal employee profile for Morris L. Maslia, was marked for identification.)

BY MR. ANWAR:

Q. I -- I looked you up on the federal government employee lookup tool, and you're welcome to look me up, too, as a federal employee. But does this document I hand you accurately reflect your GS grade and your salary while employed at ATSDR between 2004 and 2018?

A. Well, it's incorrect because I retired on December 31st, 2017.

Q. Okay. Aside from the 2018 year, for the other years, does that generally look correct?

A. I don't recall being a GS-15 all the way down to 2004 because I do recall them -- under the research grade evaluation program, what they do is, depending on the grade, but at the 13 and above they should review you every four to five years, maximum. So they would -- you -- they call in a panel and have experts and then they score you on a point basis. And then if you make above a certain -- a certain point level, then the agency has to say yes, we've got a GS-15 position available or not, okay?

So again, I just don't recall it being in 2004, but I would have to look at my own -- I know you pulled this off the -- I've got my own electronic personnel folder at home, or it was on my ATSDR LAN drive, because they wanted everybody to keep a copy of their personnel -- electronic personnel folder when they went to digital versions of it. So I could tell by those. I'm familiar with the -- whatever it is, SF-171 form that tells each year or whatever when you get promoted.

Q. Sure. Would the salary amounts, do they look roughly right?

A. They -- they -- they look, from my recollection, correct, yes.

Q. Okay. And so for that 11- or 12-year period, would it be fair sort of roughly to estimate that your total salary, cumulative salary, during that period exceeded a million dollars, correct?

A. I've never -- I've never added it up, to be quite honest about it, so I would need to add that up before...

Q. Okay. But if we added that up and I

told you it's over a million dollars, do you have any reason to dispute that?
A. No.
Q. Okay. Besides your salary as an ATSDR employee and the compensations and billings we've discussed related to your retention or your role as an expert in the litigation, have you received any other compensation related to Camp Lejeune?
A. No, I have not, nor have I ever.
Q. Now, if I remember correctly -- and you're welcome to refer to your CV as we're going through this. It's page 121 in your expert report. You started at ATSDR in 1992?
A. Let me just get there, so --
Q. Sure.
A. -- I'm on the page that you're referring to. I started at ATSDR in 1992, that's correct.
Q. And you retired in 2017, right?
A. December 31st, 2017.
Q. And as we just discussed, you worked on ATSDR's Camp -- the water modeling related to Camp Lejeune for Tarawa Terrace and Hadnot Point/Holcomb Boulevard from about 2003 to 2013, 2014?
A. Probably. I want to say through 2013.

I was being funded in part at that time by the Department of Navy, and so whatever they put in the budget for 2014, it would not have been funded by -- to my knowledge, by Camp Lejeune because the modeling was completed, okay.

Q. Okay. And give or take, for a little over -- for roughly a little over a decade, I think we said 11 or 12 years, you worked on Camp Lejeune water modeling at ATSDR, right?

A. That is correct. We did have, though, again, because I was not only project chief or scientific technical project officer for Camp Lejeune, but I was also over the exposure dose reconstruction program. We had other EDRP activities and a couple of sites that we worked in, not using Camp Lejeune money, but using the agency's other funds.

Q. Okay. You started at ATSDR in '92. You left in 2017, and you worked -- so that's, what, roughly 25 years?

A. Yes.

Q. Okay. And you worked on Camp Lejeune water modeling for close to half of that, is that right, at ATSDR?

A. Did we say 10 or 11 years, yes.

Q. Okay.
A. Maybe slightly less. Maybe slightly less, but...
Q. Understood. Was the water modeling for Camp Lejeune a significant portion of your work portfolio at ATSDR?
A. It was a substantial, but there were other sites, as I said, prior to Camp Lejeune and a couple of sites -- or a couple of analyses that were not Camp Lejeune related.
Q. Focusing on that period between 2002, 2003 to 2013, what percentage of your work would you say was related to the ATSDR's Camp Lejeune modeling?
A. I'll start after about mid-2003. I think that's when the ATSDR, I assume, got approval from either the Marine Corps or the Navy to expend the budget money on Camp Lejeune. I would say it was probably 95 percent on different aspects of Camp Lejeune.
Q. As I was looking at your -- your CV, and specifically I was looking at your list of publications, without looking each and every one up --
A. Right.

Q. -- it's on page 130.
A. Okay. Okay. I'm there.
Q. I counted about nine or ten articles that you've published related to the modeling work you did on Camp Lejeune at ATSDR; is that right?
A. That sounds about right. It would be agency reports. It would be journal articles and there were some symposia presentations.
Q. Do you have any -- well, let me ask it this way. Just ballpark, not holding you to any specific number, how many publications, symposiums, presentations, have you given related to the Camp Lejeune water modeling?
A. I would really have to go and count them up. I just don't feel answering truthfully if I just picked a number out.
Q. Would you -- I think I identified nine publications. Would you agree over ten?
A. Yes.
Q. Do you think over 20?
A. If you count some symposia presentations where we had to actually submit a manuscript, sometimes we did, and others we just did, like, PowerPoint presentations, okay?
Q. So potentially over 20?

A. Right, yes.
Q. What about over 30?
A. That may come under other activities. Like I was adjunct professor at the Emory University Rollins School of Public Health, and so I would give some case studies to my students using what was publicly released from Camp Lejeune. And I may have been asked by other ATSDR professionals who were teaching other courses on statistics or risk assessment at Emory to be a guest speaker for my -- and I would give, again, things we had already published or publicly released by the agency about Camp Lejeune.
Q. Would you agree that the work you did on the water modeling for Camp Lejeune at ATSDR was a significant part of your career at ATSDR?
A. I would say it was substantial. It would not be the complete time.
Q. And I saw on your CV that you, in 2015, received the 2015 Excellence and Environmental Energy Award, the grand prize, from the American Academy of Environmental Engineers and Scientists; is that right?
A. That is correct, sir.
Q. And was that related to the water

modeling work that you did at ATSDR on Camp Lejeune?

A. Yes, it was.

Q. What is AEEES?

A. It's a professional organization, as the name implies, of environmental engineers and other engineers and scientists, and they run a competition each year with different categories, for example, consulting small projects, government projects, and research projects.

Q. Okay.

A. And I mean, they put on webinars and things of that nature, continuing education courses.

Q. I saw the picture that you produced holding the award. You looked very happy. What did that award mean to you?

A. It meant -- it was especially meaningful not just to me, but for our entire team because an outside organization recognized the significance of our work and contribution about Camp Lejeune to the profession.

Q. Are you proud of that award?

A. Yes, I am.

Q. Would you describe it as one of the

highlights of your career?

A. Yes.

Q. How would you describe the work you've done on the Camp Lejeune water modeling at ATSDR in the context of your career?

A. I would say it was one of the similar works that I have done, just like prior to Camp Lejeune, Dover Township. Toms River, New Jersey was also a similar piece of work. It was at the U.S. Geological Survey, the work on the Floridian RASA was also a similar piece of work.

Q. Now, in your prior deposition we briefly discussed some e-mail exchanges that you had with the Bell Legal Group in a 2009/2010 time frame. Do you recall that?

A. In the September deposition?

Q. Correct.

A. I don't specifically recall that, but if it's in the verbatim transcript, then we discussed it.

Q. Okay. I'll show you one of them later.

A. Okay.

Q. And then you were retained by the Bell Legal Group in July 2022 to serve as an expert in this litigation, right?

A. That is correct.
Q. I was wondering what -- what led you or how did you decide to serve as an expert witness in this case?
A. Well, after I retired, of course, I -- I did a few consulting jobs just to keep in the profession, keep my mind fresh. And then I was approached and I felt because I had probably the most internal knowledge -- not internal ATSDR, but about the modeling I'm talking about, about what -- what we did, what the results meant, our confidence in them, and that I could advise them on those aspects of it.
Q. Are you -- how do I ask this? Is one of the factors you considered in serving as an expert in a litigation helping plaintiffs pursue their claims related to exposure to Camp Lejeune water?
A. That never -- that was never discussed with me and that was never my -- my understanding, but rather that I was a technical expert on water modeling.
Q. Do you want to help the plaintiffs in this case pursue their claims related to exposure to Camp Lejeune water?

MR. DEAN: Object to the form of the question.

THE WITNESS: That really would be a legal question. I'm not really involved in legal aspects other than being retained to explain what we did, what I did, and the meaning of the work at -- the water modeling that came from Camp Lejeune.

BY MR. ANWAR:

Q. And I guess I'm not asking you sort of in the legal sense of whether your work is being used to support the plaintiffs. I'm just asking you personally, do you want to help the plaintiffs in the litigation?

MR. DEAN: Object to the form of the question.

THE WITNESS: When we did work at ATSDR and even when I was at the USGS, we did what I would classify as science in the public's interest, okay? And so it's important to me that the public understands what we did and how we did it, and if it can help them come to a better understanding of what occurred at Camp Lejeune or Toms River, Dover Township, New Jersey, then that's a good -- good use of my time, expertise, and the taxpayer's money.

BY MR. ANWAR:
Q. So does your desire to -- or your involvement in the litigation, does that stem from a desire to explain the work that you did related to Camp Lejeune at ATSDR?
A. Yes, yes.
Q. Do you feel like your work is under attack in the litigation?
A. Not personally under attack. I believe there's been mischaracterization of the work and perhaps at different points misunderstanding of what we were tasked with or charged with doing and the reliability of the work.
Q. Do you --- is one of the motivating factors in serving as an expert for the plaintiffs, is it to defend your work?
MR. DEAN: Object to the form.
THE WITNESS: Well, I think if I'm asked a question about our work, I'm defending the -- the work, okay? So -- so but my objective is not necessarily to be hired so I can defend what we did. I would like to think that more of explaining what we did and explaining, you know, assumptions, limitations, and data analyses and things of that nature.

BY MR. ANWAR:
Q. Aside from sort of the scientific explanation portion of it or defending or explaining your work, is money a motivating factor at all serving as an expert?
A. Not at all, not at all.
Q. If the Court were to say, hey, the work that you did at ATSDR was very fine, but we don't -- we, the Court, don't believe it's appropriate for use in this -- this case, how would that make you feel?
A. Well, I would have to understand or be there when someone said -- said that. That's sort of a hypothetical. And I've never looked at the work as defending it because the Court is going to say, we don't believe it, okay? That's the best I can answer.
Q. Okay. We'll talk a little bit more about some of these other subjects later in the deposition. Did you feel like you were defending your work from the National Research Council?
MR. DEAN: Object to the form.
THE WITNESS: You mean, the results of -- of their report?
BY MR. ANWAR:

Q. I guess, did you perceive -- let me ask it differently. Did you perceive the National Research Council's comments on the ATSDR Camp Lejeune water modeling to be an attack?

MR. DEAN: Object to the form.

THE WITNESS: I believe and I believe we have explained, on a couple of occasions, internal documents as well as the published article in Groundwater, that it was a mischaracterization and misunderstanding and there was what appeared to be -- because I requested additional meetings and they would not meet with us. And I believe they made their -- part of their decision -- I didn't review the entire report, so I'm not talking about the toxicology or the epi or the rest or anything like that.

Q. Sure.

A. But they are all in conclusion that they -- there was a misunderstanding, mischaracterization, of some of the key things. So yes, I mean, it's...

Q. Yes, it was an attack, is what you're --

A. I wouldn't call it an attack, no. I would say it was a mischaracterization and

misunderstanding.
Q. Okay. What about the Navy's critique of the ATSDR water modeling for Camp Lejeune? How did you perceive that?
A. I perceived that as a very usual professional discourse that you have some work, whether it's a model, data analyses or whatever, and you publish it, whether it's a peer-reviewed journal or peer-reviewed report, and the Navy had some technical comments on the report, and so we addressed them, in other words. So -- and until this day, I still perceived it as a professional exchange.
Q. What about Prabhakar Clement's -- Dr. Clement's article?
A. Right.
Q. How did you perceive that?
A. At the time it was published, which I believe is 2010, it came right after the publication of the NRC report. And again, I thought there were some misunderstandings and mischaracterizations. I do understand now that part of it was sort of philosophical. In fact, he mentioned that in his rebuttal to us. He was looking at more philosophical issues, but I felt

the need to respond editorially to Dr. Clement's article.

Q. Sure. Now, in the instance of the NRC and the Navy and Dr. Clement, you did respond to each one of those, correct?

A. The -- to the NRC we wrote or I -- I oversaw an internal document, okay, and advised my management chain and leadership that we needed to respond to the NRC, I guess, agency, and they and CDC quickly invoked the 11th commandment, thou shall not critique the NRC.

Q. Why do you think that is?

A. I have no idea, but we point -- and that internal document was very -- I mean, it was very technically oriented in going -- I wouldn't say line by line, but topic by topic and explaining where we saw some issues with the NRC report. And I do know that -- I believe it was Dr. Portier, when he -- Dr. Portier in 2009 was not director of ATSDR, but when he became director, I provided him with a copy of that internal -- it's called document, okay, it wasn't a memo or anything like that. And he had a couple of topics in his letter to -- and I forget who he wrote exactly to, but about -- about our work, about the NRC report.

Q. If I'm understanding you correctly, you wanted to respond to NRC, correct?
A. Yes.
Q. Okay. And you had put together a response?
A. That is correct.
Q. But the response was kept, for whatever reason, by CDC and ATSDR, internal, correct?
A. I know by ATSDR. I don't know if it ever made it up to CDC --
Q. Okay.
A. -- that's over ATSDR, but it did make it up through my management chain, okay?
Q. And it was kept internal, correct?
A. That is my understanding.
Q. Okay. And you did respond to the Navy's comments or critiques, correct?
A. That is public information on the ATSDR website, yes.
Q. Okay. That -- there's this ATSDR report that's -- we'll look at it later, but it's sort of named response to the Navy's letter. Did you draft that response?
A. Yes.
Q. Okay. And then --

A. With assistance of team members and some epidemiologists.

Q. Understood. And the article that you published along with, I believe, Dr. Aral and some of the other ATSDR colleagues, Jason Sautner, maybe Rene, a response to Dr. Clement's article as well, correct?

A. That is correct, yes, the team. I listed all of the team. When I say team, from an agency standpoint, so that's why there are some epidemiologists that's coauthors on it as well.

Q. And when I say -- because we were talking -- just for purposes of the record, because we were talking about the 2000 Clement article, when I'm talking about Dr. Clement's article now, it's the article, I think, in the mid-2000s, 2010, 2011, focused on hindcasting, correct?

A. That is correct.

Q. Okay. Did you introduce the plaintiffs' lawyers to -- in this case to Dr. Konikow?

A. Yes, I did. When I say introduced, let me clarify. I think they were looking for a name of somebody who was nationally renowned in fate and transport modeling, and so from my days at USGS, I

knew Dr. Konikow.
Q. Okay. So you connected Dr. Konikow with the Plaintiffs' Leadership, correct?
MR. DEAN: Object to the form.
THE WITNESS: I just provided contact information.
BY MR. ANWAR:
Q. Okay. Did you introduce or provide contact information to the plaintiffs' lawyers in this case for Rob -- Bob Faye?
A. Yes.
Q. When did you do that?
A. I really don't remember.
Q. Was -- was it in the last 30 days?
A. It was prior to that.
Q. Last 60 days?
A. I've been, as you said, involved in this case since July of 2022.
Q. I won't hold you to a precise date. Was it in 2025?
A. No, it was -- must have been sometime in 2024.
Q. Do you recall whether it was before or after the September 26th deposition, 2024?
A. It would have been before.

Q. Did you -- do you have Bob Faye's contact information?
A. Yes, I do.
Q. What is it?
A. I've got a phone number and an e-mail.
Q. Okay.
MR. DEAN: Hold on. I have his info as well. I don't mind -- he's a retained consulting expert. He's not been disclosed as an expert. So if you were to get his contact information, I would request that you not talk to him -- talk to Mr. Faye without me being present or on the phone.
MR. ANWAR: Okay.
MR. DEAN: If at all because he is, again, a confidential consulting expert for the PLG.
MR. ANWAR: Okay. We can discuss that separately.
MR. DEAN: Sure.
BY MR. ANWAR:
Q. Did you introduce or provide contact information for any of the other experts for the plaintiffs?
A. Just the two that you have mentioned, Dr. Konikow and Mr. Faye.

Q. In documents that we received from Dr. Konikow, there was an e-mail in there between you and Dr. Konikow. I think you were e-mailing him, and it included a line, it said "don't know if Kevin explained the politics of the case now, but it's quite eye opening to me." Do you recall that?

A. I may have said that in the e-mail. I mean, if I saw the e-mail, then we could see.

Q. Sure. What did you mean by the politics of the case?

A. Well, Camp Lejeune has always been surrounded, you know, from a political standpoint, okay, because you have different parties, meaning the Navy, the CAP, ATSDR, and so on, having different points of view, so that makes it -- and you're in public health, which is -- always has politics associated with public health. And so that's what -- and then they passed or perhaps I was aware -- I was aware of the Janey Ensminger Act, okay. That would have been political to get that passed. And I believe at the time they had already passed the PACT Act, which contained the section -- I forget the exact number for Camp -- Camp Lejeune.

So that's what I was referring --

referring to, is most of the time I know the work that -- I can't speak for Dr. Konikow, but the work that I did at, say, USGS, okay, and even most of the work that I did at ATSDR, with the exception of Dover Township, Toms River, and Camp Lejeune, were not -- did not have necessarily political aspects to them in terms of legislation being passed.

Q. Understood.

A. Things like that.

Q. I -- and we talked about this in your last deposition, and I know that you were part of a group from ATSDR that testified to Congress, correct?

A. That would have been in, like, June 12th, 2007.

Q. Okay. And that was about Camp Lejeune, correct?

A. Right.

Q. Was it a House Committee Hearing, if I remember correctly?

A. It was a Senate Subcommittee Hearing.

Q. Oh, I'm sorry.

A. And I actually was -- did not provide the testimony. I believe it was Dr. Tom Sinks. I was just there, I guess, as a -- again, a technical expert, but I was seated at the table.

Q. Okay. Have you had any direct conversations -- have you directly had any conversations with any Congress members about Camp Lejeune?

A. No, I have not.

Q. You have a quote in your -- your e-mail signature block currently from Nobel prize physicist Richard P. Feynman. Do you know what I'm talking about?

A. Dr. Feynman, yes, yes, I do.

Q. And I believe the quote is "I would rather have questions that can't be answered than answers that can't be questioned"; is that right?

A. That is correct.

Q. Okay. Who is Richard P. Feynman?

A. He's a Nobel -- he's since deceased, but he was a very young Nobel prize winning physicist. And the laypeople probably know him for his participation on and his famous experiment on the Challenger explosion.

Q. Okay.

A. And I believe that's where he put that quote in, but I wouldn't swear -- swear to it, and, in fact, I just bought a copy of -- of a book about

-- about him.
Q. Okay. Why did you include that quote in your signature block?
A. I thought it's appropriate to everything in -- in life. It's very succinct. Don't be afraid to say you don't know the answer, but that's better than saying don't ask me the question.
Q. Would you agree that that quote is applicable to all of the work that you've done as an engineer or an environmental scientist?
A. I would say it's a more philosophical statement, okay?
Q. One that would apply to -- and you said any aspect of life, right?
MR. DEAN: Object to the form.
THE WITNESS: Well, that's how I am interpreting it, okay? I wasn't there when Dr. Feynman stated it or published it, so I don't know what was in his mind, but it seemed to me, from a philosophical standpoint, it, you know, it resinates with me just philosophically.
BY MR. ANWAR:
Q. Okay. We have been going for a little over an hour. Do you want to -- should we take

another break?

A. Sure, yes.

THE VIDEOGRAPHER: Okay. We're going off record. The time is 11:23 a.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on the record. The time is 11:32 a.m.

BY MR. ANWAR:

Q. We are back on the record from a short break. Mr. Maslia, are you okay to continue?

A. Yes, I am.

Q. Okay. And did you speak with your lawyer during the break?

A. No, I did not.

Q. Could you turn to page 145 of your expert report?

A. Yes. Okay.

Q. 145 is a -- includes on it a figure or a chart laying out the team that worked on the ATSDR water modeling for Tarawa Terrace and Hadnot Point/Holcomb Boulevard, their titles and sort of their roles; is that right?

A. That is correct.

Q. Okay. And you've included Xs. A dark green X for senior author of a report chapter. A light green X for a contributing author of a report chapter, and then a light red O for project management and coordination; is that right?

A. That's correct.

Q. Okay. As I -- as I look at this figure, is it fair to say that you were a senior author or a contributing author or project managed and coordinated every single chapter of the Tarawa Terrace model reports and the Hadnot Point/Holcomb Boulevard model reports?

A. I was the technical or scientific project officer over all of the Camp Lejeune water modeling.

Q. Okay.

A. It's just not shown on here. You can't print three different colors on the same box, okay? So -- and then where the dark Xs are, obviously I was the senior author on that and contributed to most of the reports, but there were some individual chapters or supplements that I did not have authorship of.

Q. But you still oversaw and managed, correct?

A. Yes, yes.

Q. Coordinated, managed?

A. Yes.

Q. Okay. In coordinating and managing every chapter of the two models, Tarawa Terrace and Hadnot Point, would you have reviewed and approved every chapter on each of those reports?

A. I would have reviewed and then said it's ready to go to -- through the agency peer review and then to external -- or if any review comes back and then go out to external peer review. It's ultimately up to the agency, I guess, Office of Science and CDC Office of Science to give the final release.

Q. Understood. Would you be the one to make the decision it's ready to go to the next step of the process, the peer review process?

A. Yes.

Q. And in making that final decision, would you -- for each chapter or each report, would you have an opportunity to review and comment and suggest edits to particular chapters of either of the model reports?

A. Yes.

Q. Okay. We talked about, at the beginning of the deposition, the -- sort of the most recent calculations you've run --

A. Yes.
Q. -- with respect to geometric bias.
A. Right.
Q. As to the Tarawa Terrace model, correct?
A. Yes, yes.
Q. That was in the last month or so, correct?
A. That is correct, sir.
Q. Aside from that, do you stand by every chapter of the Tarawa Terrace model?
A. Yes.
Q. And is that also true -- do you stand by every chapter of ATSDR's Hadnot Point model?
A. Yes.
Q. Again, aside from that geometric bias discussion that we had, is there anything that you're aware of that should be changed or corrected in either the Tarawa Terrace set of model reports or the Hadnot Point/Holcomb Boulevard set of model reports?
A. There's issues brought up by the DOJ's experts that I've responded to.
Q. Okay.
A. Okay. Absorption parameters, for

example, the results, and they do not impact at all the results of the Tarawa Terrace analyses.

Q. Understood. In preparing your expert report, either the primary -- the main one or the rebuttal report, did you rerun either of the Tarawa Terrace or the Hadnot Point and Holcomb Boulevard model?

A. No.

Q. Were your reports, the main report and the rebuttal report, were they based on the ATSDR reports that are publicly available now?

A. You're talking about my expert report?

Q. Correct.

A. Yes, they were all -- whatever was publicly available on the ATSDR website, which would be all the Tarawa Terrace expert panel reports, response to the Navy, and the Hadnot Point/Holcomb Boulevard series of reports.

Q. Okay.

A. And that's what my expert report would rely on.

Q. Okay. And I think you've clarified that for me. Basically what I'm getting at is you didn't, you know, go and put MODFLOW on your computer and run the groundwater model again. You

didn't go and get MT3DMS and run the fate and transport model again, correct?
A. Not at all, no, I do not have those on my computer.
Q. And same with EPANET and the water distribution model, you didn't --
A. I did not rerun it, although I do have EPANET on my computer at home.
Q. Okay. Do you consider yourself an expert in groundwater modeling generally?
A. Yes.
Q. Any particular aspects of groundwater modeling that you consider yourself an expert or do you consider yourself an expert in all of it?
A. I would consider myself an applied researcher, so applying the available models that have been developed by others to sites, okay, and doing that as well as experience with post-calibration analyses to assess the goodness of fit of models.
Q. In terms of groundwater modeling, do you consider yourself an expert in groundwater flow modeling?
A. Yes.
Q. Do you consider yourself an expert in

contaminant fate and transport modeling?
A. I would consider myself very knowledgeable.
Q. Okay. But not an expert?
MR. DEAN: Object to the form of the question.
THE WITNESS: I mean, I'm an expert from the standpoint that I've had courses in contaminant fate and transport. I applied some and -- but I don't do it -- I did not do it routinely, but I have run contaminant fate and transport models.
BY MR. ANWAR:
Q. Do you consider yourself an expert in water distribution modeling?
A. Yes.
Q. Why do you consider yourself an expert in water distribution modeling?
A. Well, we've applied -- when I say we, at ATSDR, we applied water distribution system modeling to a couple of sites: Dover Township, Toms River, New Jersey as well as Camp Lejeune. And we were -- for the Dover Township analysis, we were actually awarded the best practice oriented paper in 2000 by the Journal of Water Resources

Planning and Management based on the work in field monitoring of the water distribution system in Toms River, New Jersey. So yes, I would consider myself an expert there.

Q. Okay. Let's turn to page 17 of your report.

A. Of my expert?

Q. Your main report, yes.

A. Expert report?

Q. Correct.

A. Page 17. Okay.

Q. Page 17 contains a summary of your opinions; is that right?

A. It has one item.

Q. Oh, I'm sorry. 17 and 18.

A. And 19.

Q. And 19. 17 through 19?

A. Yes.

Q. Starting on 17 is a section entitled "summary of your opinions" and it concludes on page 19, right?

A. Yes.

Q. Okay. I wanted to focus on opinion number three. It states, "the reconstructed simulated monthly mean contaminant concentrations of PCE, TCE, 1-2 DCE, vinyl chloride, benzene at Tarawa Terrace, Hadnot Point and Holcomb Boulevard are contained in ATSDR report appendices A-2 for Tarawa Terrace, A-3 and A-7 for Hadnot Point, and A-8 for Holcomb Boulevard." Did I read that correctly?

A. Yes.

Q. Okay. And then opinion three goes on. It says, "these reconstructed monthly mean concentrations are also included in this report in appendixes H, I, J and K" -- well, let me -- "these reconstructed monthly mean concentrations are also included in this report in appendixes H, I, J and K, comma, are reliable and represent, within reasonable scientific and engineering certainty, the contaminant levels in selected water-supply wells and in finished water at Camp Lejeune from 1953 to 1996." Did I read that correctly?

A. That is correct.

Q. Okay.

A. The ones for Hadnot Point probably go to 2008. That's what the model runs did.

Q. Okay.

A. I'm not sure about the '96. That may have been when the wells -- all the wells -- I --

but I do recall, because we had 2008 or 2006 through 2008, a remediation rate of Hadnot Point that ran the model all the way out to 2008. So I would...

Q. When you say there that the reconstructed mean -- or reconstructed monthly mean concentrations in the ATSDR reports are reliable and represent, within reasonable scientific and engineering certainty, what do you mean by reasonable scientific and engineering certainty?

MR. DEAN: Object to the form.

THE WITNESS: When you conduct scientific and engineering analysis application and you come up with the value of -- that you believe is the most likely value and -- then there's always, you know, plus or minus a certain percent, okay, and that's accepted. That's a pragmatic engineering approximation to a modeling problem, okay? You do the best you can and see if the level of uncertainty is way beyond the information that you have in terms of giving a reliable solution or if it's within, then -- but there's always some -- some differences or errors in any of the solutions.

Q. When you say reliable there, what do you mean? Is that --

A. Reliable, to me, means that -- and I'm going to say for their ATSDR analyses, of course, that are published -- somebody could pull that off the shelf or off -- offline, I guess, now, and with the model input files, duplicate what we did, okay?

Q. In this opinion, are you stating -- are you opining that the reconstructed monthly mean concentrations in the ATSDR reports are accurate within a reasonable degree -- or reasonable scientific and engineering certainty?

A. Yes.

Q. So it's your opinion that the simulated monthly mean concentrations are accurate within reasonable scientific and engineering certainty?

A. They are the most likely values to occur.

Q. And --

A. Or to have occurred.

Q. When we're talking about reasonable scientific and engineering certainty, help me quantify that into a percentage. Are they 50 percent accurate, 75 percent accurate, 51 percent? Are they 90 percent likely to be accurate?

MR. DEAN: Object to the form of the

question. Calls for legal conclusion.

THE WITNESS: Depending on the application, not necessarily just on Camp Lejeune, but in -- generally speaking, it depends on a lot of factors. The quality of the field data. How you constructed the model. What your calibration targets may have been, or at least you try to figure them out, and so each application will have a different level of uncertainty, okay, and reliability.

BY MR. ANWAR:

Q. What do you mean by depending on the application?

A. Well, for example, we did water distribution system modeling, okay? Water distribution system modeling takes hour time steps, not monthly, but hour time steps. And we measure and we gather data because -- we personally gathered them both in -- at Dover Township and at Camp Lejeune. We had 15-minute readings per hour, okay? So that's more data. So then you have to assess that model based on the data that you have and can you accept the difference between the modeling results and the data that you -- that you have and the way you interpret the data.

In other instances you may have monthly data or sporadic data, and so the level of reliability may change. And it also depends, again, how you constructed the model. The size of the grid, how you hydrogeologically conceptualized the model. There's a lot of factors that go --go into there, so you just can't -- I don't think it's accurate to say on a blanket statement there's this uncertainty in terms of percent or not percent, you know.

Q. If the -- there is uncertainty to the simulated monthly mean contaminant concentrations, why were they -- those contaminant concentrations, I'm just wondering, why were they produced in this -- kind of this table format at the -- in multiple places in the report, but do you know what I'm referring to, at the end of Appendix A for Tarawa Terrace, for instance?

MR. DEAN: Object to the form of the question.

THE WITNESS: Can I just take a look at Appendix A?

BY MR. ANWAR:

Q. Sure. Here, we'll go ahead and mark it -- mark them both.

A. Okay. Oh, I've got a copy right here that's unmarked. That's A. No, that's not A. Here's Tarawa Terrace.

Q. Okay. I'll give you the one for the court reporter.

MR. DEAN: Just use that.

THE WITNESS: Okay. Okay.

(DFT. EXHIBIT 9, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions, Chapter A, Summary of Findings, Bates-stamped CLJA_Healtheffects-0000221172 through 0000221287, was marked for identification.)

(DFT. EXHIBIT 10, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A, Summary and Findings Bates-stamped CLJA_Healtheffects-000022136 through 0000221535, was marked for identification.)

THE WITNESS: So based on the Appendix 2 in Tarawa Terrace?

BY MR. ANWAR:

Q. I am talking about Appendix A3 and A -- A3.

A. A -- in Tarawa Terrace it's Appendix A3. It's questions and answers.

Q. Oh, I'm sorry. I have the wrong one. You're probably right. A2, yeah.

A. Okay. A2. Okay. Could you repeat the question?

Q. Sure. I guess given the uncertainty and the -- the -- the application being important, I was just wondering why were these concentrations presented in the format that they were in A2?

A. By format, what do you mean?

Q. The summary -- I mean, you -- for instance, can a person go on page A90 --

A. Okay. Hold on. A90. Okay.

Q. Stress period, 301, is for January of 1976 and the model simulated a PCE monthly mean concentration of 73.96 micrograms per liter; is that right?

A. That's directly, yes, from the model output.

Q. Sure.
A. Okay.
Q. Do you know for sure that's what the PCE concentration was in micrograms per liter in January of 1976?
A. I would say the most likely value was 74 micrograms per liter, just rounding.
Q. Okay.
A. Most likely.
Q. Didn't a moment ago you say there are sort of -- there's uncertainty associated with the model outputs and there's a range --
A. Yes.
MR. DEAN: Let him finish the question and then if I have an objection.
THE WITNESS: Okay. Okay. Oh, okay. No problem.
MR. DEAN: Can you --
BY MR. ANWAR:
Q. Didn't you say that a moment ago?
MR. DEAN: Object to the form of the question.
THE WITNESS: A moment ago I said there's -- yes, I also said there's uncertainty with the data; there's, you know, uncertainty

exists, okay?

BY MR. ANWAR:

Q. Why wasn't this numerical data presented with the uncertainty, the range, and the potential error bands for the data?

MR. DEAN: Object to the form of the question.

THE WITNESS: I believe it was in figure -- let me see if I can find the figure here. Figure -- on page A60, figure -- the figure there, A26, it's presented in terms of the 95 percent confidence.

Q. Okay. Let's turn to page -- well, let me -- let me ask some just for purposes of the record questions. When we're talking about Camp Lejeune water modeling, we're really talking about two separate water models, correct? And what I mean by that is there was a model that related to Tarawa Terrace and then there was a separate model that related to Hadnot Point and Holcomb Boulevard, correct?

A. I'd say there was an analysis related to Tarawa Terrace.

Q. Sure.

A. And then there were subsequent analyses because of the complexity of Hadnot Point and Holcomb Boulevard and the interconnection related to those areas.

Q. Was the model for the analyses for Tarawa Terrace, did that actually consist of two separate models?

A. For Tarawa Terrace? Consisted of MODFLOW and MT3DMS and then a mixing model. That would be three models.

Q. Understood. And MODFLOW is a groundwater flow model -- modeling software, correct?

A. That is correct.

Q. And MT3DMS is a contaminant fate and transport model, correct?

A. That is correct.

Q. For Tarawa Terrace, rather than running a -- sort of a water distribution model, you used the simple mixing model, correct?

A. No, that's -- that's mixing apples and oranges, okay? Let's separate off water distribution system modeling. For the groundwater flow analyses we ran MODFLOW, which generated groundwater flow velocities of different layers. That's directly imported into MT3DMS. And then we applied a flow-weighted mixing because you had different wells turning on and off. And then we used the mixing model, which was described on page A40 in equations one and two, and that was because all the wells mixed at the water treatment plant, and that was the final output to which we compared available samples that were collected at the water treatment plant.

Q. Understood. So you assumed in the Tarawa Terrace model that the -- the water from the treatment plant was the same water that the end user received, correct?

A. Yes.

Q. Now, I think that's what I was getting at. The -- now, the Tarawa Terrace analysis was completed in 2009, right?

A. The last chapter was published in 2009.

Q. Chapter A was published roughly 2007, is that...

A. In -- because of the -- excuse me. Because of the Senate Subcommittee Hearing, there was an executive summary released June the 12th, 2007.

Q. Okay.

A. And then the full Chapter A, summary of findings, was released in July of 2007. But other work had been done. Again, it was a summary document, so obviously it had results in here from -- it was just a matter of finalizing the reports.

Q. And then the Hadnot Point/Holcomb Boulevard analysis, that was completed in 2013, right?

A. March 2013, the Chapter A, summary of findings, and in that situation, rather than individual additional chapters, the agency decided to make supplements for the other contributing analyses described in the summary of findings.

Q. You would agree that when running a groundwater flow model using, for instance, MODFLOW, there is some level of uncertainty, correct?

A. Yes, yes.

Q. And when you run a fate and transport model using, for instance, MT3DMS, there is also some level of uncertainty associated with the fate and transport aspect, correct?

A. Yes, but there are different types of uncertainty, okay? In other words, there's what's referred to as scenario uncertainty, and that is your understanding or conceptualizing the system that can be an error before you ever get to the model. There's model uncertainty. For example, someone were to try to apply an analytical model, which assumes constant flow field in the groundwater, constant velocities, then that would be uncertain -- model uncertainty.

Q. And so when you're -- when you're using a groundwater flow model, a MODFLOW, and then taking the results and putting them into a fate and transport model, an MT3DMS, doesn't that certainty then accumulate because you're combining uncertainty -- uncertain results with even more uncertain results?

MR. DEAN: Object to the form of the question.

THE WITNESS: That's -- actually, if you read some papers published and all of that, it's a common mistake is to linearly add up uncertainty. It doesn't work that way, okay? It may compound it. It may get reduced or whatever, but you just can't add that you've got a 10 percent uncertainty or a 95 percent confident band on the flow model. You just can't say, okay, well, the -- the transport model has 90 percent, add the two together and call it 92 and a half. It doesn't --

it doesn't work like that.

BY MR. ANWAR:

Q. And I think you just said it could compound it, though, right?

A. You would have to look at the -- again, the specific application, the specific site that you're looking at, the specific model that you're -- you're applying.

Q. And I'm just quoting back your words. You would agree, though, it could compound it?

MR. DEAN: Object to the form of the question.

THE WITNESS: I would not necessarily say it would compound it. You would have uncertainty associated with each of the models that you applied as well as uncertainty in the data, okay, that you're calibrating to. And so that's why it's, I think, critical after you complete -- in our case it was a four-stage calibration, to try to -- or even after a third-stage, try to assess the goodness of fit of the model to data. To look at sensitivity analyses, to look at uncertainty analyses, and probabilistic uncertainty analyses to quantify that, okay?

BY MR. ANWAR:

Q. Now, let's turn to page Roman numeral three.
A. Chapter A?
Q. Chapter A, correct, of Tarawa Terrace, which is, for the record, Exhibit 9.
A. Oh, okay. I'm sorry. Roman -- the foreword?
Q. Correct. Okay. And you would agree with me, there it says, in the foreword, "the ATSDR, an agency of HHS, is conducting an epidemiological study to evaluate whether in utero and infant, up to one year of age, exposures to volatile organic compounds in contaminated drinking water at U.S. Marine Corps Base Camp Lejeune, North Carolina, were associated with specific birth defects and childhood cancers." Did I read that correctly?
A. Yes, you did.
Q. Okay. And it goes on to say "the study includes births occurring during the period 1968 to 1985 to women who were pregnant while they resided in family housing at the base." Did I read that correctly?
A. Yes, you did.
Q. Then if you go to the next paragraph,

"historical exposure data needed for the epidemiological case-control study are limited. To obtain estimates of historical exposure, ATSDR is using water modeling techniques and the process of historical reconstruction. These methods are used to quantify concentrations of particular contaminants in finished water and to compute the level and duration of human exposure to contaminated water." Did I read that correctly?

A. To contaminated drinking water.

Q. Contaminated drinking water. Thank you.

A. Yes, yes.

Q. And so you would agree with me, and I think you have before, that the Camp Lejeune water modeling for Tarawa Terrace was performed to provide data for this epidemiological study, correct?

A. It was conducted to address five questions, as I've put in my expert report. Number one was which contaminants you needed to look at. These are questions posed by the epidemiologist. You know, whether it's volatile organics, I mean, volatiles, pesticides. Another conclusion, it's a military base, so there's a numerous one. Number two, when the contaminants arrived at water-supply wells, monthly mean. And then number three, what was the concentration in the wells. Number four, what was the concentration in the water distributed throughout, in this case, Tarawa Terrace. And number five was what were the range of the values. And we interpret that, from a modeling stance, is some type of sensitivity or uncertainty analyses.

Those were -- those -- those were always from -- I guess when we first had our first kickoff meeting with the Marine Corps and Navy and all of that in October of 2003, that's what we presented to them.

Q. And that was in support of this epidemiological study that was --

A. Yes, it was in support of.

Q. Of the epi study, correct?

A. Yes.

Q. Okay. And if you turn to A98.

A. Okay. I'm there.

Q. There is a -- so A98 is a page of a question and answer section of Chapter A, Tarawa Terrace report, which is identified as Appendix A3. The question is "ATSDR's historical reconstruction analysis documents that Tarawa Terrace drinking water was contaminated with PCE that exceeded the MCL" --

A. I'm not -- I'm not following where you are. You said you were on A96?

Q. A98.

A. A98. And the --

Q. The last question --

A. Oh, okay. Okay. Okay.

Q. -- is about the results of the model, "what does this mean in terms of my family's health?"

A. Right.

Q. The response is "ATSDR's exposure assessment cannot be used to determine whether you or your family suffer -- suffered any health effects as a result of past exposure to PCE contaminated drinking water at Camp Lejeune", correct?

A. That's what it says there, yes.

Q. And you -- your -- in the chart that we looked at earlier, you're the -- the primary author of Chapter A, correct?

A. Yes.

Q. Okay. And so you wrote these words, correct?

A. I wrote these -- this section -- let me go back -- the questions and answers, okay. When I was at ATSDR they required you, if you conducted a technical analyses modeling or whether it was epi, whatever, to provide the public with a layperson's understanding, okay? So I drafted these. They were reworded by the Office of Communications and then sent back down to me to see if I agreed with their edits, which there were many. And then they were published as that appendix.

Q. Okay. And you're the primary author? You're listed first?

A. Yes.

Q. And you would stand by what's in this report today, correct?

A. Yes.

Q. Okay. Now, if you would take a look at Exhibit 10, which is Chapter A for Hadnot Point.

A. Okay. I've got a copy here. Okay. Here we go. Okay. Yes, it's unmarked.

Q. Okay. If we turn to page three again, foreword, Roman numeral three.

A. Okay.

Q. And again. There it says "ATSDR is conducting epidemiological studies to evaluate the

potential health effects from exposures to volatile organic compounds such as PCE, TCE, and benzene in drinking finished water at U.S. Marine Corps Base, Camp Lejeune, North Carolina." Did I read that correctly?
A. Yes.
Q. Okay. "Historical exposure data needed for the epidemiological studies are limited. To obtain estimates of historical exposures, ATSDR is using water modeling techniques in the process of historical reconstruction to quantify concentrations of particular contaminants in finished water and to compute the level of duration of human exposure to contaminated water." Did I -- "drinking water." Did I read that correctly?
A. That is correct.
Q. Okay. And you're also the principal author of Chapter A for Hadnot Point/Holcomb Boulevard, correct?
A. That is correct.
Q. Okay. And these are your words, correct?
A. Yes.
Q. Okay. And so again, the -- the -- the model for Hadnot Point and Holcomb Boulevard were

-- was done in support of an epidemiological study, correct?

MR. DEAN: Object to the form of the question. Asked and answered, too.

THE WITNESS: It was done to address the five objectives or questions that the epidemiologists asked us to -- to address.

BY MR. ANWAR:

Q. Okay. In support of the epidemiological studies, correct?

MR. DEAN: Object to the form of the question. I'll let him answer it one more time. The same thing happened recently in another depo.

MR. ANWAR: Please --

MR. DEAN: You keep asking the same question.

MR. ANWAR: If we need to get Judge Jones on -- I'm going to ask you to stop making speaking objections and coaching the witness.

BY MR. ANWAR:

Q. Doctor, it's a yes-or-no question. The question is --

A. Well, no, it's not because you're asking me about what the epidemiologists did. And what I can tell you is I'm not an epidemiologist.

I don't know how they used the information, but I do know that they asked us to address five objectives. And one of the objectives was to provide monthly mean concentrations in drinking water that was delivered to residents, in this case it would be Hadnot Point/Holcomb Boulevard, and also express some range of confidence.

Q. And it was for the epidemiological studies? That's what it says here.

MR. DEAN: Object to the form of the question. The document speaks for itself.

THE WITNESS: That's what it says in -- in the report, but I would like to be clear that I am not an epidemiologist, so how it's being used from once we provided -- we provided -- all we provided were the monthly mean concentrations.

BY MR. ANWAR:

Q. You're not an epidemiologist, but you felt comfortable serving as a primary author in this report that says that, right?

A. I felt confident because these were water modeling reports and water modeling analyses, yes.

Q. Okay. Let's go to page A182.

A. Okay. Okay.

Q. And this is Appendix A-9, another Q and A section --
A. Yes.
Q. -- for the Hadnot Point and Holcomb Boulevard report, correct?
A. That is correct.
Q. And per the modeling results -- in terms of the modeling results, "what does this mean in terms of my family's health." It again states, "ATSDR's exposure estimates cannot be used alone to determine whether you or your family suffered any health effects as a result of past exposure to TCE contaminated drinking water at U.S. Marine Corps Base Camp Lejeune." Did I read that correctly?
A. Yes, you did.
Q. You have both Chapter As in front of you?
A. Yes.
Q. And for the Tarawa Terrace Chapter A and the Hadnot Point/Holcomb Boulevard Chapter A --
A. Excuse me, the mike fell off.
Q. Oh, no problem.
A. Okay. Am I okay? Okay. Sorry.
Q. No, it's okay. In either of the two Chapter A reports for the Tarawa Terrace analysis

or the Hadnot Point/Holcomb Boulevard analysis, can you point me to any statement in, I guess, Chapter A or any of the reports that the models were intended to be used for exposure determinations in specific individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: The purpose of these reports were to document model analyses, data, calibrations, to provide epidemiologists with mean monthly concentrations. How they intended to use it, their epidemiological studies, or how anyone else intended to use it is -- does not disqualify the model and is not a model limitation. The text that you have read both in Chapter -- Appendices Chapter A and that, that is a statement of agency policy because ATSDR's a public health agency and they do not conduct, to my knowledge, at least when I was there, individual analyses.

BY MR. ANWAR:

Q. And so --

A. Right? So that's a statement that -- but what people can do, what anyone else wants to do with -- with these models -- we had the same situation when we did Dover Township. In fact, we had consultants call ATSDR and wanted to know, well, can you estimate for us what our exposure was at, you know, 123 Main Street -- I'm making that up.

Q. So I think -- go ahead.

MR. DEAN: Let him finish his answer.

BY MR. ANWAR:

Q. I think the --

A. The answer -- so -- and the answer was from an agency policy standpoint, no.

Q. No, none of the reports say that the models were intended or should be used to determine exposure to contaminated water in specific individuals, correct?

MR. DEAN: Object to the form of the question. Can we go off the record and have you step out of the room, please, sir.

THE WITNESS: Sure.

MR. DEAN: Thank you.

THE VIDEOGRAPHER: Okay. Going off record. The time is 12:14 p.m.

(Off the record.)

THE VIDEOGRAPHER: We're going back on record. The time is 12:16 p.m.

BY MR. ANWAR:

Q. We are back on the record, Mr. Maslia. In order to expedite things a little bit, I'm going to ask you this question. It's going to be similar to at least the prior question, but it is a different question, for the record.

In any of the ATSDR modeling reports for Tarawa Terrace, Hadnot Point or Holcomb Boulevard, any of the expert panel summaries that you put together, any of the transcripts from the expert panels, 2005 and 2009, can you point me to a single statement from any of those experts at the time or in any of your reports, the numerous voluminous reports, stating that the results of the models are sufficiently reliable and accurate to be used for exposure determinations in specific individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: We express in numerous places that they are reliable, acceptable. Again, we were not asked or -- nor were we ever asked to apply them to individuals.

BY MR. ANWAR:

Q. Okay. Let's -- I'm going to show you another exhibit.

(DFT. EXHIBIT 11, Appendix 15 Bates-stamped CLJA_Healtheffects-0000061127 through 0000061136, was marked for identification.)

THE WITNESS: Okay.

BY MR. ANWAR:

Q. I'm going to represent to you -- do you recognize this document -- I've handed you what I've marked as Exhibit 11 -- Mr. Maslia?

A. It says Appendix I-5. Let me just find -- well, that's not it. Chapter I. Oh, okay. Okay. Yes, that's the sensitivity -- that's the Tarawa Terrace Chapter I report.

Q. Okay. This is an appendix to the Tarawa Terrace Chapter I report, correct?

A. Yes.

Q. Okay. And there at the -- the second paragraph in the appendix is a disclaimer, right?

A. I don't recall putting that there, but -- can I look at my full chapter on it?

Q. Sure.

A. It's not on my Chapter I.

Q. Yeah. And that's one of my questions to you. It's on ATSDR's website currently and it's been produced in the litigation. It is attached as part of a table to Chapter I, but not directly included in the reports. And on the table we discussed earlier, you're the primary author of Chapter I, correct?

A. Yes.

Q. Okay.

MR. DEAN: Let me object to the form of the question because I think the witness just said it was not attached to his -- or you may have said, I misunderstood, that this document Appendix I-15 is not a part of the report that was released, but is now on the website; is that what you said?

MR. ANWAR: It's available on the website.

THE WITNESS: I don't know anything about that. When I left ATSDR, the only things on the website were the published reports in 2017. So no, I have never seen that disclaimer.

BY MR. ANWAR:

Q. Right. Let's -- let's read through the disclaimer together.

A. Okay.

Q. It starts "the water modeling analysis results presented herein are provided as a service to the public for informational purposes. All analyses and computer simulation results have been reviewed for accuracy and completeness based on available information and current modeling assumptions."

A. It says "all data, analyses, and computer-simulations."

Q. Okay. "All data, analyses and computer-simulation results have been reviewed for accuracy and completeness based on available information and current modeling assumptions." Did I read that correctly?

A. Yes.

Q. Then it goes on to say "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Did I read that correctly?

A. Yes.

Q. "In addition, more updated information, if and when obtained, may change interpretations presented herein. For details pertaining to assumptions and limitations, the public should refer to the aforementioned reference list above." Did I read all of that correctly?

A. Yes.

Q. I most wanted -- most importantly I wanted to focus on -- it states, "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Did I read that correctly?

MR. DEAN: Well, you can answer that. I don't have an objection to that question.

THE WITNESS: Okay. Yes, you read that correctly.

BY MR. ANWAR:

Q. And is it your testimony that you've never seen this before?

A. No, it is my testimony I have never seen this before.

Q. Were you involved in any way in drafting it?

A. Not that I recall.

MR. DEAN: Object to the form of the question. He just told you he didn't know anything about it.

THE WITNESS: I don't know when it went on the website. The last time I checked, which was not recently, maybe two years ago or whatever, I don't recall seeing it.

BY MR. ANWAR:

Q. Do you know why this disclaimer is included as part of an appendix in Chapter I and not in Chapter A?

MR. DEAN: Object to the form of the question. Asked and answered.

THE WITNESS: It's not in -- in the published report, okay? It's -- so I don't know why or who put the disclaimer there or when it went on there. As I said, to my best knowledge, when I left in -- or retired in December of 2017, the only thing on the website were these complete reports. And I would not -- I don't understand why they would pull just this out and put it like that on the website. That may -- again, somebody at ATSDR must have made a decision, but I was not involved in that, nor was this ever -- the reference citation is correct, but the disclaimer I've never seen.

BY MR. ANWAR:

Q. Okay.

MR. BELL: At a good stop -- good point for a break or not?

MR. ANWAR: I have a little bit more questioning and then we can take a lunch break.

MR. BELL: Yeah, the chef out there won't ring the bell for the employees until we go get our food because y'all are the guests of the day. I'll leave it up to you.

MR. DEAN: Well, give him five more minutes if that's okay.

MR. BELL: No problem.

(DFT. EXHIBIT 12, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Disclaimer Bates-stamped CLJA_Watermodeling_01-0000938451, was marked for identification.)

BY MR. ANWAR:

Q. Okay. I am handing you what I'm marking as Exhibit 12.

A. Okay.

Q. Exhibit 12 is a redline of the disclaimer that we just looked at.

A. Okay.

Q. Would you agree with that?

MR. DEAN: Object to the form of the question.

THE WITNESS: It looks like a big difference to me, redlined.

BY MR. ANWAR:

Q. It's been redlined, correct?
A. Well, I know. I'm -- it's...
Q. And so this is a redlined version reflecting changes that were made to, I guess, the original disclaimer -- well, let me -- let me reask that question.
This is -- so the redlined language in here is what made it into the final disclaimer that we just looked at in Exhibit 11, correct?
MR. DEAN: Object to the form of the question.
THE WITNESS: No, that's the wrong sign. There's differences here. For example -- I'll just give a quick -- it says "the documents, graphs, and water modeling analyses." It says the water modeling analyses.
BY MR. ANWAR:
Q. I've got you. Okay.
A. Okay.
Q. Have you seen this before?
A. I don't recall seeing it.
Q. Okay. I will represent to you that the meta analysis indicates that ATSDR is a custodian and you're the author.
A. Okay.

Q. And it's dated May 23rd, 2007. Do you recall this document?

MR. DEAN: I -- object to the form of the question, not that we don't accept your representation, and asked and answered.

THE WITNESS: This seems to me to be two different documents because this, the one that you handed me, Exhibit 11, okay, the appendix stuff is from the Chapter I, not -- not the cover, not the cover page. The reference is correct, but not that. If you're saying -- and Chapter I probably came out in 2009. I can take a look at the date. February 2009. Okay.

BY MR. ANWAR:

Q. Do you remember --

A. The fact that it may have been in under my ATSDR land or wherever you obtained it from, I don't know how -- how these documents are obtained by DOJ. It could have been sent as an e-mail attachment or Office of Communication or even an epidemiologist, Office of the Director, anybody saying this is what we want to use, but, whatever, I -- you know, honestly do not remember these disclaimers.

Q. Okay. It is attached to an e-mail and

I will pull that e-mail during the break. We can talk through that e-mail.

A. Okay.

Q. The one that you're -- you're included on.

A. Thank you.

MR. ANWAR: Let's take a break for lunch and --

MR. DEAN: 45?

MR. ANWAR: That's fine.

THE VIDEOGRAPHER: Okay. We're going off record. The time is 12:29 p.m.

(A luncheon recess transpired.)

THE VIDEOGRAPHER: We're going back on record. The time is 1:24 p.m.

BY MR. ANWAR:

Q. Good afternoon, Mr. Maslia. We are back on the record from a lunch break. Are you okay to continue?

A. Yes, I am.

Q. Okay. Did you speak with your -- with the counsel about your testimony during the break?

A. No, I did not.

Q. Okay. Thank you. Before we went on the lunch break, we were discussing what I had marked as Exhibit 12, which is a redlined version of Exhibit 11, Exhibit 11 being a disclaimer and Exhibit 12 being the redline of that disclaimer.

A. Okay.

Q. I'm going to show you another document that I'm marking as Exhibit 13.

(DFT. EXHIBIT 13, e-mail correspondence Bates-stamped CLJA_ATSDR_BOVE-0000157167 through 0000157170, was marked for identification.)

BY MR. ANWAR:

Q. I will represent to you Exhibit 13 is an e-mail exchange from 2007 with you and Deb Tress from ATSDR and Frank Bove from ATSDR. And the e-mail includes an attachment with -- which is a redline of the disclaimer that we were discussing before the break. Take -- take a minute to look at it, but would you agree with that?

A. Agree that this is an e-mail about this -- yes.

Q. Okay. And so if we start at the beginning of the chain, it looks like you sent an e-mail on May 23rd, 2007 to Deborah Tress and the subject is disclaimer for website. And in it you write, "Deborah, I need a disclaimer that will come up when a person enters the Camp Lejeune water modeling website. Here's my attempt. Can you please review and provide correct legal verbiage? Thanks, Morris." Did I read that correctly?

A. Yes, yes.

Q. What -- what water modeling website are you referring to?

A. Thinking back to 2007, 15 years ago or whatever, I'm looking at the date. It's May 23rd. The -- neither the executive summary or the Chapter A report had come out yet because they were June 2007, is when they came out. And the only thing I can think of is someone above me, my supervisor or the division, were thinking that just like with other ATSDR documents, they wanted to put results on the website, but they wanted a disclaimer, an agency policy-type -- type disclaimer. That's the only thing I can, I mean, recall this many years back, okay?

Q. Okay. And I think this came up in your 2010 deposition. I realize that's now 15 years ago.

A. Okay.

Q. But at one point, did the ATSDR website contain a page or have a page that allowed an individual to go in and enter sort of when they

were at Camp Lejeune and it produced numbers from the model?
A. Yes.
Q. Okay. Can you tell me about that?
A. Well, as part of our Tarawa Terrace analyses -- at that time it was just Tarawa Terrace. And, of course, ATSDR is focused on providing information to the public on their health, so we requested -- we were working with the U.S. Geological Survey. They had some web developer guys, so we requested an app that someone who resided at Lejeune or someone who didn't reside at Lejeune could put in dates, dates of service, and get an estimate, a quantitative estimate of exposure -- when I say exposures, concentrations of PCE.
Q. Okay.
A. Okay. And so the web application did go on the website. I'm trying to figure out how -- I think you showed me -- it was with this table, because that was Chapter I. That was the last chapter being -- I'm not saying we didn't have the numbers, but anyway, and at some point after it went on the website, I know I got a call and I'm sure my supervisor or the agency got a call from

the Department of Navy that they were not pleased with it at all.

Q. The website itself?

A. You have to pull it down, yes.

Q. Okay.

A. Pull the application down off your website.

Q. What do you recall about the conversation -- about the call with the Department of the Navy?

A. Only that it gave quantitative estimates of mean concentrations, and my point -- it's the team's point -- was that it's contained in the report and it was just an easier way to present if someone didn't want to read the entire report to do it, and that's all I remember, is that there was some conversations with the Department of Navy. And then our web guys said there was something about security or whatever and the web -- that application never got put back on -- on the web. So my assumption is the agency just wanted to go with tabular values right out of the reports.

Q. Okay. We'll get back to the website.

A. Okay.

Q. I wanted to focus on the e-mail

exchange and the -- the redline disclaimer --
A. Okay.
Q. -- that was attached. So it's -- based on this first -- the first thread on the chain, it sounds like you attempted to draft the disclaimer and you sent it to Deborah Tress, correct?
MR. DEAN: Object to the form of the question. Mischaracterizes the document.
THE WITNESS: I don't know. If I recall, I was probably asked to produce the table, okay, here because someone wanted it up on the website, okay? And then someone probably said, well, we need to have a disclaimer, okay? I don't know who. I don't know who, but -- and so I attempted to draft a disclaimer not being an attorney, okay --
Q. Okay.
A. -- or agency policy person.
Q. Okay. And so the next exchange is an e-mail from Deb Tress responding to you saying, "so does the website help them estimate their own exposure to the contaminated water?" Did I read that correctly?
A. Yes.
Q. And then you respond to that further up

in the chain. You say, "yes, but they cannot modify our numbers. It just provides results of modeling based on the dates they enter to a website and they can also download a graph and table as a PDF." Did I read that correctly?

A. Yes, that's what I just said about getting the tables from the report, okay?

Q. And now going further up on the chain to the first page of the exhibit, Deb Tress's response to you on May 23, 2007 says, "how about this? I'm not totally clear how this is being presented, so please edit as needed. I'm not that" -- it says considered, but I think I might be concerned "with liability by ATSDR for the use of the tool, so I took out that type of language."

A. Okay.

Q. "Thanks". Did I read that correctly?

A. Yes.

Q. Okay. And then you forward that on to Frank Bove, correct?

A. That is correct.

Q. And that's the first e-mail on the page, the top of the chain. It says, "Frank, attached is a disclaimer that will appear on the water modeling website. It's been edited by Deb

Tress. Let me know if you agree to it and then I will send to our web gurus." Did I read that correctly?

A. That is correct.

Q. Okay. So earlier you indicated you -- you at least couldn't recall having seen this disclaimer before?

A. That is correct, yes.

Q. But based on this e-mail -- this is your e-mail address and you would have received the disclaimer, correct?

A. Yes, yes.

Q. Okay.

A. That's -- I mean, as I said, it was a lot of things going on around May 2007 with the prep for the subcommittee hearing and trying to get reports approved by the Office of Science and the Office of Director and stuff and...

MR. DEAN: So for the record, so we just clarify that Bates stamp numbers ends in one -- Bove 167 and goes through 170. I haven't gone to look, but I presume the document attached is what you're saying is the document that is attached that -- that he sent to Frank Bove?

MR. ANWAR: The last document on this

chain --

MR. DEAN: 170.

MR. ANWAR: -- 170 is the attachment to that e-mail thread.

MR. DEAN: Okay. Thank you.

BY MR. ANWAR:

Q. You didn't recall it earlier, but you would have received it and you were involved in the drafting process, correct?

A. It's got my e-mail address on it and, again, it looks like Office of General Counsel, Deborah Tress, edited it, okay?

Q. Okay.

A. And probably -- and sent it back to me and then I -- I didn't accept or reject the redline. It's blue on here, but that's fine. I just sent it on, as you can see by the title of the attachment, is disclaimer underscore MLMOGC reviewed.

Q. Okay.

A. Okay. So that's -- I forwarded it on to Dr. Bove.

Q. Okay. And Exhibit 11, which we discussed before the break, was the Chapter I, Appendix I-5 document. Do you recall that?

A. It's the table from Appendix I-5.

Q. Yes.

A. Again, the final version of the report -- the numbers are the same, but the final version of the complete report was not published until February of 2009, so this must have been -- I can -- I can only surmise that once this was published in 2009, they went back and replaced the original tables. Same numbers, but original tables, okay? We had completed the Monte Carlo simulation, but we had not had the Chapter I report approved, okay? So it's, you know, I guess I'm confused as to -- because the e-mail is dated 2007.

Q. Yeah.

A. The report is not -- typically we would get a report approved and then if we wanted to pull a table or a PDF or a figure or whatever from it, we would do it that way. So it's the same table. I've checked the numbers, or spot-checked the numbers, and it's the same -- same table. So maybe it was -- the report wasn't drafted when we went ahead and put that, you know, forwarded that to Dr. Bove.

Q. Do you have any idea why the disclaimer didn't make it into Chapter I itself, the full report?

A. No, that's -- that's a mystery to me. I will say to give credit to ATSDR leadership and management, they did believe in the peer review and expert review panels that we put together, and every report went through at least two peer reviews, one internal and one external, and so I think that's why none of the reports really -- with the -- we'll get to Hadnot Point in a minute, but none of the reports contained any disclaimers like -- like you're showing here. So I don't know what prompted the disclaimer, but...

Q. Well, I will -- I will represent to you that -- and you're, obviously, welcome to go look for it yourself. The Appendix I disclaimer is still included on the website as part --

A. On the website.

Q. -- of the table -- as part of a table document. In the disclaimer where it says "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system" --

A. Are you referring to the redline or blue line -- I mean, blue line or redline?

Q. On Exhibit 11.

A. Okay. I'm sorry. Okay. Okay. Go ahead.

Q. The final version that's on the website now.

A. Okay.

Q. In the middle of the disclaimer, it says, "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Do you agree with that statement?

MR. DEAN: Object to the form of the question.

THE WITNESS: I would say it has to say that because what we're presenting is a Monte Carlo simulation result, so you've got the calibrated value, the probability at 2.5 percent, the probability at 50 percent, and the probability at 97.5 percent. So your exposure may be someplace in the middle there in between those ranges. So from that standpoint, that's a correct statement because, you know, a person's individual exposure could be within that range anywhere.

Q. Okay.

A. And can I just qualify something?

Q. Go ahead.

A. When I use the words from my standpoint of exposure, I'm talking about the estimated value of the contaminated drinking water. I'm not referring to exposure like ingestion, inhalation, thermal exposure, okay? I'm just -- so I'm using the word exposure in that sense.
Q. You're using exposure in -- in the sense of drinking water?
A. Drinking water. Drinking water. But the definition of exposure -- exposure assessment is you have to really look at which pathway or multiple pathways, okay, someone may -- may have been or may be exposed.
Q. Understood. Let's turn back to your rebuttal report, which is Exhibit 6.
A. This is 5.
Q. I know, a lot of documents.
A. Four. I've got a copy here, if that's okay.
MR. DEAN: Yeah.
THE WITNESS: The tabs are just typographical edits. Not technical, typographical.
BY MR. ANWAR:
Q. That's your version of --
A. Yeah, that's my version of my response

report.

Q. Okay. Your rebuttal report?

A. Yes.

Q. Which is -- I've marked as Exhibit 6.

A. Yeah, it's here someplace.

Q. Do you have any, like, markings or writing in that?

A. I only corrected -- due to the Maslia-genetic OCD, you know, like, I referenced date is incorrect, but nothing technical. No technical changes or technical reinterpretations on here.

Q. Okay. Just like a typo?

A. Yes, yes, yes.

Q. Okay. Let's -- let's turn to page 27.

A. Okay. Okay.

Q. Page 27, at the bottom of it, contains a section in your rebuttal report, Section 4.3, excuse me, volatilization of VOCs during water treatment process, correct?

A. Yes.

Q. And this is a response to the opinions of DOJ's expert Remy Hennet about VOC losses that would have occurred during the water treatment and distribution process at Tarawa Terrace and Hadnot

Point, correct?
A. It would have occurred only during the water treatment process. It's not possible for it to occur during the distribution because you're dealing with closed pressurized pipes.
Q. Okay. You would agree during the water treatment process, correct?
A. Well, that's -- yeah, that's -- yes.
Q. So I don't want to necessarily read this line by line.
A. Okay.
Q. Unless you want to direct me to a specific portion, but I'll start more generally.
A. Okay.
Q. For much of this it appears that you are restating Dr. David Sabatini's opinion on how VOC losses are calculated and the extent of the VOC losses that would have occurred; is that right?
A. That is correct.
Q. Okay. And do you defer to Mr. -- Dr. Sabatini on those opinions?
A. Yes, the calculations that he did, the interpretations that he did, I defer to him. That's his area of expertise.
Q. Okay. You're not doing any independent

calculations on VOC losses, correct?
A. No, I'm not.
Q. And you're not doing any independent interpretation of those calculations of VOC losses, correct?
A. I'm doing comparisons.
Q. You're comparing Dr. Hennet's opinion with Dr. Sabatini's opinion, correct?
A. And -- and the Marine Corps' consultant, AH Environmental.
Q. Okay.
A. And our experts who served on the expert panels.
Q. Determining VOC losses or calculating them, that's not your expertise, correct?
A. That is correct.
Q. Okay. So turning to page 30 in your report.
A. Okay.
Q. Actually, it might be 29. Sorry about that.
A. Okay.
Q. Okay. I misspoke again. I'm sorry. It's page 31.
A. 31?

Q. Yeah.
A. Okay. I'm there.
Q. Okay. So in the -- in the second paragraph there, the first large paragraph, you go on to discuss -- it says, "additionally, in contrast to Remy Hennet's contention that ATSDR ignored or did not account for VOC losses during storage treatment and distribution"...
A. I'm there. I'm following.
Q. "This issue, including the results of the AH Environmental Consultants report, was discussed in detail with the expert panels convened by ATSDR in 2005 and 2009." Did I read that correctly?
A. Yes, yes, you did.
Q. Okay. And a little further down it says, "excerpts from the verbatim transcript are provided in Appendix A", and you're talking about the expert panel. "The consensus was there was negligible volatilization, at most 10 percent, from the spiractors." And -- so -- and then you quote, "so although we said it's probably negligible and I agree with Tom's number here, at 90 percent what's going in is coming out on the other end." Did I read that correctly?

A. Yes, and then it references Appendix A at the end of the sentence.
Q. Correct.
A. Okay. To be clear, that's not my quotation.
Q. Correct. That's from the expert panel, correct?
A. Yes.
Q. And that's Dr. Pommerenk?
A. Yes.
Q. Okay. And the last sentence there is, "in light of the conclusions of AH Environmental Consultants, 2004, and the recommendations of its expert panels, ATSDR made the decision to consider any potential VOC losses from storage, treatment and distribution as negligible." Did I read that correctly?
A. Yes.
Q. And I believe you reference in it in your report, but I'll pull out the actual document as well.
A. In which report? The expert report?
Q. It's in your expert report, but let me -- I'm going to pull out the -- the AHE report for you. Hang on a second.

(DFT. EXHIBIT 14, ATSDR Support Estimation of VOC Removal report from AH Environmental Consultants Inc., Bates-stamped CLJA_Watermodeling_010000071446 through 0000071512, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 14. Exhibit 14 is the 2004 environmental -- or AH Environmental Consultants report, correct?

A. That is correct.

Q. It's the one that you reference in your rebuttal report, correct?

A. Yes.

Q. If you turn to page 4-4.

A. Which page? Oh, report page four?

Q. Report page 4-4. Thank you.

A. Okay.

Q. At the top of the page there it states, "based on these observations, there is some uncertainty in removal estimates from the effluent pipes. Additional uncertainties are introduced by varying head losses in the pipes caused by calcium carbonate scale built-up and manual clearing -- cleaning. However, it is estimated that PCE and TCE removals due to aeration at the spiractor effluent pipes are likely to be no larger than 15 percent." Did I -- Did I read that correctly?

A. Yes, yes.

Q. So AHE's report determined up to or no larger than 15 percent, correct?

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. And let me -- let me repeat the question. This AHE report determined that PCE and TCE losses or VOC loss due to aeration at the spiractor effluent pipes are likely to be no larger than -- no, to be -- than 15 percent?

A. That's what it states.

Q. Okay.

A. That's what the report states.

Q. And looking back at page 31 of your rebuttal report, that last -- that paragraph we were just looking at, the last sentence is, "so in light of the conclusions of the AHE consultants, 2004, and the recommendations of the expert panels, ATSDR made the decision to consider any potential VOC losses from storage, treatment, and distribution as negligible." Did I read that correctly?

A. Yes.
Q. Whether it's 10 percent VOC losses or up to 15 percent VOC losses, is it your opinion that 10 or 15 percent is negligible -- a negligible percent of losses?
A. Yes, compared with the differences, for example, in water sampling or the quality sampling, the uncertainties associated with well scheduling operations. And you've got to look at, you know, everything, not just isolate on -- on the water treatment plant, but considering everything 10 percent -- percent, we assumed and we were, I believe, justified in assuming it was negligible, okay? That is an -- the approach we took was a pragmatic engineering approximation through a modeling issue.
Q. For purposes of determining exposure in an individual, is a 10 or 15 percent VOC loss -- would you consider that to be negligible?
A. You would have to speak with the epidemiologist or toxicologist, okay? I couldn't say on an individual level, okay?
(DFT. EXHIBIT 15, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa

Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Response to the Department of the Navy's Letter on: Assessment of ATSDR Water Modeling for Tarawa Terrace, Bates-stamped CLJA_Watermodeling_01_09_0000033263 through 0000033326, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 15.

A. Okay. Response. Okay.

Q. And I wanted to direct your attention to page six, I believe, of the report.

A. Okay. The pages, I don't believe, are numbered.

Q. I think they're on the top left. Well, and let me --

A. Can you give me a Bates number because this doesn't have a report page number.

Q. Before I begin, let me -- let me start by asking you a few questions.

A. Sure.

Q. This is the ATSDR response to the Department of Navy's letter or their critiques on the Tarawa Terrace modeling, correct?

A. That's -- yes, this is --
Q. And it's entitled, on the first page there, response to the Department of Navy -- to the Department of the Navy's letter on quote -- colon, assessment of ATSDR water modeling for Tarawa Terrace, correct?
A. That's correct.
Q. Okay. Did you write this response?
A. Again, other reports, I wrote parts of it and I coordinated other people's response. I may have asked them for input and if they could respond to a certain section or not, but I coordinated the overall report.
Q. Okay. So in coordinating it, similar to the other reports that you oversaw and coordinated, would you have reviewed and had an opportunity to review the -- to comment on the report?
A. Yes.
Q. And ultimately, what was decided, would you have had an opportunity to sign off on the report?
A. It would have come from me in going up through the clearance process, report clearance process of the agency, okay? And so I would have

been the one that put it into the clearance process at the first stage once I was satisfied with the report.

Q. So you would have -- you would have approved it and then pushed it up the chain, correct?

A. Yes.

Q. Okay.

A. Well, technically a report is only approved by either the Office of the Director or the Office of Science at CDC, okay? An author cannot approve an agency report. They can submit it, they can comment on it and all of that, but it's only those two, Office of Director and Office of Science at CDC, when I was there.

Q. And perhaps "approve" is a bad term because it may be a term of art --

A. Right.

Q. -- within an agency, but you would have had an opportunity to review, comment and sign up -- sign off on it and then send it up the chain to be approved, correct?

A. Yes, that is correct.

Q. Okay. So on the page with the Bates ending in 33272, if you could turn there.

A. Yeah, yeah. 272?

Q. Correct.

A. Okay. I'm there, 33272.

Q. Okay. And then the page before, 33271, it's a Department of Navy comment statement 7.1 and it's an excerpt from their letter. It says, "however, all comparisons did not fall within the calibration range. At the water treatment plant, 12 percent of the simulated PCE concentrations failed the calibration standard at the water supply wells, a majority, 53 percent, of the simulated concentrations fell outside the calibration standard."

A. Correct.

Q. Did I read that correctly?

A. Yes.

Q. Okay. And so then ATSDR responds. And if you turn the page, as part of the response on the last page there it states, "to address the issue of the intended use of the water modeling results by the current ATSDR epidemiological study, the DON, Department of Navy, should be advised that a successful epidemiological study places little emphasis on the actual or absolute estimate of concentration and, rather, emphasizes the relative level of exposure. That is, exposed individuals are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to the, quote, true measured PCE concentration." Did I read that correctly?

A. Yes.

Q. Were you involved in -- did you -- did you write that section?

A. No, I did not.

Q. Okay. But you reviewed it and you signed off on the response before you sent it off to the appropriate --

A. I did not. It seems to me, looking at the language or the verbiage in that last paragraph, that that was written by an epidemiologist, and what I would have done as we were preparing this report -- as I said, we had a team. I may have forwarded it to the epidemiologists of the study and asked them specifically would they review it and care to add anything to it.

Q. But you oversaw the response and you reviewed it?

A. Yes.

Q. And you signed off and sent it up the chain to be approved, correct?
A. That is -- that is correct.
Q. Okay. And so as I understand it, as I'm reading this, it's -- and this is coming as part of a response to a concern, so maybe you wrote about -- raised about the accuracy of the model based on the calibration. As far as -- it sounds like for purposes of the epidemiological study that was being conducted in which the modeling was supporting, the absolute concentration values produced by the model didn't matter; would you agree with that?
MR. DEAN: Object to the form.
THE WITNESS: Well, it doesn't say didn't matter. It says little emphasis is placed on it.
BY MR. ANWAR:
Q. Okay.
A. And again, it's from -- I would interpret this, because I know I did not write this section, that that's -- you really need to ask an epidemiologist on the epidemiological interpretation of that.
Q. What it says is that that is

successful -- that the -- the intended use of the water modeling results by the current epidemiological study places little emphasis on the actual absolute estimate of concentration and rather emphasizes the relative level of exposure, right?

A. That's what it says.

Q. All right. And then it says, "that is, exposed individuals, in effect -- are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to the true measured PCE concentration", correct?

A. That's what that -- that sentence that you just read says.

Q. Okay. So if in that context for the -- of the water modeling and what was happening at the time, when you-all were -- so let's turn back to the discussion in your rebuttal report about the VOC losses --

A. Okay.

Q. -- and ATSDR's characterization of 10 or 15 percent of VOC losses as negligible. If ATSDR was performing an epidemiological study that was ranking exposure level and maintaining the rank order of individuals, does it matter -- it doesn't matter whether the VOC losses are 10 percent, 15 percent, 25 percent, does it?

A. It's an epidemiology question or toxicology or a combination of both, okay? Again, in the response, again, I can tell that's not the way I write. It was written by an epidemiologist in there and I just -- I'm not comfortable answering an interpretation from one or the other, okay?

Q. The point I'm getting at is that whatever the concentration level, you know, we're talking about is produced by the model, let's say 100, across the board for individuals, the same amount is coming off the top for the VOC losses, so 10 percent, 15 percent, it doesn't change the rank of the order -- the rank of individuals for purposes of the epi study, right?

MR. DEAN: Object to the form of the question.

THE WITNESS: Again, that's an epidemiological analysis. I've never done one of those. I've never ranked, okay, so I don't know what assumptions they are using to put into there. I know they are using the mean monthly concentrations that we reconstructed, but that's as far as I can go.

BY MR. ANWAR:

Q. ATSDR made the decision -- treated VOC losses as negligible because the water modeling was supporting an epi study, right?

A. No.

MR. DEAN: Object to the form of the question.

THE WITNESS: One has nothing to do with the other. I think we're comparing apples and oranges here. The VOC potential volatilization was geared towards our water modeling and taking the results of the simple mixing model and then putting it through the water treatment process. We did not model the water treatment process and, you know, distributing the -- the water to wherever, locations within Camp -- Camp Lejeune.

If -- back up. Based on -- again, I'm referring to the AH report, our experts. We had one of our distribution system experts, and it was our conclusion that 10 percent, 15 percent, was well within engineering applications. That is typically done in -- in engineering applications. You go from theory -- from contaminant fate and transport equation, groundwater flow, and then you have to make some assumptions, okay, some simplifying assumptions or pragmatic --

SIRI: I'm sorry. I didn't quite catch that. Can you please say that again?

BY MR. ANWAR:

Q. Siri wants you to repeat it.

A. Okay. I didn't know someone was listening, but -- and so that -- that's what our focus is. Our focus was never on how the epidemiology were going to interpret or use the results other than that the most likely estimates were mean monthly concentrations.

Q. When you're building a model and you're -- you're starting with the conceptual model, isn't part of the -- developing the conceptual model understanding what the purpose and the model will be used for?

A. No, the purpose is to get -- in terms of, if we can get specific, a groundwater flow model, for example, your conceptual model would be how does water move through the different aquifers or different layers. And contaminant transport, if there's a contaminant source or sources, how do those contaminants then mix or move with groundwater, and then how are they mixed with the different wells that may or may not intercept contaminated water, and then how they're distributed, okay?

And so your groundwater flow has specific equations with some parameters that you have to make assumptions on. The contaminant fate and transport has equations that we have to make some engineering approximations or simplifications, and the treatment process we -- we said after looking also at the data, the data, the sampling data that was provided by whoever did the lab analyses that came -- provided to us by our points of contact at Camp Lejeune, but somebody did the analyses, that there was very little negligible indication of any kind of VOC loss from the untreated, where all the raw water went in, to the treated. And that's -- I put that in -- is this the rebuttal report? I put that in the rebuttal report. We had some sampling data that showed that.

Q. I guess one of the things I -- and this is just me, like, leveling --

A. Right.

Q. -- and not, you know, taking off the

lawyer hat. One of the things I sort of struggle with is this idea that when the modeling was being performed, that the purpose for which the model was being used is somehow divorced from the decisions that were made with respect to building the actual model. And I'm saying candidly, like, reading the e-mails, the documents --

A. Right.

Q. -- it's all over the paperwork and the documents at the time that the modeling was built to support the epi study. And I think -- it sounds like, to me, you're saying that when you're building the model, you just had no idea what they were doing with the -- the model results.

MR. DEAN: Object to the form of the question. You can answer.

THE WITNESS: As I said before, if you look at the start of the project, the start, they asked us -- they saw what we did with Toms River, New Jersey and came to us and said, well, can you do the same thing with Camp Lejeune, meaning monthly concentrations or monthly -- yeah, monthly water concentrations. And so that's where we started and there were, again, the five objectives that I've stated previously, and that's how we designed the model, is to be able to reconstruct concentrations to meet those five objectives and to, you know, express some reliability, uncertainty associated with them.

How the epidemiology side or toxicology side of -- of the agency would then take those and what analyses they would do, as I said, we were blinded to that, okay? I could never tell you -- to this day, I do not know who was classified as a case, who was a controlled, where they lived, what -- how they served, when they served or anything like that. Because in developing these -- the models for historical reconstruction, they should be, as I termed it, robust, meaning anyone, not just the epidemiologists, anyone should be able to take the results of your model and apply them as they see fit given the uncertainties, the limitations of modeling.

BY MR. ANWAR:

Q. Frank Bove was the epidemiologist performing the studies, correct?

A. He was the senior epidemiologist. There was also -- now it's Dr. Perri Ruckart.

Q. Okay.

A. Those are the two people I interacted with.

Q. Dr. Bove and Dr. Ruckart, correct?

A. Yes.

Q. And if you were developing the model, you were certainly communicating with Dr. Bove, correct?

A. There were e-mails, but not -- he was not questioning us and what assumptions we were making. They would more communicate with us on two aspects. One, there's a CAP meeting and we need an update on the modeling and, two, when are we going to have some final results that we can use for the epi study, okay?

Q. Okay. You were communicating with Dr. Bove when building the model, though, correct?

MR. DEAN: Object to the form of the question.

THE WITNESS: When you say building, are you talking about calibrating the model or doing the conceptual groundwater flow model and what type of code we were going to use?

BY MR. ANWAR:

Q. Any aspect of developing either of the Tarawa Terrace model or the Hadnot Point/Holcomb Boulevard model. During the course of it, you were

discussing what Dr. Bove's needs were, correct?
MR. DEAN: Object to the form of the question. Mischaracterizes his prior testimony.
THE WITNESS: We communicated about what results they would need, the epidemiologists would need, and could we provide them. They indicated that they would need, at one point, trimester information. So if we could give them monthly, that would -- they would be comfortable with -- with monthly values.
BY MR. ANWAR:
Q. Was Dr. Bove permitted the opportunity to weigh in on modeling decisions? So, for instance, parameter inputs that you decided on and assumptions that were made?
A. I may have copied him if I sent out a group e-mail, if we were discussing modeling things, but he would not come back and say, no, you should use, you know, 100 or 30 or whatever parameter. We never had those kinds of discussions. He left that strictly to the water modeling team.
Q. So turning back to your rebuttal report.
A. Okay.

Q. I think it's page 31.
A. Okay.
Q. There -- actually, I may have told you the wrong page again. Give me one second. Okay. It's page 30, actually. I'm sorry.
A. Okay.
Q. At the top of that page it starts, "in addition, Remy Hennet's assertion that" --
A. Wait. Page 30.
Q. 30 of your rebuttal.
A. This says rebuttal.
Q. It's the first full sentence.
A. Oh, okay. I see it. Okay.
Q. It states, "in addition Remy Hennet's assertion that ATSDR did not account for such VOC losses is incorrect." And then it goes on, "first ATSDR analyzed sampling data of water from both pretreatment and posttreatment." And then you list in a table sampling data for the Hadnot Point water treatment system?
A. Correct.
Q. And the rest of that is a discussion about the sampling data from the Hadnot Point water treatment system. I don't see anywhere in that paragraph any discussion about Tarawa Terrace. And

it's true that the Tarawa Terrace model didn't account for VOC losses at all, right?

A. No, we said they were negligible at each treatment facility. It's just that at Hadnot Point we actually had sampling data, okay? A pair and a triplet, okay? And, for example, for July 27th, 1982 for TCE, we have -- the untreated water is 19 micrograms per liter and that same day -- I can't say what time it was taken at, but we've got treated water at 21 micrograms per liter, allowing for measurement error. It appears to me that there is no VOC loss and that is in sampling data that -- and so, again, you can calculate using equations, but the sampling data showed no VOC loss.

Again, on here there is -- at the top of page 31 it says "at the Tarawa Terrace water treatment plant there's triplet measured data taken on July 28th, 1982." And in this -- in this one it's classified as finished, untreated, and treated water. So 104 micrograms per liter finished water, 76 untreated, and 82 treated water, okay?

Q. Those --

A. Now, again, you have variations like this in water -- water samples, but it does not

seem to me that there are any VOC losses.
Q. So we'll turn to the sampling data as it relates to Hadnot Point --
A. Okay.
Q. -- because that discussion is all about Hadnot Point, correct?
A. No, no, I just said this is Tarawa Terrace. I just -- the triplet is data from Tarawa Terrace. The TTWTP is our acronym for that.
Q. What page are you looking?
A. Page 31 at the top.
Q. Now, when you were comparing the sampling data to determine no VOC losses, so for both Hadnot Point and Holcomb Boulevard, did you take into account whether or not the -- the wells, the contaminated wells, for those two treatment systems had been pumping?
A. We do not have information on sampling data, I believe, on any of the sampling data, whether the wells were pumping or not -- not pumping. We may be able to make some judgments based on before and after if it's at the same -- same -- same well, whether the well was pumping or not, but we had no information on the pumping status of the well, but that would not have -- you

would not have lost any VOCs in the well because it's not that you have air space in there. The well is screened down through the aquifer, okay? It's completely filled with water.

Q. Well, you're -- you're basing the conclusion at the top of page 31 as it relates to Tarawa Terrace, and I think for Hadnot Point as well, you're comparing finished water samples versus untreated water samples, and you're reaching the conclusion, it seems to me, that in comparing those, just the -- the sampling results, there were no VOC losses, right?

A. Well, the data indicate that and then taking that in addition to what our expert panel said, maybe 10 percent or so, that leans you towards the minimum for the negligible losses because I would expect if there were VOC losses, and let's say 10 percent, I would expect to see that in the sampling data to be reduced for the sampling data from the untreated water, which is probably the raw water tank where all the wells mix in together, go through the treatment process, and then they put it into a treated water tank either elevated or underground. I would have expected to see some losses.

Furthermore, I might add, in the period January 28th through February 8th, 1984, there was an eight-day period when they had to shut down the Holcomb Boulevard water treatment plant. Holcomb Boulevard was never served with -- did not -- the treatment plant was -- never had contaminated water, but when they shut down during that eight-day period, the distribution system going into Holcomb Boulevard received contaminated Hadnot Point water. And if you just look at some of the values, and I put the ranges in there. I believe there's a CLW document that lists them all the way from 24.1 to over 1100. So again, I'm going to ask again, where are the losses?

Q. So for instance, for Tarawa Terrace, the -- the source or the primary contaminated well was TT26, right?

A. That -- that was the main well, yes.

Q. And there's statements in the reports, and we'll look at them, that -- but would you agree that when TT26 was pumping, the -- the contaminant concentration levels were higher?

A. Yes.

Q. And when TT26 was not pumping, the contaminant concentration levels decreased, and I

think you stated in your expert panel that -- in one of the expert panels that the concentration levels went down to almost zero?
A. Well, that's shown in our Chapter A report, too. When they shut the well down for maintenance, okay, so it was not pumping, the concentrations at the water treatment plant went down to near -- near zero, and that also is what proved to us that TT26 was the driving force or the driving well in that whole -- whole system.
Q. So the only point I'm trying to make with respect to comparing finished samples from finished water versus untreated water at Tarawa Terrace and at Hadnot Point, I mean, simply -- context matters. Simply comparing samples from untreated water and finished water doesn't tell you whether the well was pumping, whether the contaminants were increasing, whether the well -- whether the well had stopped pumping and the contaminants were decreasing, you can't make a determination on VOC losses solely by comparing a finished water sample and an untreated water sample?
MR. DEAN: Object to the form of the question. Compound. Complex.

BY MR. ANWAR:

Q. You can answer.

A. Okay. I think you are confusing -- and I don't mean that as a personal attack.

Q. Sure. No offense taken.

A. Confusing different mechanisms and different aspects of the entire process of delivering, obtaining water from the aquifer to the delivery point, okay? The samples -- there's some samples at TT26, okay, that's at the well, and that -- that says nothing about -- and honestly, that says nothing about the treatment process. The treatment process occurs after all the wells mix in in the entry to the water treatment plant, okay?

So if I take a sample, and let's say untreated water, which will be the raw water tank, okay, and I get a -- a value, a concentration, and then I take a similar sample and I'm assuming they are using the same testing methodology at the treated end, which would be on the other side of the spiractors, the other side, and I don't see any -- any losses, any changes, decreases in concentration, excuse me, can I -- then what I am saying is it's a good assumption, a good engineering assumption, that even -- whatever losses there are are so negligible that we're not able to measure them. Or the people that measured them, the same -- the ATSDR did not actually measure those -- those samples, okay? And that's, again -- and everything that we do in modeling and interpretations and all of that, it's sort of a weight of evidence approach.

Q. Sure.

A. Okay? So we've got the AH report. We've got our expert panel. We've got -- these members actually did water distribution system testing at various -- not at Camp Lejeune, but at various locations, and we've got sampling data. So you've got to take it all -- all together, okay?

Q. I just have a few more questions on this topic --

A. Sure.

Q. -- and then we'll take a break.

A. Okay.

Q. Now, using Tarawa Terrace again as the example, TT26 was the main well that was contaminated, correct?

A. That is -- that is correct. There was some contamination at TT23, which is referred to as the TT new well. It only ran for about nine months maybe. When it was put in, it was put in to a contaminated aquifer, okay, so that's why its concentrations are high immediately. But again, TT26 was the major contributor.

Q. TT26 and TT23 weren't the only wells providing water in Tarawa Terrace, right?

A. That is correct.

Q. And the wells at Camp Lejeune, including Tarawa Terrace, were cycled, right, in terms of the usage?

A. They recycled, yes, yes.

Q. And so simply comparing a finished water sample versus an untreated water sample doesn't tell you anything about which well the water was coming from, right?

A. Well, we knew that based --

MR. DEAN: Object to the form.

THE WITNESS: We knew that based on the modeling, okay, the contaminant fate and transport model. The output of the contaminant fate and transport model were the concentrations at specific wells, okay? And you have to look in the model output and you can see which wells were turned on or off during which month. And then we had, again, a simple mixing model.

BY MR. ANWAR:
Q. And --
A. And the key is the simple mixing model mixed all -- all the wells together, okay, for conservation of mass and continuity. And so when we get a monthly concentration out of the mixing model, okay, that's what we said went into the water treatment plant.
Q. In -- in comparing finished water samples and untreated water samples for purposes of your rebuttal report in offering opinions about VOC losses --
A. Right.
Q. -- at Hadnot Point and Tarawa Terrace, did you go back and look to see what time frame the samples came from, whether the wells -- which wells were turned on and off, what information was available?
A. Let's see what this is. I looked at the treatment process, okay, because that's -- that was the focal point of those claiming there were major VOC losses versus negligible. And so I looked -- you have to look at the treatment process, okay? The treatment process starts at the mixing of all the wells into the raw water tank.

And the assumption, engineering assumption, is that there's instantaneous mixing, and we prove that in the Chapter I report because we run parallel models. We run the full-blown EPANET model, which is water distribution, and we run the mixing model. And after a week or ten days, they are equivalent to the -- out to the four decimal places. So that means you have -- the mixing model in addition to what our expert panel told us, all the wells were mixing at the water treatment plant in the raw water tank and there was instantaneous mixing compared to our monthly concentration needs.

Q. Okay. I think my last question on this, so just taking the Tarawa Terrace example here in your report at the top of page 31 where you're comparing the 104 microgram per liter unfinished water versus the 76 microgram per liter in untreated water and the 82 microgram per liter in treated water --

A. Right.

Q. -- I don't see it anywhere in your report, but -- and so I think you would agree that you don't know what percentage of water in the untreated, treated, and finished water samples at Tarawa Terrace came from TT26, right?

MR. DEAN: Object to the form.

THE WITNESS: You -- you could -- you could actually compute that because the process to get the mixing model results would be is you take the well's capacity for a given month, how much it's pumping, what the concentration is -- let me back up. Hold on. Get the chapter right. It's easier for me to explain the Chapter A here. Here. Okay. It's -- it's a model here. Okay. Page A40 in Chapter A, equations one and two. Concentration of PCE in finished water, okay? So we have all of the information. You see it's summing over however many wells were pumping versus whether they are contaminated or not. So, yes, we do know, but the assumption was -- in agreement with what our expert panel recommended -- is that you could assume instantaneous was a CSTR, continuously stirred tank reactor model, for the mixing model. And so the minute the wells hit the raw water tank, they all mixed. And to us instantly was anything less -- a good portion less than a month. And that's shown in the Chapter I report. I can tell you exactly where in a minute.

Q. Why don't we go ahead and take a break if you're --

A. Okay.

THE VIDEOGRAPHER: Okay. We're going off. Record the time is 2:33 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 2:43 p.m.

THE WITNESS: Is it possible to qualify or continue with where we left off?

BY MR. ANWAR:

Q. Sure. Did you have something you wanted to --

A. Yes.

Q. -- correct or --

A. I would like you to turn to the Hadnot Point/Holcomb Boulevard Chapter A report.

Q. Sure. What page are you --

A. Page A38, Figure A15.

Q. A38, A15.

A. Yes.

Q. Okay.

A. Okay. This is the same mixing model that we talked about at the Tarawa Terrace. You'll notice the equations on page -- the next, page A1 and A2 are the same equations one and two in Tarawa Terrace report in Chapter A.

Q. Okay.

A. What I want to point out to is -- and this is a conceptual or a schematic. If you look at the distribution network of pipes on the left-hand part of the Figure A -- mixing model approach is the title of that section.

Q. Okay.

A. You'll see that there are little -- towards the right there's HPWTP, that tank represents HP, and you've got contaminated, meaning red, or uncontaminated, blue, symbols there mixing into the -- into the HPWTP. Now, we did not do step-by-step treatment process. What the assumption is, and a correct assumption, an approximation, is that they all instantaneously mixed in the raw water tank. Once they mixed in the raw water tank, if, in fact, there's this massive VOC loss, you would see it in the samples, and we didn't. And so our assumption was that there was negligible losses within the treatment process, and so what -- the concentration in the tank through the mixing model is the same as the contamination anywhere throughout the distribution system.

Q. Okay. But you're talking sort of --

you're talking in the context of model -- still the model, right?

A. That's exactly correct, yes.

Q. And at the end of the day, a model is an approximation of reality, right?

A. Yes.

Q. There is no way to perfectly replicate reality, right?

A. No, a model is an approximation. Some are closer approximations and some are -- are not as close, but it is an approximation. But at the end of the day, if we are going to test the model out, I'm speaking generically now of the model, then that's where we go and gather some field information or sampling information and see if it, in fact, proves or supports -- that's probably a better word -- supports the assumptions that we made using this model.

Q. The pumping data for Tarawa Terrace and TT26, the wells in Tarawa Terrace and TT26 in particular, that was limited, right?

A. The pumping data? We had -- we had monthly data. We had some early on in the -- early, early '50s or '40s. We had some annual pumpage data. And then in -- I believe from about

-- for Hadnot Point from about 1998 through 2008, we had daily pumping values.

Q. You said from 1998 to 2008?

A. That's my recollection, yes, we had daily -- daily values.

Q. Well -- and those values are sort of outside the time period we're -- we're interested in, right?

A. No. Again, you've got the epidemiological study, which goes from '68 to '85, but we're using -- and I'm going to limit this right now to groundwater flow and contaminant fate and transport models; those are boundary-valued problems. So you've got to take them out or start them from a period of known water level, a period of known concentration, and run them out until you get back to a period of known information.

We -- at Hadnot Point we had some known information because they were doing remediation pumping so that the models there went out all the way to 2008 because it was another set of data in addition to the 1980s data that could get -- build confidence, substantial confidence, in the modeling results. So the models went out or started based on hydrogeologic and modeling concepts and frametimed where -- and part of the model went through the epidemiologic study period, the two -- in other words, the epidemiology did not control when we started or ended the model.

Q. 1998 is after 1987, right?

A. Yes.

Q. And --

A. If you're interested in building confidence in your model and testing out the goodness of fit of your calibration, if you've got another set of information past the epidemiology -- again, the epidemiology doesn't impact how we're calibrating or developing the model -- then you want to use that.

Q. I guess more broadly speaking, you know, we can debate the points of the actual modeling, which, you know, you're an expert on it and I'm not. But if ATSDR's modeling accounted for VOC losses, why was it necessary to make a statement that the VOC losses were -- were negligible and, you know, why was it necessary to make that -- that determination?

A. Okay. Because you needed to somehow quantify, I felt, what he meant by negligible. He does not say zero. He said negligible, okay? And

I'm speaking again in terms of pragmatic engineering applications doing modeling; you make these kinds of assumptions, okay? He also had wanted to make sure someone -- when we say negligible, if they read the expert panel and saw Dr. Pommerenk, who is, I believe, AH consultant for the Marine Corps who sat on our expert panel saying, well, less than 10 percent, then someone reading our reports would say, okay, negligible 10 percent -- even if there's VOC losses, there's somewhere less in that -- in that range, and now I'm looking at sampling data and it doesn't appear to be from the sampling data any -- even 10 percent loss anywhere, so negligible is a good approximation.

Q. You -- and coming out of the expert panel, you-all landed on 10 percent, right?

A. That's what the expert panel said, okay? And that's when we got together either in a team meeting, not part of the expert panel, but, you know, subsequent, because the expert panel made many recommendations, which we typically either generally followed, and we, you know, we would just say, oh, well, it's 10 percent, that's negligible compared to the variation and all the other parameters. Sampling data, aquifer properties, and things of that -- well operations, things of that nature. So we were confident with the -- had confidence in assuming negligible VOC losses.

Q. And the AEE report said up to 15 percent, right?

A. Yes.

Q. And so when -- when we're talking about negligible in terms of the decision ATSDR made in determining VOC losses were negligible, we're talking about between 10 and 15 percent, right?

MR. DEAN: Object to the form of the question. Mischaracterizes the prior testimony.

THE WITNESS: I would say it was 10 percent because the representative of AH Consulting Dr. Pommernek, who was also representing the Department of Navy, U.S. Marine Corps on the expert panel then -- then said, well, you know, I'll give you that 90 -- there's a 90 percent passthrough, so that's 10 percent. And then we also had other water distribution system experts on there and -- like Dr. Walski, Dr. Grayman, Dr. Clark, and they indicated in their experience that there would be even less than 10 percent negligible.

Q. Okay.

A. And they have done analyses with other water distribution systems like Tucson, Arizona, Redlands, California and so on.

Q. Let's turn to Exhibit 10, which is Chapter A for Hadnot Point and Holcomb Boulevard.

A. Okay. Oh, I've got it open right here. Okay.

Q. And let's turn to page A1.

A. Okay.

Q. So just -- just so the record is clear, we're now discussing the analysis for Hadnot Point/Holcomb Boulevard, right?

A. That is correct, summary of findings.

Q. And footnote number seven on the first page states, "for this study, finished water is defined as groundwater that has undergone treatment at a water treatment plant and was subsequently delivered to a family housing unit or other facility. Throughout this report and the Hadnot Point/Holcomb Boulevard report series, the term finished water is used in place of terms such as finished drinking water, drinking water, treated water or tap water." Did I read that correctly?

A. Yes.

Q. So ATSDR modeled -- ATSDR said it

modeled water that had undergone treatment at a -- at a water treatment plant at Hadnot Point, correct?

A. That's not what that says, or that's not what I interpret that to say. What that is is trying to define what finished water is, okay? There are different names. Some people would say potable water, okay? It's not the same as potable water. It's not the same as groundwater. It's treated water, but that statement does not say we modeled the treatment process. And I've -- I've never maintained that we modeled the treatment process.

Q. Okay.

A. And our expert panel in 2005 also said that the treatment process did not have to be modeled.

Q. Let's turn to page A33.

A. Okay. Okay. I'm there.

Q. Looking at number nine.

A. Okay.

Q. It states, "reconstructed simulated monthly mean concentrations of PCE, TCE, 1-2-DCE, and vinyl chloride and benzene for finished water at the Hadnot Point water treatment plant were

determined by using a materials balance model
simple" --
A. Materials mass balance.
Q. Excuse me. "Materials mass balance model, simple mixing, to compute the flow-weighted average concentration of the aforementioned contaminants. This computational method is based on the principals of continuity and conservation of mass, Masters 1998. The use of the materials mass balance method is justified because all raw water from water supply wells within the Hadnot Point water treatment plant service area was mixed at the Hadnot Point water treatment plant prior to treatment and distribution." And then it says, "details of this method are described in a subsequent section of the report." Did I -- did I read all that correctly?
A. Yes.
Q. Would you agree that what ATSDR called finished water at the Hadnot Point water treatment plant was based on a material mass balance model, simple mixing, to compute flow-weighted average concentrations of contaminants?
A. Yes.
Q. And agree that mass -- a mass balance

-- agree it was a mass balance model based on continuity and conservation of mass?

A. Yeah, that's what equations A1 and A2 in this report and equations one and two in the Tarawa Terrace Chapter A report -- the first equation is continuity. The second one is conservation of mass.

Q. Agree that continuity and conservation of mass means the simple mixing model assumed that mass of all contaminants entering the water treatment plant were conserved through the water treatment plant?

A. Yes.

Q. Okay. And they continued, correct?

A. What do you mean?

MR. DEAN: Objection to form.

BY MR. ANWAR:

Q. It assumed that they continued the --

A. You mean the flow continued?

Q. The mass of the contaminants.

A. I'm not following you. Are you asking did the concentration from one -- once it's mixed at the raw water tank is the same as the concentration in the finished water tank?

Q. I think you answered my question.

Let's -- would you agree ATSDR modeled influent to the water treatment plant as having the same contaminant concentrations as the effluent from the water treatment plant?

A. No, we modeled -- the influent, to me, by definition, would be the different wells coming into the raw water treatment tank. If you look at the water distribution system utility maps, you'll -- you'll see that the raw water from wells were typically piped over to the raw water tank through concrete pipes, okay, underground pipes. So once all the wells fed into there, in the raw water tank, I assumed there was instantaneous mixing, as the mixing model does, okay, and then that -- that would equal the finished water concentration.

Q. Okay. Let's look at A62.

A. What? I'm sorry?

Q. A62.

A. On HP report?

Q. Yes.

A. Page 62. Okay. Okay.

Q. Looking -- focusing on Table A18, you would agree that Table 18 shows, among other things, measured TCE concentrations at the Hadnot Point water treatment plant?

A. Yes.
Q. Looking at TCE, you would agree there are only a few measurements each of treated and untreated water?
A. Yes.
Q. Agree the data is insufficient to conclude no treatment losses, right?
MR. DEAN: Object to form.
BY MR. ANWAR:
Q. You can answer.
A. Okay. Using the data that we have, you always want more data as a modeler, okay, always. That's -- okay. So if you're asking me as a modeler would I want more data than this, yes, but we were working with the data that we had and that was presented to us. And given this data, I see, again, July 27th, treated -- or let me see the exact wording, untreated and treated, footnote five and six, they are approximately the same value. That's the data I referenced in my rebuttal report. So you use that data because that's what we have.
Q. Direct me to that again.
A. On page A62, if you go to 7/27/82, the first listing has a footnote five which says untreated. The second listing, 7/27/1982, under

TCE, it says 21.
Q. You said 7/27/1982?
A. Yes.
Q. TCE. And then the listing underneath it, you're saying is --
A. It gives the treatment status.
Q. And your -- your opinion is that the model indirectly accounted for treatment losses based on those two points of data?
A. Based on those two points. Based on, also, the January 28th through February 4th, 1985 shutdown of the Holcomb Boulevard treatment plant where we just saw huge slugs of TCE within the Holcomb Boulevard treatment system -- not treatment, but distribution system. So again, we used a weight of evidence approach. And then, again, referring back to the expert panel report that said, well, we did 10 percent, we -- we said that justified the assumption of negligible.
Q. For the samples that you're -- that we're discussing, the 7/27/1928 for TCE.
A. Yes, uh-huh.
Q. ATSDR didn't know if HP651 was pumping on that day, right?
A. We could go back to the reconstructed

-- reconstructed pumping schedule and -- and figure out if it was pumping or not. I would have to look -- I would have to look at our pumping schedule.

Q. Okay. But that's a reconstructed pumping schedule, correct?

A. It's still the only thing close to reality that we have.

Q. But it's not reality, right?

MR. DEAN: Object to form.

THE WITNESS: It's what we used to reconstruct and then compare these values to -- to that. So it was -- it was pumping in the model.

BY MR. ANWAR:

Q. For -- in the absence of pumping data for Tarawa Terrace, at least --

A. Right.

Q. -- ATSDR assumed that a well was pumping unless you had evidence affirmatively disproving that it was pumping, correct?

A. That is correct. And we then tested that out through an uncertainty analysis by varying the pumping through a Monte Carlo-type uncertainty analysis, but the calibrated model assumed continuous pumping unless it was shut down for maintenance purposes.

Q. And with respect to the samples that we've been discussing, the July 27, 1982, ATSDR didn't know if HP651 was pumping the day before either, right?

A. No, there's no indication as to the status of the water supply wells feeding the raw water tank. These are taken at the treatment plant, not at the wells, if I'm -- yes, these are taken at the treatment plant. So the wells have already mixed, on, off, whatever.

Q. When you say no indication, what do you mean?

A. There's no -- this table here is from the water treatment plant, okay?

Q. Yeah.

A. So it does not contain an indication as to which wells were on, which wells were contaminated, which wells were on and not contaminated, and which wells were off, okay? This -- this particular table, okay? This is a result of applying the -- a mixing model, a flow-weighted mixing model.

Q. When you say this is the result, what do you mean "this?"

A. Well, if you look under the

reconstructed column, the middle column there.

Q. Yeah.

A. Okay. That's what -- once we got the concentrations out of the model for each of the Hadnot Point wells --

Q. Yeah.

A. -- and we can tell which ones were operating, which ones were not and have a zero there, and then we knew what the reconstructed concentration is, so then we would tabulate those into an Excel spreadsheet, do the flow-weighted mixing in the Excel spreadsheet.

Q. And, you know, I'm talking about not the reconstructed schedule, but about real-world data?

A. I understand that, but, again, as I think we've discussed real early on, if my recollection is correct, these are one point in time samples, okay? And we are -- we are doing monthly simulations, monthly results. So that's, you know, just -- you need to keep that in mind when you're looking at data versus modeling results.

Q. Agree -- you would agree that you don't know the percentage of water in those samples that came from HP651?

A. Not in the -- not in the samples, but I would know -- I would have to tabulate it, but I would know in the reconstructed column.

Q. But the reconstructed column is a simulation, right?

A. That's our best estimate, most likely estimate.

Q. Okay. And that's because you don't know the real-world data on whether -- what percentage of water in those samples came from HP651?

A. Not from the sampling data. However, you do have the previous table, I think, or somewhere in here, it's early on, there is a table -- let's see. Here you go. Page A48.

Q. So I wanted to actually change topics a little bit.

A. Oh, sure. Okay.

Q. Shift gears a little bit. You would agree that it takes time for water to get through the -- the water treatment plant, right?

A. Compared to the groundwater system, it's instantaneous. I'm talking about hours or maybe even minutes compared to days or months or longer than that, you know. That's -- I think, as I said previously, water distribution system models use an hour time step, and you typically would measure pressures. If you had any concentrations, you would measure those at, say, at 15-minute intervals, so you're talking about a much more rapid process.

Q. Similar to our discussion on TT26 for Hadnot Point, you would agree that whether -- whether HP651 was pumping had a significant impact on the concentration of TCE entering the Hadnot Point water treatment plant, right?

A. Yes.

Q. And you would agree that when HP651 stops pumping or stopped pumping, concentration of TCE entering the Hadnot Point water treatment plant would go down very quickly?

MR. DEAN: Object to the form.

THE WITNESS: Well, we could look at the graph on page A63 in Chapter A here, Figure A27. And you do see up and down with -- of TCE at the water treatment plant, which is indicative of cycling on and off of HP651. But unlike TT26, the only time it goes to zero or close to zero is after they completely turned the well -- the well off.

Q. But when HP651 stops pumping, concentration of TCE entering the HP -- the Hadnot Point water treatment plant goes down, right?

A. It -- it gets reduced, but because there were so many -- there were other wells pumping and contributing to the water treatment plant and supplied -- supplied water, some of those other wells, if they were contaminated, would -- would, you know, add to the concentration at the water treatment plant.

Q. You would agree that when HP651 stops pumping, at that very moment water coming out of the Hadnot Point water treatment plant entered into it with TCE concentrations from when HP651 was pumping, correct?

A. Could you repeat the question again? I'm sorry. I didn't follow.

Q. Sure. So when -- when HP651 stops pumping, the water that was pumping into the Hadnot Point water treatment plant doesn't immediately go away, right?

A. That is correct.

Q. That water that had been pumping from HP651 continues through the water treatment plant, correct?

A. Yes. Again, the pipes are pressurized and water is flowing full, okay? A storage tank is not pressurized like the distribution pipeline, but it's full, and so it's not that you have no water stopped at 651 and then the raw water tank has no more water in it. It's still filled with the previous day's concentration, and if 651 was not pumping on a particular day, you would still have contaminated water in that raw water tank.

Q. And so carrying that through to conclusion, if 651 stopped pumping and that water -- but the water that had been pumping from 651 into the Hadnot Point water treatment plant entered into it and then continued to be distributed, the finished water sample from -- from that water that pumped through 651 -- or excuse me, from the 651 water that had pumped through the Hadnot Point water treatment plant would reflect that contaminated water, right?

MR. DEAN: Object to form.

THE WITNESS: Okay. Could you clarify that?

BY MR. ANWAR:

Q. Sure. So a moment ago you agreed with me that when HP651 stops pumping, at that precise

moment the water that had been pumping into the water treatment plant at Hadnot Point doesn't go away, right?
A. That is correct.
Q. It -- that water that had been pumping from 651 remains in the water treatment plant, correct?
A. Yes, the water that's there the previous day when HP651 was pumping, let's say -- for argument's sake let's say it's still there, okay, but over a day's period it probably moved through the treatment process.
Q. And a moment ago we -- we discussed that ATSDR treated or used a mixing model for purposes of finished water, correct?
A. That is correct.
Q. And so -- well, let's -- let's -- stepping away from the model, that water in the Hadnot Point treatment plant from 651, that doesn't immediately disappear, that still ends up in the finished water, correct?
A. That is correct.
Q. Okay. And then 651 is now stopped and other wells are pumping water to it, correct?
A. They are compensating for the loss of

the volume of the well, okay? Because at the end of the day, when we were there in 2004 and historically, having spoken with past operators, they had to keep their tanks, finished water tanks nearly filled for fire protection, okay, so they -- you would have had to compensate for HP651 with other -- other wells.

Q. And those other wells pumping into the HP treatment plant could include wells that weren't contaminated, right?

A. That is correct.

Q. So in that case, if you were to take an untreated sample and compare it to the treated sample from the -- the HP651 water that went through the system, the treated water would be higher, likely, than the -- the untreated water sample taken at the water treatment plant?

A. Again, I think we need to view this in terms of the historical reconstruction that we did on a monthly basis. Even though -- even though the distribution system does the EPANET model, you can do hourly calculations, meaning you can do daily calculations. The output from the contaminant fate and transport model and the mixing model are valid on a monthly basis. So over a month, you would have seen 651 come back on.

Q. But again, we're talking about the model simulation world and not the real world?

A. But that's what we did at ATSDR. I mean, that's -- that's the whole concept of historical reconstruction or modeling in general, is that we used models and applied models where we may not have information, real data, and you build confidence by the calibration process to use -- use those models. We took, at ATSDR, the sampling data that was provided to us by the Marine Corps, Department of Navy or other -- other water quality labs and that's the data that -- that we had.

Q. I'm going to hand you what I'm marking as --

MR. ANWAR: I'm sorry. Can you remind me, is this 15? I forgot to write one down. 16.

(DFT. EXHIBIT 16, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A-Supplement 2, Development and Application of a Methodology to

Characterize Present-Day and Historical Water Supply Well Operations, was marked for identification.)

BY MR. ANWAR:

Q. Did I actually hand you the exhibit?

A. No.

Q. Sir, do you have the exhibit?

A. No, you didn't tell me what 16 was.

Q. Sorry. I just put the sticker on it and I lost my train of thought. I'll just put another sticker on it.

Okay. I'm handing you what I've marked as Exhibit 16.

A. Supplement 2. Okay.

Q. Can you turn to page -- so for starters, this is part of the Hadnot Point/Holcomb Boulevard analysis, correct?

A. Yes, it's Supplement 2 of Chapter A.

Q. Okay. And the title is "development and application of a methodology to characterize present-day and historical water-supply well operations", correct?

A. That is correct.

Q. Okay. If you could turn to page S2.2.

A. 2.2. Okay. 2.2. Okay. Background?

Q. Yeah.
A. Okay.
Q. And so at the top of that page on the right-hand side --
A. Right.
Q. -- paragraph starting "detailed daily data."
A. Let me just take a look. Okay. I'm there.
Q. Okay. So it starts by stating, "detailed daily data pertaining to the pumping schedule of the wells are available subsequent to January 1998", correct?
A. That's -- yes, that's what we previously discussed.
Q. Sure. And then "prior to 1998, data pertaining to wells operation are limited or unavailable", correct?
A. That is correct.
Q. And then it goes on to state, "similarly, daily water treatment plant raw water samples are available" --
A. Raw water volumes.
Q. Volumes. Excuse me, are -- let me reread that.

A. Okay.
Q. "Prior to, similarly, daily water treatment plant raw water volumes are available after December 1994", correct?
A. That is correct.
Q. "And then between 1980 and 1994, monthly raw water volumes are available. Yearly volumes are available for some times -- for some years prior to 1980. A trendline was used to estimate raw water flows for years prior to 1980 when no data exist. Monthly raw water flow percentages were then calculated using known monthly data for the period 1980 to 2004. These values are used to estimate monthly raw water flows prior to 1980. This methodology is based on two assumptions: Similar characteristics of the operational patterns of the wells and water treatment plants for the periods of time before and after January 1998 and, two, the quality between total water volume delivered to the water treatment plant from the operating wells and the water treatment plant raw water volume data at all times." Did I read that correctly?
A. Yes, you did.
Q. Okay. Agree -- you'd agree that prior

-- based on this, prior to 1998, data pertaining to well operations was limited or unavailable?
A. Yes, that's what that says.
Q. Agree that according to this, that there were daily water treatment plant raw water volumes available after 19 -- after December 1994, correct?
A. Yes.
Q. Agree there were monthly raw water volumes available for 1980 to 1994, right?
A. Yes.
Q. And then there were some yearly volumes prior to 1980, right?
A. That is correct.
Q. ATSDR had to estimate pumping schedules due to the lack of this data, right?
A. We had to estimate pumping schedules to get the operational -- I'm equating operational and pumping schedules to be able to code them in -- on a monthly basis to the -- to the model, to the groundwater flow and contaminant fate and transport.
Q. And so if we go on to the next paragraph, data availability.
A. Okay.

Q. "Four types of data sources pertinent to water supply well operation -- operational records and water treatment plant raw water records are used in this supplement." It says "these are daily operational records, January 1998 to June 2008. Number two, Camp Lejeune historic drinking water consolidated document repository records. Number three, Camp Lejeune water documents. Number four, U.S. Geological Survey. Using these data sources, operational chronologies for 1996" -- excuse me.

A. Wait.

Q. "Using these data sources operational chronologies for 96 wells supplying groundwater, in parentheses, raw water, to the Hadnot Point water treatment plant and Holcomb Boulevard water treatment plant were developed." Did I read that correctly?

A. Yes, yes.

Q. You would agree that ATSDR didn't use pumping data from the '80s, but used data from pumping schedules after 1998 to estimate pumping schedules during 1953 to 1987?

A. The way the methodology that's described in Supplement 2, there was a training period and then a predictive period. So the training period typically went from 1998 to 2008 because that was known information on a daily basis. And once we obtained the characteristics of the operating wells based on that, then we could go out and where we either had partial data or missing data, use the prediction from there and apply the prediction to the data gaps.

Q. So for Hadnot Point/Holcomb Boulevard analysis and the model, you used predictions based on pumping schedules after 1998, correct, to -- to let me ask that again.

So based -- for Hadnot Point/Holcomb Boulevard you used pumping schedules from after 1998 and predicted backwards the pumping schedules during 1953 to 1987, right?

MR. DEAN: Object -- object to the form.

THE WITNESS: Again, it says -- I think it was up -- yeah, we also used -- for data we're missing a trendline, which is an accepted statistical approach in engineering. And the algorithm developed by who is now Dr. Telci, the first author on here. At the time he was with Georgia Tech, used the training period for periods of known water supply operations and then used the predictive period for when we had to predict the operations. So you have a combination of both training and prediction.

BY MR. ANWAR:

Q. And that's training and prediction, but that's -- that's both simulated pumping schedules, correct?

A. No, well, the training was based on daily data, okay, and all we're interested in is monthly.

Q. The training was based on pumping schedule data after 1998, correct?

A. Yes, yes.

Q. And then the simulated is the pumping schedule from 1953 to 1987, right?

A. It would go through '98, actually. I mean, for -- Hadnot Point/Holcomb Boulevard didn't come online until '72, so you have different periods there, but, yes, it would -- that's the predictive period, is where you had either limited -- because you might have a month information here and there and stuff like that, but that's -- or unknown information that you would use the predictive values that came out for each well, each certain well.

Q. Let's turn to page S12.

A. Okay. Okay.

MR. DEAN: S2.12 or just S12?

MR. ANWAR: I'm sorry. It's S2.12.

MR. DEAN: Okay.

MR. ANWAR: I've been staring at these documents too long.

BY MR. ANWAR:

Q. And at the top of the left-hand --

A. Right.

Q. -- page it says, historical reconstruction period, 1942 to 2007, prediction process, correct?

A. Right.

Q. And this is the -- the training and the -- this -- this paragraph in this section is addressing the training and the prediction process you were just describing, correct?

A. I believe it is. This shows the start of prediction process. There should be another flow chart somewhere, I seem to recall.

Q. I wanted to just ask you about some of the language in the first paragraph.

A. Okay. Sure, sure. Go ahead.

Q. It says, "similar to the training process, the prediction process, PP, is structured as a series of calculations and checking steps. The results of the steps were placed in separate sheets of a Microsoft Excel workbook." And then that last sentence, "because some wells did not physically exist during the training period, surrogate wells were selected to represent these untrained wells." Did I read that correctly?
A. Yes, yes.
Q. And so you would agree in the training process for reconstructing historical well pumping schedules, ATSDR used surrogate wells for wells that were untrained?
A. No, for wells that -- wells that did not physically exist, okay? If you look at Figure S2.2 on page S2.4.
Q. 2.4?
A. Yes. It's a full-page figure.
Q. Okay. Oh, I see. It's 2.4 --
A. S2.4, Figure S2.2.
Q. Okay. Yeah, I'm looking at 2.40. Go ahead.
A. Okay. For example, you can take an example here, let's just look at -- coming down,

HP604, okay? It stops operations at about 1960, but then you've got HP637. So HP604 may be -- or HP637 may be a surrogate well because HP604 no longer exists. And I think we list the -- somewhere in here there's a table -- oh, there you go. The surrogate wells, okay. Table S2.2 on page S2.13, there's a list.

Q. Okay. So --

A. And looking at those wells and looking at that figure, you can see which wells were surrogate for wells that were no longer operating.

Q. On S2.13.

A. Yes.

Q. Table S2.2.

A. Right.

Q. Just looking at that, the surrogate wells include -- let me double-check. Surrogate wells were used for HP651, HP634, HP602, HP603 and HP608, right?

A. 608, yes.

Q. You would agree that ATSDR modeled reconstructed pumping schedules for these wells -- strike that.

Okay. You would agree that ATSDR modeled reconstructed pumping schedules for these

wells based on 1998 to 2008 pumping schedules for different wells, correct?
A. Say that -- say that again.
Q. Sure. So a moment ago we talked -- you know, we -- we went through a list of the wells, 651, 634, 602, 603, 608, for which surrogate wells were -- were used, right?
A. Yes.
Q. And to determine the pumping schedule for these wells, 651, 634, 602, 603, 608, ATSDR reconstructed the pumping schedule for surrogate -- based on surrogate wells from 1998 to 2008, correct?
A. Yes.
Q. Okay.
A. That was the training period.
Q. Let's go back to Exhibit 10, which is Chapter A for Hadnot Point/Holcomb Boulevard.
A. Okay. I'm right here. Yes.
Q. Give me a second and I will catch up with you. Turn to page A84, please.
A. Okay. A84. Okay. Where it says "trichloroethylene source release date sensitivity analysis?"
Q. Correct.

A. Okay.

Q. So this is a discussion in Chapter A for Hadnot Point/Holcomb Boulevard about TCE's source release date and the sensitivity analysis that was performed, correct?

A. Yes.

Q. Okay. So I wanted to start by reading from that first paragraph on the left.

A. Okay.

Q. Which starts, "historical records delineating the timing and volume of inadvertent releases of solvents during routine -- routine operations from leaking" -- it says "UST". Those are underground storage tanks, right?

A. That's correct.

Q. Okay. "From leaking UST systems or from disposal solvent waste, spent dry cleaning filters or other materials, were not available for the Hadnot Point/Holcomb Boulevard study area." Did I read that correctly?

A. Yes.

Q. "For modeling purposes, a median source release date of nine years from the date of the underground storage tank system installation or site development, in the case of the HPLF area", which is a Hadnot Point landfill area, "was used in the contaminant fate and transport models." Did I read that correctly?

A. Yes.

Q. "This source release date formulation is consistent with empirical data indicating that the median time frame for leak development in underground storage tank systems, typically in piping and joint components, is nine years from installation date." And there's a source to an EPA document and another cite source. Did I read that correctly?

A. That is correct.

Q. Okay. Then it goes on to state, "UST systems were not the source of contaminants in the Hadnot Point landfill area. However, given the lack of historical information, a similar source release time frame, in this case seven years from site development, was applied to the Hadnot Point landfill area sources within the model." Did I read that correctly?

A. Yes.

Q. Would you -- you'd agree, based on this paragraph, that historical records delineating or providing information about the time and volume of

solvent contaminant releases from underground storage tank systems, disposal of solvent waste, spent dry cleaning filters or other materials wasn't available for the Hadnot Point area?
A. That is correct. And that is why we went to external references or other references like the ones that we -- we cited, the EPA report '6/'87 and the Gangadharan, et al., '87. I think they discussed something like over 12,000 tanks that they analyzed that -- and so we -- we felt that was a good source of information to use.
Q. ATSDR -- still based on this paragraph, you would agree ATSDR, the Hadnot Point/Holcomb Boulevard model, assumed all underground storage tank systems began releasing contaminants nine years after the system was installed, right?
A. It's -- typically it was the piping joints, okay? I think we say in there the actual tank did not necessarily leak, but it was at the pipe joints because of the construction methods back then in the '40s and '50s and '60s, unlike today where you have to have a concrete pad, solid, and then you put the tank on. They just dug the hole, put the tank on, then when they -- and connected the pipes. And when the tank filled up,

then the pipes flexed, and that's where you got the leakage.

Q. So it -- ATSDR, the Hadnot Point/Holcomb Boulevard model assumed that the piping joints for underground storage systems began releasing contaminants nine years after the systems --

A. Yes, based -- based --

Q. -- were installed?

A. -- on the references that we cited.

Q. Okay. And as you indicated, based on references, that was based on an EPA study on underground storage tank system leaks, that following nine years was the median time frame for leak development?

A. Yes.

Q. ATSDR assumed contaminant sources in Hadnot -- in the Hadnot Point landfill started seven years --

A. Yes.

Q. -- after site development, right?

A. Yes.

Q. Okay.

A. That's because the landfill, to our knowledge, was unlined and it was not tanks. It was just disposal of landfill material, contaminated landfill material.

Q. And it was necessary to make these assumptions about sort of the contaminant start dates because the information of when the underground storage tanks and the Hadnot Point landfill began releasing contaminants, that's not available, right?

A. You're talking about the Hadnot Point industrial area or the landfill?

Q. Well, let's -- let's break them up.

A. Okay.

Q. So the assumption was made about underground storage tanks systems beginning to release contaminants nine years after the system was installed, right?

A. Yes, that would be the Hadnot Point industrial area.

Q. And -- but that's because -- and that assumption was made because the data available precisely identifying or pinning down when the underground storage tanks began releasing contaminants does not exist?

A. That is correct.

Q. Okay. And the same is true for the --

the Hadnot Point landfill assumption, correct?
A. Right. And we used a shorter time period, again, because there were not underground storage tanks, per se. It was a landfill, most likely unlined, okay, and not individual tanks, but just waste thrown or disposed of into the landfill. So we assumed it would have a, you know, two-year, short period until it started leaking for the modeling purposes.
Q. But -- okay. Understood. But in terms of real-world data, in terms of the actual data, precisely pinning down when the Hadnot Point landfill started releasing contaminants, that doesn't exist, right?
A. Not to my knowledge, but that, again, is part of the model -- model calibration process, okay? That makes the source, then, a calibration parameter both in terms of strength and in terms of duration.
Q. Okay. And if -- turning to the next page, A85.
A. Yes.
Q. That's the calibration you're -- you're referencing, right?
A. That's a sensitivity -- you're in the

sensitivity analysis section, which is part of the uncertainty analysis. We wanted to see the impact of varying, again, the source release date.

Q. And that's what I meant. So this -- as I read the sensitivity analysis, you varied the release source -- the source release date from a period of -- let's see -- minus nine years, meaning nine years before the calibrated source release date, to plus nine years, meaning nine years after the calibrated release source date, correct?

A. That is correct.

Q. And in all of these scenarios, nine years before the release -- calibrated source release date, the model was still able to -- well, strike that.

Well, can you remind me, what was the calibrated source release date?

A. Hold on. Let me see. I have to go back to off the top of my head. Well, the model started in 1942 for Hadnot Point.

Q. Sure.

A. Hadnot Point landfill industrial, 1942, I believe. So nine -- nine years after that would be 1951, so that would be the calibrated.

Q. Okay. I've got you. Let's -- looking

-- returning back to the sensitivity analysis.
A. Okay.
Q. As -- you agree that this shows the effect of the calibrated model of varying the start date of contaminant sources, right?
A. Yes. What it does not show, as any sensitivity analysis, it doesn't show whether that's realistic or not. These are numerical, okay? In other words, it just shows numerically how the concentrations would shift forward or backwards depending on the release date.
Q. In all of these scenarios, nine years earlier than the calibrated source release date --
A. Right.
Q. -- five years earlier than the calibrated source release date, the actual calibrated source release date, which I see there, it appears to be 1951, 1952?
A. Yeah, that's what we said, yeah.
Q. Yeah. Five years after the calibrated release source date --
A. Right.
Q. -- nine years --
A. Right.
Q. -- after the calibrated release source

date, they all seem to converge during the period of the epidemiological study. Do you see that?
A. Yes.
Q. And so based on the sensitivity analysis, it's possible any one of these ranges could have been the release source date?
A. No, because we assumed, as we did with Tarawa Terrace, that we had a -- the calibrated parameters would be your most likely to have occurred, okay? And then these others are just seeing the impact on -- on the model, I mean, that's, you know, a five-year or nine-year change is a pretty major, major change --
Q. Don't these --
A. -- of the release date, okay, so -- but the most likely one is the calibrated one. I think that's important to understand.
Q. I understand that the -- the most likely is the -- you know, it's your opinion the most likely --
A. Yes.
Q. -- is the calibrated?
A. Yes.
Q. But doesn't the sensitivity analysis show that plus or minus nine years or five years

from the calibrated source release date, that it's possible?

A. It's a possibility.

MR. DEAN: Object to the form.

THE WITNESS: It's a possibility, but, again, that's -- typically, when you're conducting sensitivity analyses and uncertainty analyses, you want to get an understanding of how the system is reacting to changes in -- in this case, it's a single parameter.

Q. I'm going to mark another exhibit.

(DFT. EXHIBIT 17, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter C: Occurrence of Selected Contaminants in Groundwater at Installation Restoration Program Sites, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 17.

A. Chapter C. Okay.

Q. This is Chapter C for the Hadnot Point/Holcomb Boulevard analysis, correct?
A. That's correct.
Q. I would like you to turn to C98.
A. C98. Okay. Well, okay. Let's -- let me rearrange the clip so I can...
Q. What's that?
A. Let me rearrange the clip.
Q. Sure.
A. Okay. C98. Okay. Table C8.
Q. Yes, Table C8. And Table C8 is entitled -- or titled "summary of analysis for benzene, toluene, ethylbenzene and total xylene and water samples collected at Hadnot Point water supply wells, Camp Lejeune", right?
A. Right.
Q. Okay. I wanted -- directing your attention to HP602.
A. Okay.
Q. It has concentrations there for one, two, three, four, five, six, seven, eight dates there between 1984 to 1981, correct?
A. Yes, with two below detection limits.
Q. Correct, so two below detection limits for HP602?

A. Yes.
Q. And then the other five above detection limits with some value?
A. No, there's six.
Q. Oh, there's six. Excuse me.
The other six are above the detection limit with some value and they are all ranging from 1984 to 1991, correct?
A. That is correct.
Q. And it appears five of the samples, the -- for benzene there at HP602 are from '84?
A. Is that a question? I'm sorry.
Q. Yeah, is that right?
A. Okay. I've got one from '84, one, two, three, four. Four above detection limits are from 1984.
Q. Okay. And then there's one from '85, one from '86, then one from '91, correct?
A. Yes, that's correct.
Q. And then if we go down to HP608.
A. Okay.
Q. There are four samples between '84 and '86, correct?
A. Yes.
Q. And one appears to be below the

detection limit?

A. Right.

Q. Okay. You would agree that this table, it summarizes the measurements of benzene at the Hadnot Point water supply -- water supply wells, right?

A. Yes.

Q. And agree that benzene -- you would agree that benzene at the Hadnot Point source wells found only benzene above the detection limit at HP602 and HP608, correct?

A. 608, yes. Let me -- 608, that's correct, and then -- yes, above -- yeah, above the detection levels, yes.

Q. And the samples at 602, the concentration levels of benzene and the samples at 602 are much higher than the samples at 608, right?

A. Yes.

Q. For instance, the highest sample there, at 602, is 720 micrograms per liter, right?

A. Yes.

Q. And the highest sample at 608 appears to be four micrograms per liter?

A. Yeah, yes.

Q. Okay. So you would agree that the

driving source of benzene contamination at the Hadnot Point water treatment plant was HP602, right?

A. I would actually like to look at my graphs here because we really need to look at -- okay. Benzene. HP602, yes.

Q. That was the --

A. Yes.

Q. -- driving source of benzene contamination for that Hadnot Point water treatment plant, right?

A. That's -- that's the measured data that we have, so yes.

Q. Okay.

A. Based -- based on the measured data.

Q. Okay.

A. And the -- and the supply list.

Q. Let's turn back to -- I'm jumping around a little bit -- Chapter A for Hadnot Point, which is Exhibit 10.

A. For Hadnot Point? Yeah, I've got it right here.

Q. Actually it's Supplement 1 for --

A. Okay. I don't have Supplement 1. I've got Supplement 2 that you gave me.

Q. Okay. Let me mark it, then.

THE VIDEOGRAPHER: Sir, I'm going to need to change the media when you get to a stopping point.

MR. ANWAR: Sure. Let's stop right now.

THE VIDEOGRAPHER: All right. Going of record. The time is 3:59 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time the 4:10 p.m.

BY MR. ANWAR:

Q. We are back on the record from a short break, Mr. Maslia. Are you okay to continue?

A. Yes.

Q. Okay. Did you speak with your counsel outside or during the break?

A. No, I did not.

Q. Okay. Thank you.

I'm handing you what I'm marking as Exhibit 18.

(DFT. EXHIBIT 18, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the

Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A-Supplement 1, Descriptions and Characterizations of Data Pertinent to Water-Supply Well Capacities, Histories, and Operations, was marked for identification.)

BY MR. ANWAR:

Q. Okay. This is Chapter A, Supplement 1 for the Holcomb Boulevard/Hadnot Point analysis -- or the Hadnot Point/Holcomb Boulevard analysis.

A. Right, that's correct.

Q. And it's titled "descriptions and characterizations of data pertinent to water-supply well capacities, histories and operations", right?

A. Yes.

Q. Okay. If you could turn to page S117.

A. Okay. I'm there.

Q. S117 is a figure for well HP602, right?

A. It's a table, yes.

Q. Table. You'd agree that this table shows what ATSDR concluded about HP602 operating history and capacity history, right?

A. Yes.

Q. Okay. You'd agree that well HP602 had

a relatively small capacity, right?
A. I would say -- I would say it'd probably have an average capacity. I mean, there's some -- like 69 goes down to 50 or 30, it looks like. They then redeveloped the well. So I would say it's average. It's average capacity.
Q. If you compare it to HP well 608 on page S126.
A. HP608. Okay.
Q. Would you agree that the capacity for well HP602 was less than, generally speaking, the capacity for well HP608?
A. Yes.
Q. And focusing back on HR602 on S117.
A. Okay.
Q. Would you agree that the capacity fluctuated significantly?
A. Yes, it fluctuated.
Q. Okay. And it fluctuated in a range from 30 GPM on September 4th, 1969 --
A. Right.
Q. -- to 154 GPM on October 24, 1984, right?
A. Yes.
Q. Looking at the table for HP602, you

would agree that HP602 was out of service multiple times, correct?

MR. DEAN: Object to the form.

THE WITNESS: No, it's only out of service one, two, three -- three times.

BY MR. ANWAR:

Q. I see -- it was out of service April of 1979?

A. Yes, that's one. Oh, out four times. Out.

Q. It was out of service in October of 1981?

MR. DEAN: Which well? 60 --

THE WITNESS: 602.

MR. DEAN: Okay.

BY MR. ANWAR:

Q. You agree with that?

A. Yes, yes -- well, no, it says out. Again, these records are directly from either the water utility at Camp Lejeune or the well driller or whatever. So it says out. It does not say out of service. I don't know if that means -- if that means it was just out on that date or whatever, but the rest of them say out of service.

Q. Okay. It was -- it says out of service

on October 1981, correct?
A. Yes.
Q. So there's an October 1981 that says, quote, out, and then the following entry on the table is October 1981, out of service, right?
A. Yes, to me indicates we had, at least on that one, a multiple record or two different sources of records.
Q. And then November 30th, 1984, it was out of service as well, right?
A. Yes.
Q. So it was out of service at least three times, correct?
A. Yes.
Q. And then as of November 30th, 1984, it was permanently closed or terminated, right?
A. Well, service was terminated and then abandonment would be in '94, permanently closed.
Q. What -- what do you understand the distinction to be between service terminated and abandoned?
A. Service terminated would indicate they just stopped using it, but it might still be available for emergency purposes, whereas, abandonment would mean that they would, I would

say, pull the well screen out, pull the pump out, and maybe they seal it up with bentonite, concrete, the hole up.

Q. Okay.

A. That's the difference. There's an example for -- at Tarawa Terrace for TT23 that -- it says it was out of service, but, in fact, we have records that show during April of '85 they actually used it because they were short of water, okay? So unless it's abandoned, the well casing pulled and then concrete up -- that's what service terminated means to me, is that it's not being used.

Q. Okay. Based on the information in the table, which I assume comes from the available data, HP602 wasn't used after November 30th, 1984, right?

A. That's what that indicates.

Q. Okay.

A. We have no -- no data between -- or there's -- yeah, no data listed in the table between -- after November 30th, 1984 and June 1994. So just looking at those two pieces of data, it's terminated in '84 and then abandoned in '94. There's no indication on here as to whether it was used for emergency purposes or other things like that.

Q. Okay.

A. Which is always a possibility with a well that's not abandoned.

Q. Turning the page back to S16 -- excuse me, S126. Looking at the table on HP608.

A. Yes. Okay.

MR. DEAN: S?

THE WITNESS: 26. 1.26.

MR. DEAN: I guess I don't have that one.

THE WITNESS: Is this Supplement 1?

BY MR. ANWAR:

Q. You'd agree that ATSDA -- ATSDR determined capacity of HP608 ranged from 115 GPM to 230 GPM?

A. Yes.

Q. And as we discussed a few moments ago, compared to 60 -- HP602 --

A. Wait. Hold on just a second. It continues on page S127. It's got a capacity of 226 on 1983 -- March 21st, 1984.

Q. I see that. So my question was, do you agree that the range for -- ATSDR determined the capacity of HP608 to be in the range of 115 GPM on the low end and 230 GPM on the high end?

A. Yes.

Q. And --

A. I just wanted to make sure we had the full table in front of us.

Q. No, I appreciate that. Compared to -- and we discussed a moment ago, and you're welcome to turn back to look if you would like, but for HP602 the range was 30 GPM to 154 GPM?

A. Yeah, that's correct.

Q. Okay. You agree that the table on -- for HP608 on page S127 shows that service was terminated for HP608 on December 6, 1984, correct?

A. Yes, that's what it states.

Q. Okay. I would like to turn back to Chapter C.

A. Chapter C. Okay.

Q. For the Hadnot Point/Holcomb Boulevard analysis.

A. Yes. Okay. Chapter C.

Q. If I could direct you to page 108.

A. 108. Okay.

Q. Page C108, there's a Table C12 on it, right?

A. Yes.
Q. Okay. So there are three entries there, November 19, 1985, where benzene was detected at 2500 micrograms per liter, right?
A. Yes.
Q. And then there's an entry December 10, 1985 where benzene was detected, 38 micrograms per liter, right?
A. Yes.
Q. And then there is an entry just below it, December 18, 1985, where benzene was detected, one microgram per liter, right?
A. That's correct.
Q. Okay. Outside of those three entries in November 1985 and December 1985, according to this table, benzene was never detected above the detection limit at the Hadnot Point water treatment plant, right?
MR. DEAN: Object to the form.
THE WITNESS: Based on the sample data? We're talking about the data in this table?
BY MR. ANWAR:
Q. Yeah.
A. With the exception of those three readings that you cited, everything else was below

the detection limit.

Q. And just for the record, the -- we're looking at Table C12. It's entitled "summary of analyses for benzene, tolune, ethylbenzene and total xylene in water samples collected at the Hadnot Point water treatment plant at Camp Lejeune", right?

A. Yes.

Q. Okay. So these are samples collected at the Hadnot Point water treatment plant?

A. Right.

Q. Okay. And so a moment ago -- so for -- still focusing on C12 on -- Table C12 on November 19, 1985, December 10, 1985, and December 1985. Do you see that?

A. Yes.

Q. A moment ago we looked at tables with the operating and pumping histories for HP602 and HP608. Do you recall that?

A. Yes.

Q. So at the time of these three detections for benzene, HP602 and HP608 were shut down, right?

MR. DEAN: Object to the form.

THE WITNESS: I need to -- let's see.

Supplement 1, I'm guessing, yeah.
BY MR. ANWAR:
Q. Yeah, and if you want to --
A. Share the dates.
Q. -- go look over it, it was -- the 608 is on S126 and 27.
A. Okay. November 19th, '85. November 19th, '85.
Q. HP608 --
A. Yes, yes, it was not, according to this table, not operating, not in service.
Q. Yeah. And according to the table, it was terminated in December, December 6th, 1984, right?
A. Right.
Q. So almost -- it had been shut down for almost a year --
A. Right.
Q. -- by the time the benzene was detected --
A. Uh-huh.
Q. -- at the Hadnot Point water treatment plant, right?
A. That's correct.
Q. Okay. Then 602, which is page 17,

S117.

A. Okay. I'm there.

Q. And we discussed this service was terminated November 30th, 1984?

A. Yes.

Q. And it, likewise, had been shut down almost a year by the time benzene was detected at -- above detection limits at the --

A. Right.

Q. Or strike that.

It too -- the HP602 was -- also had been shut down in November 30th, 1984, which was about a year after benzene was detected at the Hadnot Point water treatment plant, correct?

A. No, we've got '85 at the water treatment plant. Is that what you're speaking with, the benzene detections at the water treatment plant?

Q. Correct.

A. That was in November '85 and it says service terminated November 30, 1984.

Q. So almost a year had passed, right?

A. Yes.

Q. Okay. Would you agree that -- well, strike that. Let me ask it this way. Residual benzene from HP602 or HP608 used -- before December 1984 was not the source of benzene in the November and December 1985 samples we just looked at, right?

MR. DEAN: Object to the form.

THE WITNESS: Again, this well says service terminated. There's always the possibility that they were operated and not recorded as operated. I'm saying we observed at that Tarawa Terrace, but -- and for the 2500 part per billion, if you go to the Chapter C report, it might be in this report also, we noted that the base chemist, Elizabeth Betz, noted on that one that it was not representative, okay? She did not say -- the samples don't say that that's not a valid sample. It said it was just not representative.

And we actually had a phone interview with her and there's some documentation, with Elizabeth Betz, to ask her did that mean that sample was, you know, not valid and all of that. I asked the question and she answered to me that, no, she just meant that benzene sample -- especially benzene samples would go up and down, up and down until there was no regularity to the concentrations.

BY MR. ANWAR:

Q. Well, in that conversation, was she referring to the 2500 micrograms per liter?

A. I specifically asked her about that, yes.

Q. And your understanding is -- from her is that that sample from Hadnot Point water treatment plant was not representative?

A. Yes, but I asked her -- that's marked on the JTC lab reports. It's not -- and it's also marked in our Chapter C.

Q. Sure.

A. Just to be clear. And I asked her what was meant or what was her understanding of not representative, and she said that -- and it's recorded in the notes or meeting notes that we had with her, phone conference, that she meant that there was just -- the benzene sampling data would go up and down, up and down by a large amount, and so that's why it was not representative. She did not say -- I asked her and she said she -- because I asked if she meant that she would consider that sample or, you know, or it was an erroneous sample, and she definitely said, no, she just -- her meaning was that it was -- the sampling data went

high and low, high and low.
Q. As you sit here today, you don't have any reason to believe that the residual -- residual benzene from HP602 or HP608 used before December 1984 was the source of benzene samples in November, December 1985?
A. We really did not do a residual analysis and, as you know, benzene is a floater. It floats on top of water, so like salad dressing with oil and vinegar. When you shake it up, maybe stir it up, and then it separates out. So we really did not do a residual analysis to see you know, that specificity.
Q. But you don't have any definitive data demonstrating that it was residual benzene from HP602 or HP608 used before December 1984 that was the source of this November, December 1985 benzene samples?
A. Well, we've got our reconstructed values at the water treatment plant.
Q. Well, and we don't need to look at those.
A. Okay.
Q. I'm just talking in terms of the real-world data, not in terms of the model right

now.

A. Okay. So again, ask your question again.

Q. Just some terms of real-world data, you don't -- there isn't any real-world data available or that exists demonstrating that HP602 -- residual benzene from HP602 or HP 608 used before December 1984, which is when those two wells closed, was the source of the November/December 1985 measurements in the Hadnot Point water treatment plant?

A. I do not have data for those wells after they went out of service.

Q. Now, Tarawa Terrace, if I remember correctly, ATSDR didn't use nondetects in the geometric bias; is that right?

A. What's published in the published title, yes, that's correct, we did not ignore the data. They're published in the table, but when we went to compute the geometric bias, we did not include the nondetects because there's a whole area of analysis about nondetects value -- what value should you include or what value should you assign or not assign and things of that nature.

Q. And in the published data you didn't --

ATSDR didn't use nondetects in the geometric bias, which was used to assess calibration, right?
A. That is correct.
Q. Okay.
A. But we did publish it in the tables accompanying -- accompanying that, okay, for both the wells and -- supply wells and the treatment plant.
Q. And as I understand it, from the very beginning of our conversation today, it sounds like you've done some additional work with respect to geometric mean -- or geometric bias?
A. Yes.
Q. Okay. And was that only for Tarawa Terrace?
A. It was for Tarawa Terrace and I'd have to look at my notes. I might have done it for the Hadnot Point water treatment plant.
Q. That would be reflected in your notes?
A. Yes.
Q. And do you intend to offer that opinion if called to testify at trial?
A. That we -- that I reassessed the computation?
Q. Yes.

A. Yes. Well, I mean, I will defer to the attorneys on that, but I have notes that I'll turn over to the attorneys.

Q. Okay. How --

MR. DEAN: Well, I mean, you should answer his question fully because you can update and amend your opinions pursuant to the rules in the deposition if he asked. So if you've completed your answer, fine. If you didn't, finish answering his question.

THE WITNESS: No. I mean, I looked again, as we discussed earlier today, after reading Dr. Konikow's report, and he discussed the issue of using duplicate samples or triplicate samples within the same day or same month when the model results only provide you one value per month. So then I went back and recomputed using that approach. So if we had two samples in a month, then I would take an average. If you had three, I would take an average, so I would compare one to one.

Q. Okay. I have to find my place again. Okay. How did ATSDR assess calibration of the Hadnot Point mixing model for benzene with only -- or primarily nondetect data points?

A. Let me get to Chapter C and in table -- on Table A18 on page A62, we've got supply well.
Q. Is this on Chapter A or Chapter --
A. Chapter A. I'm on Chapter A, yes. Chapter A of Hadnot Point.
Q. Okay. What -- what page were you looking at?
A. I was on page A62. Okay. I misspoke. That was the water treatment plant, okay? We had measured data and then we had reconstructed data. So I may have computed a geometric mean just, like, on scratch paper, but I did not publish it as part of the Chapter A for Hadnot Point/Holcomb Boulevard report.
Q. Why did you treat that differently than for Tarawa Terrace?
A. I really don't -- don't know. I know we were under a timeline crunch to get it out and it just may have been that it was not -- that I looked at -- I just looked at visually the values, reconstructed versus measured, and said, you know, that was, you know, provided a good fit. And also looked at the wells on page -- well, they're graphs and stuff like that, but also there's a table earlier on. Somewhere there's a table. And just

said that I was satisfied with -- with the -- with the fit or the goodness of fit of the calibrated results with the available water treatment plant data.

It was also -- with Tarawa Terrace we had just PCE, okay, one constituent. Whereas here we had multiple constituents and I may have -- I said, well, maybe we need to look into each one individually or something like that. It was a little more complex computation, and so it did not end up in -- in the published report.

Q. Would you agree that not assessing geometric bias affects uncertainty and reliability for the Hadnot Point model?

A. Not necessarily because, again, geometric bias just gives me an estimate; is the model way over or way under or it's in the ballpark, okay? And again, I'm looking at the plot. A graphic is just as good as a geometric bias. A geometric bias is putting a quantitative estimate on a graphic, okay? Had this graphic, and so it was just a computation that was not done for this -- this analysis. You can go back and -- and do it. I mean, as I said, I've got my notes.

Q. Okay. If you could turn back to

Chapter C on page C106.

A. 106?

Q. Yeah.

A. 106. Okay. I've got it.

Q. On C106 there's a Table C11, right?

A. Yes.

Q. It states, "summary analyses for PCE, TCE, 1-1-DCE, trans-1-2-DCE, 1-2-DCE" -- it says, "1-2-DCE, total 1-2-DCE, and vinyl chloride in water samples collected at the Hadnot Point water treatment plant, Camp Lejeune", correct?

A. Yes.

Q. Okay. I just wanted to ask you a few questions about this.

A. Sure.

Q. You'd agree that this table summarizes measured PCE and degradation product observations at the Hadnot Point water treatment plant?

A. Yes.

Q. You'd agree that vinyl chloride was never detected above the reporting limit at Hadnot Point water treatment plant?

A. There's -- on February '85 the value -- estimated value of 2.9.

Q. Where are you looking? February --

A. C11, February 5th, 1985 all the way across the last column. It says 2.9J.

Q. Okay. Aside from that one time, would you agree that vinyl chloride was not detected above the detection limit?

A. Let me make sure this goes -- is this the same -- Table C10, C11. You're just talking about Table C11, right?

Q. Correct.

A. Yes, that would be --

Q. You would agree that aside from that -- that one time in -- on February 5th, 1985, that vinyl chloride was never detected above the detection limit?

A. Yes.

Q. And this is for that Hadnot Point water treatment plant, right?

A. That's correct.

Q. Okay. And then you would agree that DCE was rarely detected above the detection limit at the Hadnot Point water treatment plant?

MR. DEAN: Object to the form.

THE WITNESS: No, where there's a trans-DCE, 1-2-DCE on February 5th, again, 1985, of 150 micrograms per liter.

BY MR. ANWAR:
Q. So that's that one time?
A. Yes.
Q. Would you agree, aside from that one time, that DCE was not detected above the reporting limit at the Hadnot Point water treatment plant?
MR. DEAN: Object to the form.
THE WITNESS: Yes.
BY MR. ANWAR:
Q. Okay. Let -- jumping around. Let's turn back to Chapter A for Hadnot Point/Holcomb Boulevard.
A. Okay. Okay.
Q. I would like to direct your attention to A46.
A. Page A46?
Q. Correct.
A. Okay.
Q. There are a series of graphs there entitled Figure A18, correct?
A. A18, yes.
Q. And A18 is titled "reconstructed or simulated and measured concentrations of TCE at selected water supply wells within the Hadnot Point industrial area." Did I read that correct?

A. Yes.
Q. Okay. And the wells reflected on these graphs are HP602, HP608, HP634, and then there's well HP601 and, slash, HP660, correct?
A. That is correct.
Q. Would you agree that these -- this figure shows calibrated model values at HP well 601, 602, 608 and 634?
A. They show the -- yes, the red line is the simulated values.
Q. Okay.
A. Or reconstructed values, and the black dots are the measured.
Q. So the -- for instance, at HP602 there are one, two, three, four, five, six measured values reflected on the graph, right?
A. Yes.
Q. For HP601 it looks like there are three measured values on the graph, right?
A. Yes, they are measured for HP660, which was the replacement well.
Q. For 601, right?
A. Yes.
Q. For HP608, it looks like there are four values reflected on the graph?

A. Yes.
Q. And for HP634 it looks like there is one value reflected on the graph?
A. Yes.
Q. Those are the measured values we're talking about, correct?
A. That is correct.
Q. And then the -- that red -- the red line is what the model is simulating as estimated concentrations?
A. Yes, that's correct.
Q. These graphs show some measured values, but they show none of the nondetect values, correct?
A. That's correct.
Q. And you would agree that if we turn to -- you might keep this page open --
A. Okay.
Q. -- but also turn to Chapter C, C95.
A. Right. C95?
Q. Correct.
A. Okay. I'm there. Table C7.
Q. Yes.
A. Okay.
Q. C7, "summary of analyses, PCE, TCE, DCE

and vinyl chloride for water samples collected at Hadnot Point water treatment plant", right?
A. Right.
Q. Okay. For HP634 there, there are four values below the nondetect limit, right -- or excuse me, there are four -- four nondetects?
A. In Table C9 -- I mean, on Table C7?
Q. Yes.
A. For 634 there's -- yes, that's correct.
Q. And if you go back and look at A46, there's one measured value reflected there, right?
A. That's correct.
Q. But those -- those four nondetects are not reflected?
A. That's correct. The issue with trying to graphically represent nondetects gets back to what value are you going to use. If we use the detection limit, then someone can argue, well, you don't know that definitively because it was nondetect. If you want to use half the detection limit, again, that's just an estimate. There are some other complex methods where people -- Dennis Helsel and others who have worked in the nondetect area, that you can estimate and quantify the nondetects, but for our purposes we used the

graphics in the reports as -- and companions to the tables. So if someone wanted to see what all the values were, they could go to the -- to the table and see that we had nondetects and we also had above detection limits.

Q. Okay. Let's -- let's look at -- and let me mark it. Let's switch gears a little bit.

A. Okay.

Q. I'm going to hand you what I'm marking as Exhibit 19.

(DFT. EXHIBIT 19, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina Chapter A-Supplement 6, Characterization and Simulation of Fate and Transport of Selected Volatile Organic Compounds in the vicinities of the Hadnot Point Industrial Area and Landfill, was marked for identification.)

THE WITNESS: Okay.

BY MR. ANWAR:

Q. Here you go.

A. Supplement 6. Okay.

Q. Exhibit 19 is a Hadnot Point/Holcomb Boulevard Chapter A-Supplement 6, right?
A. That is correct.
Q. Okay. And it's titled "characterization and simulation of fate and transport of selected volatile organic compounds in the vicinities of the Hadnot Point industrial area and landfill", right?
A. That is correct.
Q. Okay. Can I have you turn to page S645?
A. Okay. 645. Okay.
Q. And S645 includes a discussion of -- it's entitled discussion and limitations, correct?
A. That is correct.
Q. And that's of the Hadnot Point/Holcomb Boulevard analysis and model, correct?
A. Yes, yes.
Q. Okay. Looking over on the right-hand side, second paragraph, it starts, "for contaminant fate and transport modeling reported herein, however, insufficient water quality data existed to conduct a statistical analysis for assessment of model calibration fit. In addition, specific data pertinent to the timing of initial deposition of

contaminants to the ground or subsurface chronologies of waste disposal operations such as dates and times when contaminants were deposited in the Hadnot Point landfill or descriptions of the temporal variation of contaminant concentrations in the subsurface generally are not available."

Did I read that all correctly?

A. Yes.

Q. Okay. And then it goes on, "determining these types of source identification and characterization data became part of the historical reconstruction, whereby the contaminant fate and transport model was used to test source locations, varying concentrations, and beginning and ending dates for leakage and migration of source contaminants to the subsurface and the underlying groundwater flow system." Did I read that correctly?

A. That's correct.

Q. Okay. So then the next starts, "conducting a robust uncertainty analysis using Monte Carlo analysis requires simulating thousands of realizations. When using available computational equipment, the Hadnot Point industrial area and the Hadnot Point landfill models have a simulation time of about six to eight hours for each simulation. The lengthy simulation times and the substantial data limitations therefore make a comprehensive uncertainty analysis computationally prohibitive based on available resources and time limitations. Thus, the ranges of values presented in the sensitivity analysis section of this report assess a limited number of input and output model parameters. The results, in other words, range of concentration presented in the sensitivity analysis reported herein, should not be considered or interpreted as the results of a robust and comprehensive uncertainty analysis, but do provide insight into parameter sensitivity and uncertainty in a qualitative sense."

Did I read that all correctly?

A. Yes.

Q. Based on the two paragraphs we just read together, you would agree that ATSDR did not conduct a statistical analysis to assess model calibration and fit at Hadnot Point because there wasn't sufficient water quality data, right?

MR. DEAN: Object to the form of the question and misstates and mischaracterizes the

document.
THE WITNESS: I'm just seeing where we said that on this -- I'm sure I'm --
MR. BELL: Are y'all allowed to have candy bars?
MR. ANWAR: Sure.
MR. BELL: I know it's late in the day. Someone said, well, don't give him anymore.
THE WITNESS: Yeah, it's -- as it states in the report, insufficient water quality data and the statistical analysis for assessment of model calibration is not -- was not conducted, okay? I believe they were referring to -- this was the -- this was the groundwater flow -- the contaminant fate and transport groundwater model, not necessarily the mixing model and -- at the Hadnot Point water treatment plant, okay? That may have been able to have been computed.
BY MR. ANWAR:
Q. But you agree statistical analysis to assess model calibration fit wasn't conducted because -- because there was insufficient water quality data, right?
A. Yes, that's what it says.
Q. Okay. And in this paragraph, when it's

referencing water quality data, you would agree that means measurements of contaminant concentrations, right?

MR. DEAN: Object to the form.

THE WITNESS: That's what I would interpret it to mean.

BY MR. ANWAR:

Q. Okay. So earlier, just, I think, a few minutes ago, we talked about geometric bias at the Hadnot Point mixing model?

A. Right.

Q. Would you agree this says one wasn't done?

A. Again, I'm looking at -- this is strictly a groundwater contaminant fate and transport. It would have been done or could have been done in the summary chapter, Chapter A, but I do not see it there, so it was not conducted.

Q. One was --

A. It was not computed. Let me just -- it was not computed like it was computed for Tarawa Terrace.

Q. One wasn't computed for the fate and transport model for Hadnot Point, correct?

A. One was not computed for the water

supply wells at Tarawa Terrace -- let's go back. We computed geometric bias for the water supply wells and then we also computed a geometric bias for the water treatment plant, okay? So Supplement 6 is strictly the groundwater flow model, so there was not one conducted -- computed for the supply wells at Hadnot Point and Holcomb Boulevard.

Q. Okay. I just want to make sure. There was not one computed for the supply wells, correct?

A. That is correct.

Q. And would you agree there was not one conducted for fate and transport?

MR. DEAN: Object to the form.

THE WITNESS: That would -- that would be the supply wells.

BY MR. ANWAR:

Q. Okay. I've got you.

A. Okay. The fate and transport model, you would pull out the concentrations at the well locations.

Q. Okay. That's what I wanted to make sure I understood. Thank you.

And so now kind of looking back at the paragraphs we just read.

A. Okay. Hold on. Go back there.

MR. DEAN: Page 45, 645. I think that's where...

THE WITNESS: Yeah, I'm there.

BY MR. ANWAR:

Q. It says, you'd agree, "that specific data pertinent to the timing of initial deposition of contaminants to the ground or subsurface chronologies of waste disposal operations such as dates and times when contaminants were deposited in the Hadnot Point landfill or descriptions of the temporal variation of contaminant concentrations in the subsurface generally were not available at Hadnot Point", right?

A. That's what it says, yes.

Q. Okay. And you agree that historical -- quote, historical reconstruction, as used in the paragraphs, had to include testing source locations, varying concentrations, and beginning and ending dates for leakage and migration of source contaminants to the subsurface and the underlying groundwater flow system?

A. That would be the calibration process.

Q. You'd agree that a comprehensive uncertainty analysis wasn't done at Hadnot Point because, as it states in the paragraph, "lengthy

simulation times and substantial data limitations were computationally prohibited" --
A. Yes.
Q. "Prohibitive."
A. Yes, that's what it says.
Q. ATSDR did a sensitivity analysis, but it said, results should not be considered or interpreted as results of a robust and comprehensive uncertainty analysis, correct?
A. Yes.
MR. DEAN: Object to the form.
BY MR. ANWAR:
Q. And your answer was yes, right?
A. Yes, I'm confirming what -- you read it from the report.
Q. It's the last sentence of the last paragraph. So ATSDR did a sensitivity analysis, but said its results should not be considered or interpreted as the results of a robust and comprehensive uncertainty analysis, right?
MR. DEAN: We can stipulate you read that sentence correctly.
BY MR. ANWAR:
Q. And you agree with that, right?
MR. DEAN: Object to the form.

THE WITNESS: It can be considered qualitative. That's what we say in here, okay? We did conduct sensitivity analyses.

BY MR. ANWAR:

Q. Let's jump ahead -- or let's jump to -- back to Supplement 6 -- or we are on Supplement 6.

A. Yes.

Q. So let's turn to page 44, S6.44.

A. 44, okay.

Q. So the page before.

A. Okay.

Q. On page S6 there is a Figure S6.23, correct?

A. Yes.

Q. And the figure is titled "variations in reconstructed simulated finished water concentrations of TCE derived using a Latin hypercube sampling methodology on water-supply well monthly operational schedules for Hadnot Point/Holcomb Boulevard study area", correct?

A. Yes.

Q. Okay. This is the -- the -- the figure for the uncertainty analysis on the Hadnot Point/Holcomb Boulevard model, right?

A. Yes, at the water treatment plant.

Q. Okay. At the water treatment plant.
And agree that the results of this uncertainty analysis at the Hadnot Point water treatment plant where reconstructed monthly well operations -- okay. Let me ask that again.
You agree that the results of the uncertainty analysis here were -- for reconstructed monthly well operations schedules were varied?
A. Yes.
Q. And this -- this reflects the -- the water-supply well monthly operational schedules, correct?
A. Yes.
Q. It's an uncertainty analysis about the water-supply well monthly operational schedules, correct?
A. That is correct.
Q. Okay. And the uncertainty analysis shows -- the uncertainty analysis was varied, right?
MR. DEAN: Object to the form.
THE WITNESS: I'm not sure I understand what you mean by the uncertainty analyses was varied.
BY MR. ANWAR:

Q. The results of the uncertainty analysis were varied, correct?
MR. DEAN: Object to the form.
THE WITNESS: The results were not varied.
BY MR. ANWAR:
Q. I thought a moment ago you agreed they were varied.
MR. DEAN: Object to the form.
THE WITNESS: You asked me about the water-supply wells.
BY MR. ANWAR:
Q. Okay.
A. That's the parameter that was varied.
Q. Okay. Understood. Ah, yeah. And you'd agree -- so let me -- just so the record is clean, agree this -- the -- this uncertainty analysis at Hadnot Point is where reconstructed monthly well operations schedules were varied, correct?
A. Yes.
Q. Okay. Thank you. And you agree that the results of this uncertainty analysis suggests that changes in pumping schedules produce very different modeled monthly mean contaminant

concentrations, right?

MR. DEAN: Object to the form.

THE WITNESS: There's variation from the mean to the high or low.

BY MR. ANWAR:

Q. There's significant variation, right?

MR. DEAN: Object to the form.

THE WITNESS: I don't know if I would call it significant. If you compare it to the data spread, it's not -- it's greater than at Tarawa Terrace.

BY MR. ANWAR:

Q. You agree it is greater than Tarawa Terrace, right?

A. Yes, but we still considered it to meet our modeling objectives.

Q. You'd agree this was a Monte Carlo simulation like in Tarawa Terrace, but unlike Tarawa Terrace, only the one input parameter, well pumping schedule, was varied, correct?

A. It was a Latin hypercube sampling, which is a variant of Monte Carlo simulation when Monte Carlo simulation becomes computationally prohibitive. So it is a Monte Carlo, but it's Latin hypercube sampling.

Q. A moment ago we were talking about the degree of variation. Would you agree that the variation is hundreds of micrograms per liter?
A. Once -- you're talking about the reconstructed results or the sampling data?
Q. The -- the reconstructed results.
A. Once HP651 kicks in, yes, after July -- I think June or July of '72.
Q. That's where you see the -- on the figure, Figure S623, dot 23, it spike up, correct?
A. Yes.
Q. Now, looking at this Figure S6.23, you would agree the gray line show all of the Monte Carlo simulations drawn on the same chart?
MR. DEAN: Object to the form of the question.
THE WITNESS: They -- they show all the Latin hypercube sampling results on -- on this graph.
BY MR. ANWAR:
Q. Why not show the 95 percent realization balance like ATSDR did for Tarawa Terrace?
A. It was not -- with Latin hypercube you -- you had -- in this case we used ten equal subdivision or sampling points, okay? That's the

definition of Latin hypercube, is you have an equal probability within each sampling domain, which we had ten. And so it was just not possible to compute a confidence limit, but -- using -- using that approach.

Q. Okay.

A. But it did give us both a quantitative, in terms of high/low, and qualitative feeling of the model results at the water treatment plant.

Q. Got it. I think we are in the home stretch, about 40 minutes left, probably 40, 45. Why don't we take a quick five or five or ten. I would like to take a look at my notes and --

A. Okay. Sure.

MR. ANWAR: Thank you.

THE VIDEOGRAPHER: Going off record. The time is 5:10 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 5:23 p.m.

BY MR. ANWAR:

Q. We are back on the record from a short break. Mr. Maslia, are you okay to continue?

A. Yes, I am.

Q. Did you speak to your lawyers during

the break?

A. No, I did not.

Q. Okay. I may bounce around a little bit. I wanted to ask you a few questions about your rebuttal report, your opinions in your rebuttal report. Dr. Spiliotopoulos pointed out, for the Tarawa Terrace model, that the KD values and the bulk density values for the calculation of the retardation factor contained errors. Do you recall that?

A. He pointed out that the bulk density did.

Q. Okay. And my -- my understanding of your opinions about that are essentially that you don't dispute the error, but it doesn't, in your opinion, change the analysis much; is that right?

A. It's not so much of an error. What was used originally was the wet bulk density, and it was pointed out to us in 2009, by one of the experts on the Hadnot Point/Holcomb Boulevard panel when we had sent the Tarawa Terrace report, that we had a wet bulk density. So we went back and changed that value and, of course, you've got to understand is that in the contaminant fate and transport equations, bulk density and distribution coefficient are not included. What's included is retardation factor, okay? And we originally had a retardation factor of 2.93. So if we adjusted the bulk density to drop down, that means we could adjust KD up. They are compensating, okay, because they are calibration -- KD is a calibration parameter.

Q. Sure.

A. And that resulted in the exact same retardation factor of 2.93, and it resulted in identical to the decimal place concentrations that we had published in the Chapter A report.

Q. Okay. And thank you for -- for explaining that. The -- if I'm understanding your testimony correctly, it's not so much that the -- the difference of opinion about bulk density or the error, as Dr. Spiliotopoulos has described it, doesn't exist; it's that it's offsetting such that it doesn't impact the retardation factor?

A. That is correct.

Q. Okay.

A. Our retardation factor was consistent -- it was identical to what it was in the published report, okay, but it was also very consistent with existing literature values as well for PCE in this

type of terrain.
Q. Now, the retardation factors -- excuse me, the bulk density and the KD value used for Hadnot Point and Holcomb Boulevard model or analysis is different than the one for the Tarawa Terrace model, is that --
A. I would like to just compare the two so we're --
Q. Sure.
A. -- comparing apples to apples here. So let get me to Hadnot Point. Okay. There's -- I'm looking at page A41 for the Hadnot Point report. Ah, here you go. So you asked about bulk density.
Q. Yeah, the -- let's start with bulk density.
A. Well, yes, but, again, as I said, we corrected the one that was in Chapter A once we realized that was a wet bulk density. The corrected value came very close to 46,700 grams per cubic foot.
Q. Okay.
A. Which is what we used in the Hadnot Point.
Q. But the values for the actual calculation -- for the actual -- how you calculated

the retardation factor between Tarawa Terrace and for Hadnot Point, can you direct me to the page that you're looking?

A. Okay. I'm on page A41 of the Hadnot Point/Holcomb Boulevard report.

Q. Sure.

A. And then also page A29 of the Tarawa Terrace report.

Q. Okay. Okay. Let's come back to that.

A. Okay.

Q. I'm going to mark what is, I think, Exhibit 20 now.

(DFT. EXHIBIT 20, letter dated February 21, 2007 from Morris Maslia to Dr. Leonard F. Konikow Bates-stamped CL_PLG-Expert_Konikow_0000000006 through 0000000021, was marked for identification.)

BY MR. ANWAR:

Q. Here you go. This -- the first page of Exhibit 20 is dated February 21, 2007, correct?

A. Yes.

Q. And it is a letter from you to Dr. Leonard Konikow enclosing feedback to comments that Dr. Konikow had raised about the Tarawa Terrace analysis, correct?

A. Yes, he was a peer-reviewer, external peer-reviewer --
Q. Okay.
A. -- on that particular chapter for Tarawa Terrace.
Q. Now, these -- these responses to Dr. Konikow's concerns or what are identified as major concerns were drafted by Bob Faye, correct?
A. Yes.
Q. Did you have a chance to review these before they were sent out?
A. I -- I reviewed it. It's been a while since I've seen these, but I did -- did review it.
Q. Would you have discussed the responses with Bob Faye before they were sent back to Dr. Konikow?
A. Not necessarily discussed it. If I had an issue with the response, I may have talked to him.
Q. Okay.
A. And asked him, but I typically -- my approach was not to micromanage the modelers, right? So since Bob Faye was the primary author on Chapter F, I assume that's what this chapter is -- yes, then I would allow him to develop the

responses. And, of course, he was a subcontractor to ATSDR through Eastern Research Group, so that's -- that's who he would send the responses to and they would provide me with a copy.

Q. Okay. So on -- let's call it the page ending in Bates label 08.

A. Okay. Okay.

Q. Actually, let's go to 09.

A. Okay.

THE WITNESS: Do you need a copy? Do you need a copy?

MR. DEAN: I have one.

THE WITNESS: Oh, okay. Okay.

BY MR. ANWAR:

Q. Number three, Dr. Konikow raised as a major concern, "the reliability of the estimate of the biodegradation rate constant based on the assumption that concentration declines" -- excuse me. Let me read that again.

Number three of Dr. Konikow's major concerns reads, "the reliability of the estimate of the biodegradation rate constant based on the assumption that concentration declines observed at one location over a period of several -- several years can be explained solely by biodegradation."

Did I read that correctly?
A. Yes, you read that correctly.
Q. Okay. And it looks like Bob Faye's response there was "the author never claimed that the biodegradation rate computer using field data was reliable or the sole reason for the observed decline in PCE concentration." Did I read that correctly?
A. Yes.
Q. Okay. Do -- do you agree with that statement?
A. That's Mr. Faye's opinion as the person who did the -- the model in response to Dr. Konikow's question or comment, but, you know, what is generally being said is that some of these transport parameters, like biodegradation rate, that's very limited field -- field data, and so, you know, there could be any possibilities for the decline in the concentration. And I think that's what Dr. Konikow was raising as well.
Q. And the next sentence says, "rather, the computed rate was presented as an approximate value useful to begin model calibration." Did I read that correctly?
A. Yes. And I would agree with that.

Q. So if you go on, the rest of it reads, "well TT26 is located on a direct migration, slash, advective pathway from the PCE source at ABC One-Hour Cleaners." Did I read that correctly?
A. Yes.
Q. Do you agree with that?
A. Yes.
Q. Okay. And then it says, "to the extent that migration of PCE mass towards and away from supply well TT26 occurred at about equal rates during 1985 to 1991, the computed degradation rate of 0.00053 per day approximates a long-term average degradation rate." Did I read that correctly?
A. Yes.
Q. It goes on to say, "on the other hand, if a significant quantity of the PCE degraded in the vicinity of supply well TT26 was replaced by advection, then the degradation rate computed using equation three is probably a minimum rate," correct?
A. Yes, that's what you read.
Q. Okay. And do you agree with that?
A. I agree with that concept, yes. He's basically saying we had two data points at TT26 in '85 and '91, and so that's what was used to compute

the initial -- to start model calibration.

Q. And then it goes on to say, "the report does not state or indicate that the decline in PCE mass at supply well TT23 is due entirely to biodegradation rate -- biodegradation. Rather, the report indicates that the computed first-order degradation rate is an estimate used as a basis to begin model calibration," correct?

A. Yes. It's important to understand that the value that we ended up for the calibrated rate, which is five times ten to the minus four per day, 0.0005, compares extremely favorably with the values that Dr. Clement came up with in his model for his paper.

Q. That who came up with?

A. Dr. Clement.

Q. Okay. And you're talking about the Dover Air Force Base model?

A. Yes, yes, very similar lithology. We did have a gravel zone in there, but, again, he came up with -- I think it was somewhere around one to four times ten to the minus four. I would have to look at the paper and see.

Q. That's okay.

A. But that's, you know...

Q. I wanted to turn your attention to the Bates page ending now in 15.
A. Yeah, could I just make sure I gave you the right numbers?
Q. Sure.
A. Here we go. Okay. Here you go. The estimated -- the field estimated apparent reaction rates range from 3.5 to seven times ten to the minus four per day for PCE, and we're smack dab in the middle with five times ten to the minus four.
Q. Let's turn to the page ending in 15.
A. Okay.
Q. There is a comment about -- towards the bottom of -- about mass loading. Starting page 59, it says, "mass loading, disagree, see my comments under major concerns item five. The reviewer seems to assign a high degree of accuracy and credibility to the PCE mass computation that is unwarranted." Did I read that correctly?
A. Yes.
Q. And then it says, "as explained previously, the computation of PCE mass was highly interpretive and somewhat subjective process frequently based on questionable data." Did I read that correctly?

A. Yes.
Q. Do you agree with that?
A. Not necessarily. We had data from ABC Dry Cleaners, PCE data, and we used a technique that was published in Groundwater journal that's documented in the Chapter E and the Chapter F -- F report in -- the key fact takeaway, and I mentioned this in -- I believe it was my expert report, is that the mass computed using the field data and the mass determined from the MT3DMS model were the same order of magnitude, which gave us -- it's almost another calibration check, okay?
Q. The comment goes on to say, "field data applied to the PCE mass computation were limited both spatially and vertically," right?
A. Right.
Q. And that's a true statement, right?
A. That is. They were limited, but they were still field data available.
Q. And then, "the computation was accomplished regardless of data limitations to provide an estimate of a minimum mass loading rate to begin model calibration." Did I read that correctly?
A. Yes.

Q. Okay. Now, for the Tarawa Terrace model, ATSDR assumed mass loading on January 1, 1953, correct?
A. That is correct.
Q. And I think, was it -- without pulling up the report, was it 1300 -- or no, 1200?
A. That was the calibrated value, is 1200. We started at 200. And again, that is a calibration parameter that you're free to adjust during the model calibration process. We're adjusting, you know, conductivity. You're adjusting reaction rate. You're adjusting a number of parameters. And so it was adjusted and the best fit value came up to, I believe, 1200 grams per day.
Q. Okay. And I understand that DOJ's expert has offered a -- well, let me -- let me ask you this: You reviewed Dr. Spiliotopoulos's report, correct?
A. Yes.
Q. Okay. And you saw that his opinion that the -- the later start date for ABC Cleaners, correct?
A. Right, correct.
Q. Of July 1954, correct?

A. That is correct.
Q. Okay. And in the ATSDR Tarawa Terrace model, the start date was assumed to be January 1, 1953, correct?
A. That is correct.
Q. And on day one, the calibrated mass loading rate is 1200 micrograms per liter, correct?
A. No, grams per day.
Q. Per day. I'm sorry.
A. Yeah, grams. The way it was input to the model as a source loading rate, so it would be grams per day.
Q. Thank you for that. It was assumed to be a constant 1200 micrograms per day, correct?
A. The calibrated value.
Q. For Tarawa Terrace?
A. Yes.
Q. Okay. In the real world, if contaminants on the surface were to start leaking, would they immediately reach the aquifer?
A. They would within, in this case, probably a couple of years.
Q. So in -- in -- for Tarawa Terrace it's your opinion that whenever ABC Cleaners released PCE into the -- onto the ground, it would have

taken a couple of years for it to reach the aquifer?

A. To reach any of the supply wells pumping. In other words, it would have gone vertically horizontal and, of course, the -- say TT26 is pumping, is putting tremendous gradient, vertical gradient, down right near to the well, so it would have fallen horizontal and then vertically down into the well -- a well casing or a well screen and been pulled -- pulled up. And the assumption was, again, the engineering assumption, that it started on January 1st, 1953 when ABC Cleaners started operations.

Q. Okay. So you assumed the constant -- the calibrated constant mass loading rate on day one, but you agree in the real world it may have taken a couple of years for contaminants from ABC Cleaner to actually get to the supply wells, correct?

A. It may have, but we did not do -- you would have to do an unsaturated zone modeling or analysis to actually quantify that.

Q. Why did you-all decide to assume a constant mass loading rate on day one?

A. Because if we did not assume a constant value, that would be, to me, indicative that we must have had some additional data to say that, you know, it was a certain rate this day, a different rate in another day, and so on. So we did not have that information, so in keeping with accepted model calibration practice, we assumed the constant rate that we computed -- we computed initial, which was a minimum value, and then through the calibration process increased it using calibration to check results for the available contaminant concentration data at the wells.

(DFT. EXHIBIT 21, e-mail correspondence Bates-stamped CLJA_Watermodeling_05-0000021184 through 0000021188, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 21.

A. Okay.

Q. I hope that's right, 21. We were just talking about mass loading with respect to Tarawa Terrace. I would like to shift gears to -- to sort of mass loading with respect to Hadnot Point/Holcomb Boulevard.

A. Okay.

Q. And this is an e-mail from Barbara

Anderson to you dated -- the first e-mail -- well, I guess the chain, both of them, are dated September 26th, 2011, correct?

A. It's September 26, 2011, yes.

Q. Okay. And this e-mail is discussing mass loading of benzene, correct, or, I guess, LNAPL, light non-aqueous phase liquid?

A. I believe this is discussing the LNAPL that's dissolved because -- it says LNAPL on it, so I'll leave it at that right now.

Q. The third paragraph states, "the first scenario is a simple step function. The second scenario incorporates some information we have about the Hadnot Point fuel farm area and conceptualizes the source strength LNAPL area as increasing over time. In reality, the LNAPL footprint grew and spread as the UST system leaks and releases progressed. At some point in time the LNAPL footprint grew to be the size that -- that GT calculated from the free product data, 1988 to 1999, but it was not that size from the beginning start date. This is shown in scenario two."

Did I read that correctly?

A. Yes.

Q. And do you agree with Barbara Anderson that in reality the LNAPL footprint grew and spread as the underground storage tank system leaks and releases progressed?

A. Conceptually, yes, I would agree with that.

Q. And scenario two shows a -- the leaks and releases progressing over time, correct?

A. That is correct.

Q. Whereas, the scenario one is a step function that shows immediate mass loading or release right away, correct?

A. That is correct.

Q. And for the Hadnot Point/Holcomb Boulevard model as it relates to LNAPL, ATSDR used scenario one, correct?

A. I would have to go back and read -- the LNAPL was rather complicated because we had the folks at the multi-environmental simulations lab at Georgia Tech looking at the volume and then the movement within the saturated zone to the water table. And then we had the other people, like Barbara and Mr. Elliott Jones, who did the fate and transport part, looking at it moving the water table.

So I would have to go back and -- and

look at how each one characterized the mass loading rate or the source -- source rate and -- but I know Barbara was our data analyst, and I think the task here was to look at two different conceptualizations for how mass loading at the Hadnot Point industrial area and fuel farm could have occurred.

Q. Okay. And scenario two is more realistic, right, in the real world?

MR. DEAN: Object to the form.

THE WITNESS: Again, that's -- I think that's an data analysis engineering call as to what it could be.

BY MR. ANWAR:

Q. Okay.

A. You know, where it's almost -- you'd have to run a sensitivity analyses on here and see which one provided you closer agreement.

Q. Okay. As you, Mr. Maslia, sit here today, are you planning to amend or supplement your expert report in the case?

A. Well, we mentioned about the geometric bias. I don't know if that amends my report or -- and we included that extra paper reference --

Q. Okay.

A. -- from Clement, so that definitely, I think, should be in there. And, you know, I don't have any intentions of any major changes based on additional modeling that I'm -- I'm doing. I'm not planning on doing any.

Q. When you say no intent on major changes --

A. Right.

Q. -- are you planning to -- and when I say supplemental disclosure, are you planning to provide, like, another written document with additional or updated opinions --

MR. DEAN: So --

BY MR. ANWAR:

Q. -- major or minor?

MR. DEAN: Let me -- let me take over here and answer for the witness, if it's okay. And that is, as you know, DOJ recently belatedly produced a bunch of photos from Dr. Hennet without any sort of a disclosure of what it is. So we can't respond to our experts until we sort of know some explanation as to what that is. So that could potentially, depending on Mr. Hennet's deposition, trigger something from him, but he nor any of our experts at this time can answer your question about additional thoughts or opinions or whatever. And, of course, there's been some correspondence about this. Mr. Bain has sent a letter and we've responded. So we just -- he's reserving that right as to that stuff.

MR. ANWAR: Okay. Well, we will wait to see -- we'll wait to receive the documents related to the geometric bias and we will reserve our right to keep the deposition open or to reopen it. And I think I only have a few minutes left, so thank you for your time. I'll reserve those final minutes. Thank you for your time today.

THE WITNESS: Okay. Thank you.

MR. DEAN: Okay. Let's go off the record, if it's okay, for maybe about ten minutes. Take a break. Let me get my thoughts together. I've got some questions. They won't be long, but I've got a few questions.

THE VIDEOGRAPHER: Okay. Going off record. The time is 5:56.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 6:15 p.m.

EXAMINATION

BY MR. DEAN:

Q. All right. Mr. Maslia, I just have a few questions, so I don't think we'll be long, okay?
A. Okay.
Q. Oh, there we go. So earlier you were shown Exhibit 9, which is the Chapter A Tarawa Terrace report, and I want to ask you if you can look at your version and turn to page -- I believe it's A -- excuse me. You were shown Chapter C.
A. Hadnot Point?
Q. Hadnot Point, page C98. So it looks like it's Chapter C.
A. Yeah, I'm trying to find...
Q. Can you tell me what that exhibit number was?
MS. SILVERSTEIN: 17.
THE WITNESS: I've got Exhibit 17.
BY MR. DEAN:
Q. Okay. So take a look at Exhibit 17; put it in front of you.
MR. ANWAR: What page are you on?
MR. DEAN: Page C98.
THE WITNESS: Okay. C98. Okay. I'm at C98.
BY MR. DEAN:

Q. Do you remember Mr. Anwar asking you quite a few questions about the sampling for benzene at Hadnot -- or HP602?
A. Yes, I do.
Q. Okay. And y'all went over -- spent quite a while on reviewing those different sampling results. Do you remember that?
A. Yes.
Q. Now, can I have exhibit number --
MR. DEAN: Do we just want to continue the same number sequence?
MR. ANWAR: Whatever you want, yes.
(DFT. EXHIBIT 22, Appendix A5 Bates-stamped CLJA_Watermodeling_010000942748 through 0000942750, was marked for identification.)
BY MR. DEAN:
Q. I'm just going to use this just to shortcut it. I believe it's the end of -- this is Appendix I-5, Exhibit 22.
A. Okay. That's from the Chapter A report for Hadnot Point/Holcomb Boulevard.
Q. Correct. Now, you -- you were also asked some questions about the same time -- y'all were having a discussion about when the well was on and when was well was off. Do you remember that?

A. Yes.
Q. Okay. Can you explain to me as it concerns those sampling that was done post-turning off of the well, what the significance would be for those test results as it concerns the existence of the continuing contamination?
MR. DEAN: Object to the form.
THE WITNESS: Well, what these plots show, show early time, '51, the contamination in '68, the wells are pumping. November '84, the wells are pumping and shut off. And then it shows the plume -- this is the benzene plume, I believe, yes, benzene. It still shows it migrating under the hydraulic gradient, which is heading east to northwest, okay?
Q. Okay. And what is the significance of that with regard to the validity of any of the either calibration or contaminant testing concentrations after the well was shut off?
MR. DEAN: Object to the form.
THE WITNESS: What that indicates to me, and I think we had this discussion, is even though the tables that we have based on information provided by the Marine Corps for the Navy shows a well shut off, if you're still observing benzene

concentrations in the water treatment plant, there had to be some wells pumping, okay? Maybe not continuously, but the plume is still moving past the well. I'm looking at well -- well 602 there, and even in 2008 there's still a plume over there. So if that well was ever turned on again, even though it says out of service, you would -- it would -- you would get benzene.

Q. Sorry.

A. This is similar to what we observed at Tarawa Terrace with TT26, and even though they shut down TT26, the plume kept moving.

Q. Okay. And were samples taken for concentrations in the area of the wells after those wells were shut down?

A. Were they?

Q. Yes.

A. I would have to look and see on the Chapter C report.

Q. Now, the Prabhakar Clement article that was previously -- I believe it was marked as an exhibit, the 2000 paper.

A. Yes, that one.

Q. Okay. Exhibit 1.

A. Okay.

Q. When did you locate that paper?
A. I would say within the last six months.
Q. When you were giving your 2010 deposition and responding to a question from the plaintiff's lawyer in that case -- well, strike that.
Before I go there, who was defending you during that 2010 deposition?
A. Mr. Adam Bain from the Department of Justice.
Q. Okay. And did you meet with him and prepare for that deposition in -- in -- either by phone or in person?
A. I met with him in the afternoon along with attorneys for CDC's Office of General Counsel on the 29th, the day before, for a few hours in the afternoon.
Q. Okay.
A. And since I had never been deposed before, he went over the ground rules and --
Q. And during that meeting or any other conversations y'all had, did Mr. Bain ever question the validity of your work at -- for which you were about to testify to?
A. No, he did not.

Q. Now, you -- he asked -- excuse me, not he. The plaintiff's lawyer in that case asked a question to which you responded something -- I'm using the word mob, do you remember that?

A. Yes.

Q. Referring to the work or some of the work that was done here. Were you aware at -- in 2010, or had you seen Dr. Clement's paper at that time?

A. I had not seen this particular journal article.

Q. All right. I'm going to show you Exhibit 23.

(DFT. EXHIBIT 23, Author's reply by T. Prabhakar Clement from Ground Water, January-February 2012 Bates-stamped CLJA_Watermodeling_010000092109 through 0000092111, was marked for identification.)

MR. ANWAR: And I'm just going to note for the record that conversations that took place when you were an employee of ATSDR and the Department of Justice are privileged.

THE WITNESS: Okay.

MR. DEAN: And I'm not sure I agree, but I don't think it matters, just for the record.

You know what, I don't think I have an extra copy of this. I'll show it to you. I don't have an extra copy of it.

MR. ANWAR: I have a copy.

MR. DEAN: It's the response to...

BY MR. DEAN:

Q. So I'm going to show you Exhibit No. 23. And can you tell me what that document is?

A. This looks like Dr. Clement's response to our editorial review or editorial comment on his 2010 paper about hindcasting.

Q. And can you read the first -- let me see. I think it's just the first full sentence.

A. I believe I've got a copy if you want me to just use my copy and then...

Q. Yes, it's -- it's actually the first full sentence. It's a rather long sentence, but...

A. Yeah, I got --

Q. You can just use this one.

A. Oh, okay. Okay. Okay.

Q. Can you read into the record --

A. The first full sentence?

Q. Yes, sir. Now, let's give it a little context. What is Dr. Clement responding to?

A. Dr. Clement published an article in

Groundwater, in the same journal, I believe it was in 2010, about basically hindcasting, historical reconstruction to us, when is enough enough, and used the Camp Lejeune project as a case study or an example.

Q. Okay. And who is Dr. Clement as it concerns his relationship with any of the Camp Lejeune work? What -- what role, if any, did he play at any point in time with regard to Camp Lejeune work?

A. Dr. Clement was the hydrogeologist and modeler expert on the National Research Council that assessed ATSDR's Camp Lejeune work.

Q. So when people refer to the 2009 NRC report, he was the water modeler that was -- served as one of those panel members?

A. He was the only water modeler.

Q. Okay. So later on he must have written an article in 2010 about additional information about Camp Lejeune?

A. Yes.

Q. Okay. And can you read into the record what he said in his response to ATSDR's response?

A. Okay. In the response to our editorial.

Q. Yes.
A. Okay. "The goal of my article was not to review the Camp Lejeune, in parentheses, CLJ, modeling studies." Do you want me to continue?
Q. You can -- you can read the next line.
A. Okay. "Rather it was to use the CLJ problem as an example to highlight issues related to model complexities and to speak -- and to spark an open debate on when, where, and why we should limit model complexity."
Q. Okay. Now, you spent a lot of time, both you and Mr. Anwar, using a word, "uncertainty?"
A. Yes.
Q. Okay. And of course, lawyers and the general public may use the word "uncertainty" differently than water modelers; is that correct?
A. Yes.
Q. So what -- when you were referring -- using the word with -- uncertainty in responding to questions that used the word "uncertainty", can you explain to the Court and jury what is an uncertainty -- what is uncertainty definition or an uncertainty analysis as you're using it in this deposition?

A. I'm using it in this deposition and the modeling analyses.

Q. Is uncertainty unusual in water modeling work?

A. Not at all.

Q. And explain that to the Court, sir.

A. Again, that -- that was -- I'll say that was one of our primary concerns and disagreement with the NRC report because it -- it described the uncertainty about data about modeling. We never disagreed that there was uncertainty. An example being you have a sample measurement and, you know, you can have a lower value or a higher value. And so the uncertainty would be that range in there in terms of numerical analysis, like Monte Carlo gives you upper band, a mean, and a lower band. And so that band is the uncertainty or the confidence, okay? So when we're talking about uncertainty, we're also talking about the confidence that we have in the results.

Q. Okay. And you expect to see the word "uncertainty" in any -- everyday garden variety of water modeling project?

MR. DEAN: Object to form.

THE WITNESS: They should. If you look

at some of the earlier modeling procedures or protocols of models -- when I say earlier, prior to 1980, prior to 19 -- you might see sensitivity analysis and that's part of uncertainty analysis, but good modeling practice would include both sensitivity analysis and an uncertainty analysis.

BY MR. DEAN:

Q. All right. Let's go to one other area real quick. I don't know the exhibit number. It's the e-mail related to the disclaimer.

A. Oh, okay. Here, 11.

Q. Okay.

MS. SILVERSTEIN: The e-mail is Exhibit 13.

THE WITNESS: Here you go. 13.

BY MR. DEAN:

Q. 13, yes.

A. The exhibit is 12.

Q. Yeah, the disclaimer. So with regard to Exhibits 12 and 13 having to do with this issue that arose, it appears, in May of 2007, do you remember having a conversation of questions back and forth with Mr. Anwar?

A. Yes, I do.

Q. Okay. And -- but I didn't hear him

ask, nor did I -- or maybe I missed it, but did you -- did someone reach out to you and complain or did some -- something come to you from another department or agency upset about what was being posted on the website that generated the need for a disclaimer on the website?

MR. DEAN: Object to form.

THE WITNESS: I recall that it was conveyed to me in the source sent to me, the Department of Navy, where or who -- I'm not sure, it could have been a representative at Camp Lejeune that -- my point of contact, but the message was that the Navy was upset about anyone being able to access values on the ATSDR website.

Q. And calculate for their own benefit specific numbers?

A. Yes, yes, yes.

Q. Okay. So up until the time, based on your information from a source that it's the Navy that made this complaint, there was not any consideration for the need for a waiver; is that fair?

MR. DEAN: Object to form.

THE WITNESS: We -- we did not have that in our protocol so to speak --

BY MR. DEAN:

Q. Sure.

A. -- that we needed to put up a disclaimer.

Q. It still today doesn't show up in the written published reports, bound, produced reports, other than on the website?

A. No, no, it does not appear in the reports.

Q. And when you were communicating with the lawyer about a form of a disclaimer, Ms. Deborah Tress in May 2007, do you know whether or not she was communicating with Adam Bain and the Department of Justice at the same time with regard to this disclaimer?

MR. DEAN: Object to form.

THE WITNESS: I do not know. We were just told --

BY MR. DEAN:

Q. And for the record, Ms. Deborah, Debbie, Tress, she's a lawyer, in-house lawyer, employed by the federal government working for the ATSDR CDC in-house counsel?

A. At the time of that e-mail, she was the CDC in the CC Office of the General Counsel and we were told she would be the one handling any Camp Lejeune-type issues.

Q. Okay.

A. From a legal standpoint.

Q. So late this afternoon, probably in the last hour or so, you answered some questions with regard to timing of contaminants to Tarawa Terrace TT26. Do you remember that?

A. Yes.

Q. And I believe it is Alex Spiliotopoulos's report where he has some suggestions and a graph where he has the contaminants going -- instead of going through the water column, dropping into the ground -- are you familiar with what I'm referring to?

A. Yes, I am.

Q. Okay. How is the most reasonable way in which you expect contaminants that get into the water column -- are they going to continue in the water table or are they going to drop in the ground, is my first question?

A. Well, they're going to go along a pathway, a horizontal pathway. And as I put in my rebuttal report and Dr. Konikow explained, they'll -- they'll go horizontally almost until they reach the well, and that's because you've got a cone of depression around the well as the well is pumping, and then go very rapidly vertically into the -- into the well.

Q. And scientifically, why does -- why -- why is that? Why does that occur, in your opinion?

A. Because the groundwater is -- velocity is flowing with the gradient. So the gradient is decreasing or the water level is decreasing as you approach the well.

Q. Okay. And is the contaminants -- is the -- traveling in the water table versus reaching the well itself, is one faster than the other?

A. Yes, the -- the last, let's call it, the few -- few feet or where the cone of depression of the well is going to much more rapidly pull in any contaminants, and the time is going to be much more shortened because of the high velocities at the well and within the cone of depression.

Q. I'm sorry. My dog is -- they can't find my -- my wife can't find my dog, so I told her where he was at.

Okay. Let's give this back.

A. Okay.

Q. Between the time -- when did you --

remind me when you retired?
A. December 31st, 2017.
Q. Okay. When you retired on January the -- January of 2018 until the unfortunate time when I gave you a call in '22, did you do any work on Camp Lejeune during that time frame?
A. No, I did not.
Q. Okay.
A. Nor did I speak to anyone.
Q. Okay. Let me ask a -- the timing question, let me ask one last different way. For purposes of the timing of contaminants to reach the aquifer, is that different from the time for it to reach the water table?
A. Well, conceptually, the aquifer in Tarawa Terrace that we modeled starts at the water table, okay? And we didn't look at -- we didn't on MODFLOW, MT3DMS, did not look above the water table. It was maybe about 10 feet, 15 feet of saturated zone. And so we looked at everything -- all our models assume it's at the water table, and that the timed travel through the unsaturated zone, so typically down vertically, would be minimal.
MR. DEAN: All right. I believe that's all the questions I have. Thank you.

MR. ANWAR: I just have a couple of follow-up questions in my --
THE WITNESS: Sure.
MR. ANWAR: -- few remaining minutes.

EXAMINATION

BY MR. ANWAR:
Q. Mr. Dean showed you, I think, what was marked as Exhibit 22.
A. Yes.
Q. If you would like to take a look. My only question about this is Exhibit 22 is the depiction of plumes at Hadnot Point -- the contaminant plume at Hadnot Point, correct?
A. Yes, yes, yes. It's the -- you're talking about benzene?
Q. For the benzene plume, correct?
A. Yes, yes. Let's see, what -- what page you're on?
Q. It's A146.
A. A146. Okay. Okay. I'm there.
Q. My only question about it is that what we're seeing here is a visual depiction of the reconstructed plume based on the model, right?
A. That is correct.
Q. Okay. I'm going to mark one exhibit.

(DFT. EXHIBIT 24, e-mail correspondence Bates-stamped CLJA_ATSDR_BOVE-0000108607 and 0000108608, was marked for identification.)

BY MR. ANWAR:

Q. I'll hand it to you, Exhibit 23. 24. I'm sorry. Let me fix that. I can't count. I will represent to you this is an e-mail exchange that starts between you and Dr. Clement and then that you forward on to the ATSDR team in February of 2008. Would you agree with that?

A. Yes.

Q. Okay. And in the -- the e-mail exchange -- the e-mail from Clement, Dr. Clement, to you at the bottom of the chain, he's offering some -- some -- his sort of feedback and some compliments about the work that you-all did with respect to the Tarawa Terrace analysis, correct?

A. It does not specifically say Tarawa Terrace. However, given the date of that, it would have been Tarawa Terrace because we would not have probably even started on Hadnot Point.

Q. Sure. And the subject says sensitivity analysis on well --

A. Oh, okay. Okay.

Q. -- TT26, right?

A. Okay. Yes.
Q. Okay. And he says, "yesterday I read most of your report and I found them to be very thoughtfully organized. It is a complex problem, but you guys did the best possible job a modeler can. They are lucky to have you guys as a modeling team. Thanks for your support." Did I read that right?
A. Yes.
Q. Okay. And then you forward it to your team and you say, "look at the second paragraph from Dr. Clement, a member of the National Research Council committee on contamination of drinking water at Camp Lejeune. It's nice to get words of praise from unbiased and technically competent colleagues about our abilities and work." Did I read that correctly?
A. Yes.
Q. Okay. And I understand that subsequently the NRC report was published, correct, in 2009?
A. That's correct, that's correct.
Q. And after the NRC report, Dr. Clement published his -- his article on hindcasting, and then you-all -- you and Dr. Aral and the ATSDR team

had a response, and then he published sort of a response to your response, correct?
A. Right, that's correct.
Q. Okay.
A. That's typically what's done in the journal article type.
Q. Sure. Do you -- in your view, as you sit here today, is Dr. Clement still an unbiased and technically competent colleague?
MR. DEAN: Object to the form.
THE WITNESS: Yes, I never -- I never said he was biased. We always said it was the NRC report, the final -- the final report. Again, I think we discussed this in my previous deposition, that that is what really caught the entire team by surprise because we were providing information and data to Dr. Clement. I think we also provided it to Dr. Knuckles and some other people.
Q. Sure.
A. And the feedback was this is, you know, great -- great stuff, great job and all of that. And the report -- and especially the -- I guess, what is it, the public summary or whatever, really just took a 180-degree opposite turn.
Q. Okay.

A. Okay.

MR. ANWAR: Those are all the questions I have. Thank you.

EXAMINATION

BY MR. DEAN:

Q. Mr. Maslia, he's -- I'm just focusing on Exhibit 24, and Mr. Anwar is pointing out the -- your use of the word "unbiased" --

A. Right.

Q. -- with respect to the reference to Dr. Clement on February 21st, 2008. Do you see that?

A. Yes, I do.

Q. At the time that e-mail was sent and words that you're issuing, the NRC report had not been issued yet, right?

A. Yes, you're correct.

Q. And it had not been issued until July -- I think it's July 2009.

A. June 2009.

Q. June 2009. Have you now read Susan Martel's deposition and all of the exhibits that are attached to it?

A. Yes.

Q. And do you have an opinion as to

whether or not the NRC was, in fact, biased or unbiased in the issuance of that final report?

A. The NRC report, I believe, contained numerous -- numerous -- it contained -- it contained mistakes, mischaracterizations, and it appeared to us to be -- and I'm talking about the project team, including the epidemiologists and whatever toxicologist, that it was a biased report.

MR. DEAN: Thank you. I have no further questions.

MR. ANWAR: Nothing from me. Thank you.

THE WITNESS: Thank you.

THE VIDEOGRAPHER: Okay. Then we're going off record the time is 6:49 p.m. This concludes today's deposition.

(The witness, after having been advised of his right to read and sign this transcript, does not waive that right.)

CERTIFICATE OF REPORTER

I, Lauren A. Balogh, Registered Professional Reporter and Notary Public for the State of South Carolina at Large, do hereby certify that the foregoing transcript is a true, accurate, and complete record.

I further certify that I am neither related to nor counsel for any party to the cause pending or interested in the events thereof.

Witness my hand, I have hereunto affixed my official seal this 18th day of March, 2025 at Myrtle Beach, Horry County, South Carolina.

____
Lauren A. Balogh
My Commission expires
March 19, 2030

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IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION
Civil Action No. 7:23-cv-00897

IN RE: CAMP LEJEUNE WATER LITIGATION

THIS DOCUMENT RELATES TO:
ALL CASES

VIDEOTAPED
DEPOSITION OF: MORRIS MASLIA
DATE: March 13, 2025
TIME: 9:14 a.m.
LOCATION: BELL LEGAL GROUP
219 North Ridge Street
Georgetown, SC

TAKEN BY: Counsel for the Defendants
REPORTED BY: Lauren A. Balogh, RPR
____

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Leonard Konikow (via videoconference)
Deanna Havai, Motley Rice
(Via videoconference)

Alex Spiliotopoulos
(Via videoconference)
Timothy Thompson
(Via videoconference)

Bill Williams (via videoconference)

(INDEX AT REAR OF TRANSCRIPT)

THE VIDEOGRAPHER: The following will be the videotaped deposition of Morris Maslia in re Camp Lejeune Water Litigation versus United States of America, File No. 7-23-CV-897. Today's date is March 13th, 2025 and the time is 9:14 a.m. We are here today at 219 Ridge Street, Georgetown, South Carolina. The court reporter is Lauren Balogh and the videographer is Jon Landau.

At this time I will ask all attorneys present to please state their names and whom they represent for the record.

MR. DEAN: Good morning. Kevin Dean here on behalf of the PLG and the witness.

MR. BELL: Edward Bell on behalf of the plaintiff.

MR. ANWAR: Haroon Anwar on behalf of the United States.

MS. SILVERSTEIN: Kaylie Silverstein on behalf of the United States.

THE VIDEOGRAPHER: Do you want the people on the Zoom to do it?

MR. DEAN: It's up to you.

MR. ANWAR: The court reporter can take it down. That's fine.

MR. DEAN: Yeah.

THE VIDEOGRAPHER: Okay. All right. You may swear the witness, please.

MORRIS MASLIA

being first duly sworn, testified as follows:

EXAMINATION

BY MR. ANWAR:

Q. Good morning, Mr. Maslia.
A. Good morning.
Q. My name is Haroon Anwar. I am a lawyer at the Department of Justice here on behalf of the United States. We've met before at your prior deposition in fall 2024, correct?
A. September 26th.
Q. September 26th of 2024. Thank you.
A. Yes.
Q. You may remember that experience. I'm just going to go through -- go over a few rules for the deposition just so we're on the same page, but I'm going to ask you a number of questions today. If I ask you a question that's vague or you don't understand, please ask me to clarify. Otherwise, I'm going to assume that you -- you understand my question. Fair enough?
A. Fair enough.
Q. Okay. And the number one most

important rule for the deposition today, same as before, is that you are under the oath to tell the truth as if you were in an actual court of law. Do you understand that?

A. Yes, I do.

Q. Okay. And is there any reason that you'll be -- is there any reason today that you'd be unable to testify truthfully?

A. No, there is not.

Q. The court reporter is transcribing everything that we're taking down, so if we could try not to speak over each other and perhaps give a brief pause in case your lawyer needs to object, it will make for a much cleaner transcript as well as a much happier court reporter. Can we agree to try to do that?

A. Yes.

Q. Okay. We will try to take breaks about every hour. If you need to take a break sooner than that, just let me know.

A. Okay.

Q. I'm happy to accommodate you. The only stipulation I would put on that is if there's a pending question, I would ask that you answer that question and then we -- we can take a break. This is not intended to be sort of a punishment, so to speak.

A. Understood.

Q. So with that I wanted to start by asking you what you did to prepare for today's deposition?

A. I reviewed every single ATSDR Camp Lejeune historical reproduction report that I was involved with both for Tarawa Terrace, Hadnot Point. I've also reviewed my expert report that was submitted to you as well as my rebuttal report, and I also reviewed some published journal articles.

Q. What were the published journal articles that you reviewed?

A. There was a series by -- that appeared in Groundwater journal by Dr. Prabhakar Clement, who I think you may know, and ATSDR exposure dose reconstruction program staff responded to it, and then they responded to -- to ours, so it's three articles in Groundwater. His was 2010 and ours was 2012.

Q. Okay.

A. And then I've also reviewed just some articles on uncertainly analysis. An article that

I published in 2004 on use of -- contained some historical reconstruction of some smaller sites using an analytical contaminant transport system model and also contained the probabilistic uncertainty analyses using Monte Carlo simulation. So reviewed that as well as an article by Dr. Clement in 2000 at Dover Air Force Base, which is identical to Tarawa Terrace and came out with identical values for some of the parameters, and I would, in fact, like to add that to my expert report if I can.

Q. Okay.

A. I've got a copy here, if you would like to see that.

Q. Sure.

MR. DEAN: Yeah, I brought a copy.

MR. ANWAR: Thank you.

MR. DEAN: You're welcome.

BY MR. ANWAR:

Q. Thank you. So this -- we'll note this for the record as an additional material --

A. Okay.

Q. -- on your -- your reliance list.

A. Yes, yes.

Q. For your expert report. Thank you.

Aside from the articles that you -- you mentioned, the ATSDR reports and -- the ATSDR modeling reports for Tarawa Terrace and Hadnot Point, Holcomb Boulevard, and then your expert and rebuttal report, did you review any other documents?
A. Just my deposition from September 26th.
Q. Okay.
A. And the exhibits that you provided.
Q. Oh, okay. During the September 26th --
A. Yes.
Q. -- 2024 deposition?
A. Yes.
Q. Did you review any of the other expert reports in the case?
A. I reviewed Dr. Konikow's report. I reviewed Dr. Sabatini's report. I reviewed Dr. Jones and Mr. Davis's post-audit report and rebuttal. And I also reviewed the defense's expert reports by Dr. Spiliotopoulos, Dr. Hennet, and Dr. Brigham.
Q. Understood. And I understand just from attending the depositions of Dr. Aral, Mustafa Aral, Dr. Davis, Dr. Jones, and then Dr. Konikow about a week or so ago -- did you listen in to all of those depositions as well?

A. Yes.
Q. Okay.
A. With Dr. Konikow I had to step out for a couple of hours.
Q. Okay.
A. To do a medical run with my dad, so -- but I listened, I would say, to a majority of it.
Q. Did you review any of the transcripts from those depositions?
A. I -- I read them. I guess Dr. Konikow's transcript, because I wasn't there for part of it, I read that in its entirety. Okay. The other ones, just spot, you know, spot read because I was watching the entire time.
Q. Understood. Did you do anything else to prepare for today's deposition?
A. Only discuss with the plaintiff's attorney the logistics, again, of, I believe, the first time I was deposed as a fact witness versus an expert witness to them.
Q. Understood. And I'm not asking about the substance of your conversations with --
A. Right.
Q. -- the lawyers, just the circumstances of the meeting. When did you meet with the lawyers

to prepare for the deposition today?
A. Yesterday, most of the day, and on Tuesday afternoon.
Q. Okay. Who did you meet with yesterday?
A. Yesterday I met with Mr. Dean and also Mr. Williams.
Q. Was there anyone else present in that meeting?
A. Mr. Tim Thompson. He works with Mr. Williams, and that's it.
Q. Okay. About how long did that meeting last, the one yesterday?
A. Yesterday, we started about 9:30 and ended about 4:30, 5.
Q. Did you review any documents during yesterday's meeting?
A. Yes, the same ones that I had mentioned to you, and spoke about wanting to place the journal article as an addition to my materials in my expert report.
Q. Understood.
MR. DEAN: Not to interrupt, but you might want to ask him was anybody else in attendance by Zoom. Because you asked in person and he may have forgotten that.

MR. ANWAR: Sure.
BY MR. ANWAR:
Q. Were -- was anyone else in attendance?
A. Yes, another attorney, Laura Baughman.
Q. Okay.
A. With -- was in and out on Zoom.
Q. To the best of your knowledge, during yesterday's meeting, it was only yourself and attorneys for the plaintiffs attending, correct?
A. That's correct.
Q. And then on Tuesday's meeting, who was present for that?
A. I believe that was Mr. Dean and Mr. Williams and Mr. Thompson.
Q. And --
A. I don't recall if anyone was on Zoom or not. I don't believe because I did not get here until three o'clock p.m.
Q. To the best of your knowledge, the only folks in attendance on Tuesday's meeting were yourself and lawyers for the plaintiffs?
A. That is correct.
Q. Prior to yesterday's meeting and Tuesday's meeting, were there any other meetings with the lawyers to prepare for today's deposition?

A. No, no meetings.
Q. Dr. Konikow mentioned during his deposition a meeting that took place. I think he said it was in preparation for his deposition, but you were present as well; is that right?
A. That's -- yes, yes, yes, now that I recall, that was when -- I believe, if I'm not mistaken, that was in February.
Q. Okay.
A. And I think I was supposed to be -- be deposed that Thursday. That got postponed.
Q. Sure.
A. But Dr. Konikow and I were in that meeting, yes.
Q. Aside from yourself and Dr. Konikow, who else attended that meeting?
A. Mr. Dean, Mr. Williams, and I believe Mr. Thompson.
Q. Any -- anyone other than yourself, Dr. Konikow, and the plaintiffs' lawyers attend that meeting?
A. Not that I recall.
Q. Have you -- did you attend any other meetings in preparation for today's deposition?
A. No, I did not.

Q. Did you speak with anyone else in preparation for today's deposition?
A. No, I did not.
Q. Did you speak with anyone from ATSDR in preparation for today's deposition?
A. No.
Q. Now, you -- we have the -- the most recent 2020 article from Clement that you're adding to your -- your reliance list --
A. Yes.
Q. -- and have provided a copy here today. You mentioned a couple of other articles that you reviewed.
A. Right.
Q. And I was just wondering, the Clement article and the other articles that you reviewed, why did you review those articles?
A. Well, the article that I coauthored on the analytical contaminant transport analysis system, the ACT system, I think it was published in 2004, we reviewed that because it had a number of historical reconstruction cases. One was for 20 years, a dry cleaner in New Mexico, and one was -- I want to say it's Otis Air Force Base, EDB contamination, and we did 65 years, and we used an

analytical contaminant fate and transport model and conducted two-stage Monte Carlo simulation. So I just wanted to refresh my memory as to what we did and some of the parameters that -- contaminant fate and transport parameters that we used in that.

In the Clement article I reviewed -- and I reviewed that one in specific detail because Dover Air Force Base is very similar to Tarawa Terrace. About the same size, 2.4 square miles. They used a -- was testing out the RT3D model, which is the reactive transport. So they went from PCE to TCE to DCE to vinyl chloride in their analysis, and a number of their parameters are right where the parameter values that we calibrated for Tarawa Terrace, so I thought it was a good comparison article.

Q. The Clement article, I'll look at it during the break.

A. Okay.

Q. But just based on your memory, what -- what did they use that model for?

A. I think the -- the purpose was to -- was it to -- well, there was historical contamination at the Air Force base and they wanted to look at how it advanced in time, and they wanted to test out the RT3D code that Dr. Clement had developed originally when he was at Lawrence Livermore National Labs, and it was hooked in to MT3DMS, and so they were testing that out, and that's what basically I recall. And then when I started reading the details of it, it appeared to me that it was a very, very good comparison article to what we did at Tarawa Terrace.

Q. Just quickly -- and I'll mark this as an exhibit, actually.

A. Okay.

(DFT. EXHIBIT 1, article from Journal of Contaminant Hydrology entitled "Natural Attenuation of Chlorinated Ethene Compounds: Model Development and Field-scale Application at the Dover Site", was marked for identification.)

BY MR. ANWAR:

Q. Let's go ahead and mark this as Exhibit 1, but I'll -- I'll mark it and then I'll hand it to you after I have a chance to read it. The 2020 Clement article on the Dover Air Force Base site, in the abstract it states, "the numerical model developed in this study is a useful engineering tool for integrating field-scale natural attenuation data within a rational modeling framework. The model results can be used for quantifying the relative importance of various simultaneously occurring natural attenuation processes."

Does that sound consistent with your recollection?

A. Yes.

MR. DEAN: Object to the form of the question. I think you misspoke about the data, the article. I think you said 2020. If you said 2000, I apologize, but I thought I heard 2020.

BY MR. ANWAR:

Q. Okay. And I understood you, Doctor, or Dr. Maslia, Mr. Maslia, to state that this article was published in 2020, but I perhaps misunderstood.

A. Okay. Okay. It is a 2000 article.

Q. 2000 article. Okay. So I'll reask my question. This 2000 article -- and it looks like on the first page of the article it actually says it was accepted in October -- into the -- this journal in October of 1999, but let's -- let's call it the 2000 Clement article.

The abstract states, "the numerical model developed in this study is a useful engineering tool for integrating field-scale natural attenuation data within a rational modeling framework. The model results can be used for quantifying the relative importance of various simultaneously occurring natural attenuation processes."

Is that consistent with your recollection of the article?

A. Yes.

Q. To the best of your knowledge, was the model discussed in this 2000 Clement article estimating contaminant concentrations for determining exposure in specific individuals?

A. The article did not go into what the end use was, okay? I took it to mean that this was the first stage or initial stage in developing a model. It did not discuss exposure. In other words, it was not an exposure assessment article.

Q. And to the best of your knowledge, was this -- the model discussed in the 2000 Clement article used for estimating contaminant concentrations for the purpose of -- purpose of determining exposure in individuals?

A. It was used for determining contaminant concentrations.

Q. But as you sit here today, you're not aware of it being used for the purpose of determining exposure in individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: I don't know what the end use was.

BY MR. ANWAR:

Q. With respect to any -- the other articles that you mentioned, were any of those models -- strike that.

With respect to the other articles that you mentioned, were any of the models discussed in those articles used for estimating contaminant concentrations that were used to determine exposure in individuals?

A. The -- or the sites that we summarized or did an analysis for in our 2004 paper, the analytical containment transport analysis system, one of them was at a dry cleaner in New Mexico and the other one was Otis Air Force Base, which was multimedia, meaning groundwater surface water and -- and volatilization, and I know USGS has done some work at Otis Air Force Base. It's been an ongoing thing and I believe there are some components from just the general topic of Otis Air

Force Base that look at exposure. It goes -- there are people living downstream from the river that goes through the Air Force base. I don't know the details of the subsequent analysis of -- on -- on that. I believe ATSDR did use the New Mexico site, I think it's North Avenue Railroad site, if I recall correctly, and I think they did a health assessment there, okay, but I don't know the specifics.

Q. Those other articles, are those included on your -- either in your report or on the reliance list?

A. Yes, the -- the 2004 is already on my reliance list, 2004 by Maslia and Aral.

Q. And that's the one -- 2004 is focused on Otis Air Force Base?

A. And -- and the New Mexico site.

Q. Okay. So it's just one article from 2004?

A. Yes.

Q. Besides that article and this 2000 Clement article, it sounded like you reviewed a couple of other articles, perhaps related to uncertainty analysis.

A. Right.

Q. Did any of those involve using groundwater modeling to estimate contaminant concentrations for the purposes of determining exposure in individuals?
MR. DEAN: Object to the form.
THE WITNESS: Again, most of the articles that I reviewed did not state the end purpose of the -- they said the purpose of the modeling to reconstruct or predict groundwater contaminant concentrations using techniques, different techniques, and also one of the articles went into -- I think it was one of the earlier applications of uncertainty analysis using Monte Carlo simulation.
BY MR. ANWAR:
Q. So as you sit here today, you're not aware of those other articles using models to estimate contaminant concentrations for the purpose of determining exposure in individuals, correct?
MR. DEAN: Object to the form.
THE WITNESS: Again, not having been directly involved with the analysis, it's -- I really can't answer what the results were used for.
BY MR. ANWAR:
Q. Okay.

A. The articles describe the process of developing and/or calibrating models.

MR. DEAN: Object to the form. And also add that if you're going to ask him about what certain conclusions are in certain reports, that the witness is entitled to see those reports, have an opportunity to review them in detail, and then properly respond.

MR. ANWAR: I'm going to mark the 2000 Clement article as Exhibit 1.

BY MR. ANWAR:

Q. Now, earlier we talked about the other experts in the case and you having listened to their depositions and read the deposition transcripts, correct?

A. Right, yes, to -- some more detail than others.

Q. Sure. One of those experts is doctor -- professor -- or Dr. Mustafa Aral, correct?

A. Yes.

Q. Who is -- remind me, who is Mustafa Aral?

A. Well, he was a professor at the Georgia Institute of Technology. He was also director of the multimedia environmental simulations laboratory within the School of Civil and Environmental Engineering. And he had or he was the principal investigator on a cooperative agreement between ATSDR and Georgia Tech.

Q. And the cooperative agreement between ATSDR and Georgia Tech, was that in relation to the Camp Lejeune water modeling?

A. Not specifically. That was a multiyear-type agreement and it was for any site. For example, the couple of sites that I mentioned in the journal article, ACTS article, we did cooperatively.

Q. Understood. So -- but it did include the Camp Lejeune water modeling, correct?

A. Yes, it did.

Q. And if I understand your testimony before correctly, Dr. Aral was a professor that you had at Georgia Tech, correct?

A. Yes, yes, he was my -- my master's thesis dissertation chair of that -- that committee.

Q. Okay. And you know him personally, correct?

A. I know him professionally. I don't socialize with -- with -- with him, but I've known

him throughout the years professionally.
Q. Understood. What is your opinion of Dr. Aral?
A. He's very qualified. I view him as a mentor.
Q. Okay.
A. And can take his problems and analyze them from a practical standpoint and also address them through computational methods.
Q. Now, you also listened to the depositions of Jeffrey Davis and Norman Jones, correct?
A. Correct.
Q. Who is Jeffrey Davis?
A. I only -- I've never met him in person. I met him, I assume, through Zoom and he's -- to my understanding, he's a consulting engineer and modeler.
Q. You mentioned you have spoken with Mr. Davis on Zoom; is that right?
A. In a meeting, yes, in meetings.
Q. Was that during the course of preparing expert reports in the case?
A. I believe he and Dr. Jones had some questions about the Tarawa Terrace model input

files, and so I think that's where we had discussions over Zoom.

Q. And it was in the context of the -- the litigation, correct?

A. Yes.

Q. Had you met either Jeffrey Davis or Norman Jones prior to being retained by plaintiffs as an expert?

A. I have met Dr. Jones previously.

Q. Okay. You had not met Mr. Davis prior to working -- or that call with him in the context of the litigation, correct?

A. That is correct.

Q. Had you worked with Mr. Davis prior to that Zoom meeting with him?

A. No, I have not.

Q. And it sounds like you don't know him personally or socially, correct?

A. That is correct.

Q. Now, you mentioned having met Dr. Jones in the past?

A. Right.

Q. When have you met Dr. Jones in the past?

A. I served with Dr. Jones on a review of a National Science Foundation grant for the University of Alabama. And so he was the chair of the panel. And I think every year, every other year, they have to have a review status report like that, so that's -- that's where I met him in person.

Q. Around what time frame would that meeting have taken place?

A. 2021, 2022, someplace around there.

Q. Have you met him on any other occasions?

A. Not in person, but I do know of him.

Q. How do you know of him?

A. Early on or as part of the Tarawa Terrace analyses we found out that the -- I believe it was the U.S. Army Corps of Engineers or U.S. Army Corps of -- Hydrologic Center were developing a software platform called GMS. And while they were beta testing it, since we were a federal -- sister federal agency, they wanted people to test it out. So they provided us with a license, and I believe Dr. Jones was one of the original developers of the GMS software and platform.

Q. Do you remember around what time frame that would have been developed?

A. I don't know the start of GMS, but there's probably some letters in my files or e-mails. I'm going to say 2005, '6, somewhere -- maybe 2004, right when we were modeling or -- modeling Tarawa Terrace.

Q. Did Dr. Jones directly work on the model -- ATSDR's Camp Lejeune model for Tarawa Terrace?

A. No.

Q. Okay. You just had the conversation with him in the context of the GMS software?

A. No, I've never had --

Q. Oh, you didn't. Okay.

A. It was just his -- his name as the developer --

Q. Understood. Understood.

A. -- when we were provided the executable code by -- I think it was U.S. Army Corps of Engineers Hydrologic Engineering Center, and so I just saw it -- saw it through there, okay?

Q. Outside of the work with the University of Alabama and then the Zoom meeting that you described for the purpose of this litigation, have you worked with Dr. Jones in any other context?

A. No.

Q. Do you have any opinion about either Mr. Davis or Dr. Jones?
A. Both very well qualified. Very good analysts and they know their way around the GMS modeling platform. And I believe Dr. Jones is the chair of the Brigham Young University School of Civil and Environmental Engineering.
Q. What about David Sabatini, who is Dr. Sabatini?
A. I understand he's a professor -- and I forget the university, whether it's Texas or Oklahoma. Reading his report, he is -- appeared to me to be an expert in volatilization issues, and I, again, only met him over Zoom.
Q. And that was in the context of this litigation, correct?
A. Yes.
Q. Had you met him prior to the Zoom meeting in this litigation?
A. No, I have not.
Q. Do you have any opinion about Dr. -- or David Sabatini?
A. The same as the others, very competent and understands volatilization issues. Was able to assess them both from a scientific engineering

standpoint as well as present them to a layperson who is not as technically knowledgeable.

Q. Thank you.
A. Can I get a drink of water here?
Q. Sure.

(DFT. EXHIBIT 2, deposition of Morris L. Maslia dated June 30, 2010 Bates-stamped CLJA_Healtheffects-00000494487 through 0000049712, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 2. Here you go. And I asked you these questions last time around --
A. Okay.
Q. -- in September, but I just want to confirm.
A. Okay. Can I take the rubber band off?
Q. Sure. Actually, that's all -- I actually gave you all the copies.
A. Oh.
Q. Feel free to give one to Kevin.
A. Okay. Who else?
Q. And I can take that one. Exhibit 2 is a transcript from a deposition you gave in 2010 in Laura Jones versus the United States, correct?

A. That is correct.
Q. Okay. And at that time you were employed still with the ATSDR, correct?
A. That is correct.
Q. And you were, I think, in the midst of working on the Hadnot Point/Holcomb Boulevard model, correct?
A. That is correct.
Q. And the Laura Jones versus United States case, that was a prior Camp Lejeune case, correct?
MR. DEAN: Object to the form of the question.
THE WITNESS: It was never explained to me, either by the Office of the General Counsel or DOJ or the plaintiffs' attorney, what -- what exactly the case was for.
BY MR. ANWAR:
Q. The focus of your deposition, was it on your work on the ATSDR water modeling for Camp Lejeune?
MR. DEAN: Object to the form of the question.
THE WITNESS: It was for Tarawa Terrace, my understanding was.

BY MR. ANWAR:

Q. Okay. So the focus of the deposition was the Tarawa Terrace model, correct?

MR. DEAN: Object to the form of the question.

THE WITNESS: That's my --

MR. DEAN: Give me time to -- you can answer.

THE WITNESS: Okay. That -- that was my understanding.

BY MR. ANWAR:

Q. Okay. And you testified under oath during that deposition truthfully, correct?

A. Yes, I did.

Q. And you had an opportunity to -- to review the transcript and make corrections on an errata sheet, correct?

A. That is correct.

Q. And I believe the last page of the transcript is your signed errata sheet. You can take a look.

A. Yes, yes, it is.

Q. Okay. And as you sit here today, do you stand by your prior deposition testimony?

A. I will say I generally do. If there's a specific item in -- in here that there's a question about, I would have to see what that technical issue is and then I could specifically tell you.

Q. Okay.

A. Okay.

Q. As you sit here today, you don't have any changes that you want to make to that testimony?

MR. DEAN: Object to the -- object to the form.

BY MR. ANWAR:

Q. You didn't come with changes, correct?

A. No, I did not come with changes.

Q. Okay. So I am handing you now what I'm marking as Exhibit 3.

(DFT. EXHIBIT 3, deposition of Morris Maslia dated September 26, 2024, was marked for identification.)

BY MR. ANWAR:

Q. Here you go.

MR. ANWAR: Kevin, here you go, if you would like a copy.

MR. DEAN: All right. Thanks.

BY MR. ANWAR:

Q. I'll represent to you this is a copy of the transcript from your September 26th, 2024 deposition in this case. Would you agree with that?

A. It appears to be, yes.

Q. And this is deposition you gave in this case in your sort of capacity as a fact witness, correct?

A. That is my understanding, yes.

Q. And this deposition took place after you had been retained by the plaintiffs, but before you had disclosed your expert report in the case, correct?

A. Yes, that is correct.

Q. And you gave that deposition testimony under the oath to tell the truth and testify truthfully, correct?

A. That is correct.

Q. And you had an opportunity to review and make corrections on an errata sheet for that deposition transcript as well, correct?

A. Yes, I did.

Q. And I say that deposition transcript. I mean the September 2024 transcript; is that correct?

A. Yes.
Q. Okay.
(DFT. EXHIBIT 4, Acknowledgement of deponent and errata sheets, was marked for identification.)
BY MR. ANWAR:
Q. I'm handing you what I'm marking as Exhibit 4, which I'll represent to you is a copy of your signed errata sheet for the September 2024 deposition transcript. Would you agree with that?
A. Yes, it is.
Q. Aside from the changes on that errata sheet, do you have any changes to your prior deposition testimony?
A. Not that I recall at this time.
Q. Okay. Nothing that you came with to the deposition, correct?
A. Excuse me? I don't understand the question.
Q. You didn't come prepared to make changes or offer changes to your past deposition testimony as you sit here right now, correct?
A. No, I do not.
Q. Okay. I am going to hand you now what I'm marking as Exhibit 5.

(DFT. EXHIBIT 5, Expert Report of Morris L. Maslia, P.E., D.WRE, DEE, Fellow EWRI, was marked for identification.)

BY MR. ANWAR:

Q. Here you go.

MR. ANWAR: Here's a copy for you.

BY MR. ANWAR:

Q. Mr. Maslia, this is a copy of your expert report in this case dated October 25th, 2024, correct?

A. That is -- I'm looking for the date on here. There's no date on this copy.

Q. I think it's at the bottom there in the middle.

A. Oh, there it is, yes. Okay. That is correct.

Q. And to the -- you had an opportunity to sort of look through that. True and accurate copy, to the best of your review?

A. The copy is correct.

Q. And aside from the articles that you -- we discussed this morning already, is the materials-considered list on there complete and accurate?

A. Yes, as far as I know.

Q. Is there anything on -- in that report that you believe needs to be added that's not reflected in the report?
A. No.
Q. I am handing you now what I'm marking as Exhibit 6.
(DFT. EXHIBIT 6, Rebuttal Response to Reports of Alexandros Spiliotopoulos, Remy, J.-C. Hennet & Jay Brigham, was marked for identification.)
BY MR. ANWAR:
Q. Mr. Maslia, is Exhibit 6 a true and accurate copy of your rebuttal expert report submitted in this case?
A. Yes, it is.
Q. And it's dated January 14, 2024?
A. Yes, it is.
Q. And aside from the articles that you mentioned this morning, is there anything missing from the materials-considered list or the references provided with this report?
A. No.
Q. And in this report, as the title indicates, is in response to the reports of DOJ experts Dr. Spiliotopoulos, Dr. Hennet and Brigham?

A. That is correct.
Q. Do you know Dr. Spiliotopoulos, Hennet or Brigham?
A. I do not know any of them and have never met any of them.
Q. Do you know of any of them?
A. I know of Dr. Spiliotopoulos. I believe his name appeared in -- as an observer at at least one of the ATSDR expert panel meetings.
Q. Okay.
A. But I could not tell you exactly which one, okay?
Q. Have you ever met Dr. Spiliotopoulos?
A. No.
Q. Have you -- so fair to assume if you haven't met him, you've never worked with him, correct?
A. That is correct.
Q. And same with Dr. Hennet?
A. That is correct.
Q. And I assume same with Dr. Brigham?
A. That is correct.
Q. Do you have any opinion about Dr. Spiliotopoulos, Hennet or Brigham?
A. Not other than they are the DOJ's

expert witnesses.

Q. Okay. In your -- either your primary expert report or the rebuttal report, is there anything that you believe is incorrect?

A. I would -- in my expert report there was -- and there was discussion during my deposition about model bias and geometric biases. And I believe that we -- or I went back and -- because there were a number of duplicate samples. And because our model was only on a monthly time frame, it really is not correct to try to match daily or even weekly samples within monthly model output.

So if you take the average within the month of the actual sample data, you get a much closer geometric bias to 1 -- 1.5. So we overstated both in the ATSDR report, and I'm talking about Tarawa Terrace, as well as my expert report, which came from -- had that overstated or provided a higher geometric bias both for the supply wells and the water treatment plant than I believe should actually be there.

Q. Is that currently reflected in your expert report?

A. No, it's not.

Q. And it's not reflected in the ATSDR reports, correct?
A. No, no.
Q. When --
A. I'm sorry.
Q. No, go ahead.
A. My expert report reflects or copies exactly the tables out of the ATSDR reports specifically for Tarawa Terrace with that.
Q. When did you do this analysis about the geometric bias? And this is specifically for Tarawa Terrace?
A. Yes, I would say within -- as I was preparing my rebuttal report to the DOJ experts and within last month sometime, I started just reading more about nondetection of sample data and multiple samples within a month, which we had at Tarawa Terrace, Hadnot Point, and then realizing that our model results -- we only had one result per month because they were monthly time steps. So the implication was that the model could reproduce those daily or multiple monthly sampling, and they -- it really can't if you only have a one-month time step.
Q. Does it follow, then, the -- the model

certainly -- because the model produced monthly estimated concentrations, correct?
A. That is correct.
Q. And the model was not intended to produce daily estimated concentrations, correct?
A. Not the groundwater flow and contaminant transport. It was produced -- we had monthly time steps, so that would be 31, 30, 28 or 29 days, depending on which month it was, and our assumption was that represented the last day of each month, like January 31st, February 28th, and so on, but that it was equally likely to occur on any day of the month.
Q. So is it your opinion because you used daily samples, but the model was producing monthly simulated contaminant concentration estimates, that you overestimated the geometric bias?
A. Yes.
MR. DEAN: Object to the form.
THE WITNESS: We computed a geometric bias that was higher than if you had a one-to-one correspondence, one -- one sample and one model result for each month.
BY MR. ANWAR:
Q. Have you actually done the calculations

on that?

A. Yes, I have.

Q. I guess, based on the opinion that you're offering now, what is -- what is, in your opinion, the geometric bias for the Tarawa Terrace model?

A. For the supply wells, I believe it comes down to somewhere below 1.5 and recalling a value of 1.0 would be an exact match, okay? And at the water treatment plant, I believe it comes down to almost 1.0.

Q. Do you -- when you said you did the calculations, is that reflected in writing anywhere?

A. I've got notes, but not with me.

Q. Okay. If we requested those notes to be produced, would you be agreeable?

MR. DEAN: Object -- object to the form of the question. I'll let you finish. I'm not sure if you were finished.

BY MR. ANWAR:

Q. Well, we will request the notes from your lawyer and the lawyers will work it out, but if your lawyers ask you for the notes, would you be agreeable to giving it to them?

A. Yes.

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. And outside of those notes, this opinion that you're offering now, it's not reflected in either your current expert report or rebuttal report or the ATSDR reports themselves?

A. That is correct.

Q. And sort of my general high-level understanding of sort of the thrust of your main expert report at least is, is that the -- the ATSDR models for Tarawa Terrace and the model for Hadnot Point and Holcomb Boulevard are sufficiently reliable and accurate to -- in estimating contaminant levels for purposes of using them to make exposure determinations in this case; is that right?

A. I would say that the models produce reliable results on a monthly basis, the groundwater flow and contaminant transport models for both Tarawa Terrace and Hadnot Point, and that we met one of the objectives that we were required to meet by the study epidemiologists of providing mean monthly concentrations.

Q. You're serving as an expert in this case, correct?
A. That is correct.
Q. On behalf of the plaintiffs, correct?
A. That is correct.
Q. And do you understand that the plaintiffs are offering the model for purposes of estimating exposure in individual plaintiffs in the litigation?
MR. DEAN: Object to the form of the question.
THE WITNESS: When we did the model, I was not aware of the end use of it. I was concerned with and what I have presented to the plaintiffs is that it's reliable to provide monthly mean concentrations. I'm not involved in, nor have I ever been involved in, any use post-modeling results.
BY MR. ANWAR:
Q. You understand the -- and if not, I'm telling you now, the plaintiffs' lawyers are offering the model as a way to estimate exposure -- estimated exposures in individual plaintiffs. Do you understand that?
MR. DEAN: Object to the form of the

question.

THE WITNESS: I understand what you have just said, yes.

BY MR. ANWAR:

Q. Okay. And do you believe the model is sufficiently reliable and accurate for that purpose?

A. The model is sufficiently reliable and accurate for the monthly mean concentrations in groundwater and in drinking water. I don't know what analyses they are conducting with those -- with those values, nor I have ever known, even when I was at ATSDR, what the epidemiologists or how they were planning on -- on using them other than in a general framework. But the epidemiologists at ATSDR believe the model results were reliable and accurate for their use.

Q. Sort of at a high level I understood the purpose of your report as -- to be supporting the use of the model in the litigation. Would you agree with that?

MR. DEAN: Object to the form of the question.

THE WITNESS: Could you clarify which report you're speaking of?

BY MR. ANWAR:

Q. Sure. I understood the purpose of your expert report that you submitted as a litigation expert in the case for which you're consulting with the plaintiffs on as advocating for or supporting the use of ATSDR's Tarawa Terrace and Hadnot Point/Holcomb Boulevard models in the litigation.

MR. DEAN: I'm sorry.

BY MR. ANWAR:

Q. Do I understand -- am I -- would you agree with that?

MR. DEAN: Object to the form of the question. You're asking him if he understands the same thing you understand? That's...

THE WITNESS: My understanding was --

MR. DEAN: For the record, I do not know, nor has Mr. Anwar provided sufficient information about what his understanding is to get in his head in order to be able to have anyone properly be able to respond to that question, so I object to the form.

MR. ANWAR: And I appreciate your objections, Kevin. I would appreciate if you also limit your objections to form within the rules and limit your speaking objections. Mr. Maslia is the one here to testify. This isn't your deposition.

MR. DEAN: You're familiar with the rules of the road and the rules of depositions, and if you follow those rules, then I will certainly follow them as well.

MR. ANWAR: And I am sort of raising this now because if this continues to be a problem, we intend to take that to the Court, so...

BY MR. ANWAR:

Q. Mr. Maslia, I will ask you the question again. So you submitted an expert report in this case?

A. Yes.

Q. And you submitted an expert report as a paid litigation expert, correct?

A. That is correct.

Q. And you did so on behalf of the plaintiffs, correct?

A. That is correct.

Q. Did you do so with the understanding that the plaintiffs are offering the model or the -- and when I say "the model", I mean ATSDR's Tarawa Terrace model and ATSDR's Hadnot Point/Holcomb Boulevard model -- for use in the litigation?

MR. DEAN: Object to the form.
THE WITNESS: I did so as the expert and the person who oversaw the development of the ATSDR models to any technical or scientific questions pertaining specifically to the model, model assumptions, model results that the plaintiffs' attorneys may have.
BY MR. ANWAR:
Q. Okay. I just want to make sure I'm crystal clear on this because as of now the Court intends to hold a hearing on -- or the -- there's discussion of a potential hearing being held on issues related to water contamination in the case. And I imagine if the Court does hold a hearing, you'll be called to testify. And if you're asked by a lawyer or one of the judges that -- whether or not the Court should use the model for making exposure determinations for individual plaintiffs in the case, what would your answer be?
MR. DEAN: Object to the form of the question.
THE WITNESS: My response would be, from my standpoint, my professional and expert standpoint, that the model results are reliable based on our assessment of model calibration, model

results, and that the -- as long as the models are sufficiently calibrated, in my mind, anyone can use them for whatever purpose they want to use them for. In other words, we did not calibrate the models with the end result of exposure assessment. Again, we were, at ATSDR, blinded to anything with the epidemiology in terms of cases, controls, people, anything like that, other than the five objectives that I believe I listed in my expert report as to what the epidemiologists requested us to meet.

BY MR. ANWAR:

Q. Okay. Now, Appendix A, which is page 120 of your initial expert report.

A. 2020. Yes, I'm there.

Q. Is that a true and accurate copy of your curriculum vitae?

A. Yes, it is.

Q. To the best of your knowledge, as you sit here today, is it complete?

A. Yes, it is.

Q. And there's not anything that needs to be updated as far as you're aware on that curriculum --

A. Not that I'm aware of.

MR. DEAN: So there's someone who has just joined with an area code 202 number. You're not muted. Would you mind muting your phone, please. Thank you.

BY MR. ANWAR:

Q. And on page 17 of your report it states that "I'm being compensated an hourly rate of 400 for my work for preparing this report. My rate for depositions and trial testimony is 2,000 per day." Did I read that correctly?

A. Yes, you read that correctly.

Q. And is that what you're being compensated in the case?

A. Yes, as it states right here.

Q. I'm handing you what is being marked as Exhibit 7.

(DFT. EXHIBIT 7, M.L. Maslia Consulting Engineer invoices Bates-stamped CL_PLG-Expert_Maslia_0000000609 through 0000000680, was marked for identification.)

BY MR. ANWAR:

Q. These are invoices that were produced to us in response to a document, subpoena, accompanying your -- your deposition notice.

A. Okay.

Q. Are these the invoices for the -- for your expert work performed on behalf of the plaintiffs in the case?
A. I haven't gone through all of them, but they appear to be with my signature and the billable hours and expenses that I submitted, yes.
Q. Okay. Do you have an estimate on how much you've billed to date in the case?
A. No, I just submit it on a monthly basis.
Q. Sure.
A. And you would have to ask the -- whoever the accountant is for the plaintiffs or my CPA who is filing my taxes.
Q. Well, so I went through the invoices.
A. Right.
Q. According to my calculation and let's -- let's call this rough, it looks like you've billed a little over 1100 hours in the amount of about $346,000, just under $347,000, for your work in this case and that's for professional services. Does that sound about right to you?
MR. DEAN: Object to the form.
THE WITNESS: It sounds high to me, but, again, you'll have to add these up. If you're

basing them on -- on these, that's all --

Q. Okay.

A. It does sound high. The 300 number sounds high.

Q. Okay. But if it's -- if that's what the invoices add up to, you wouldn't dispute it?

A. No, I would not.

Q. And I noticed your invoices were separated out for professional services and then you had travel and related expenses, correct?

A. That is correct.

Q. Okay. And so the hours and the numbers I read to you just now were what I calculated for professional services. For travel and related expenses, again, roughly I calculated 82.5 hours in the amount of about $16,000. Does that sound about right to you?

A. It would be hard for me to answer that right at this instant of time without going through them and adding them up.

Q. Okay. If that's what they add up to in the invoices, do you have any reason to dispute that?

A. No, I do not.

Q. We've been going for about an hour.

Would you like to take a break or --
A. Sure. That would be good.
Q. Okay. Let's do that.
THE VIDEOGRAPHER: Okay. We're going off record. The time is 10:14 a.m.
(A recess transpired.)
THE VIDEOGRAPHER: Okay. We're going back on the record. The time is 10:25 a.m.
BY MR. ANWAR:
Q. We are back on the record from a short break, Mr. Maslia. Are you okay to continue?
A. Yes, I am.
Q. Did you speak with your lawyers during the break?
A. No, I did not.
Q. Okay.
A. There is one thing I would like to clarify.
Q. Sure.
A. If I could do that. When we were speaking about the improved and reanalysis of the geometric biases, I got the original thought reading Dr. Konikow's expert report where he had mentioned about duplicate values in his report.
Q. Okay.

A. So I just wanted to give credit for the initial thought about that.
Q. No, I appreciate that. You actually anticipated my question. I was going to ask you sort of as a follow-up when you decided to do that analysis and it sounds like it was in the last month or two; is that right?
A. That is correct.
Q. Okay. And it was in the context of reading Dr. Konikow's report?
A. Yes.
Q. Okay. Would that have been after he had disclosed his report?
A. Yes, yes, it was the -- I mean, what was submitted to DOJ.
Q. Okay. And was there any particular reason you decided to do the analysis or it was just the thought popped up in reading his report?
A. Well, he mentioned that -- specifically I believe it was in reference to well TT26 at Tarawa Terrace where there were, like, five samples within a short time period, like within a day or week.
Q. Yeah.
A. And that the models could not really

reproduce that, okay, on a monthly basis. And so that's when I looked at our tables that we had published in the Tarawa Terrace Chapter A report where we computed the model biases and the geometric biases, and I went back and took that suggestion and did the analysis.

Q. Okay. And you indicated you have some notes about that, right?

A. That is correct.

Q. Okay.

MR. ANWAR: We will -- we will formally request those notes be produced. We will just formally on the record request that those notes be produced and reserve the right to reopen the deposition depending on what's in the notes.

MR. DEAN: That's right. And we reserve all of our objections and -- but we will take a look at it and provide a response back to you.

MR. ANWAR: Okay. Sounds good. Thanks, Kevin.

MR. DEAN: I don't have what he's referring to here either, so...

MR. ANWAR: Okay. Understood.

BY MR. ANWAR:

Q. And then I wanted to ask you, Mr. Maslia, when we were talking about expert reports that you had reviewed, did you review Dr. Longley's report as well?
A. No, I did not.
Q. Okay. Did you review it at any point?
A. I don't know who Dr. Longley is.
Q. Okay. I wanted to ask you a few questions about the invoices. There were a couple of references to discussions with -- with Robert Faye. And it looks like you spoke with Robert Faye in August of 2024. I'll call him Bob Faye. Everyone calls him Bob Faye, it appears. And one of the notes is -- provide Robert Faye, Bob Faye, with verbiage on the use of probabilistic analysis for Tarawa Terrace models, compose table listing, ATSDR data discovery activities, and then review so -- review 2005 expert report panel. And I can direct you to where in the invoices that is if you would like to take a look at it, but --
A. Yeah, if you could, please.
Q. Sure. It's the page ending 626.
A. 626. Okay. Ah, okay. Sure. What date in particular?
Q. It's August 24.

A. Okay.
Q. Why did you speak to Robert Faye there? What was that about?
A. Well, Bob Faye and I have known each other professionally probably for 40 years.
Q. Four or 40?
A. 40. 40. 40 years, more or less. And he was the person responsible for developing the Tarawa Terrace groundwater flow and contaminant fate and transport models as well as analyzing all the hydrogeologic data. And so I had found out, maybe through Bob, that he had been retained by the plaintiffs' attorneys and I think there was a question on -- on his part as to how to properly -- or how to word something containing probabilistic analyses, which is what I did at ATSDR. Not only did that, but I was familiar with -- with that on numerous occasions of doing that, and so I think that's what the discussion was about.
Q. Do you know when Bob Faye was retained?
A. I don't know the date.
Q. But as of this day, August 24th, 2024, you spoke with him and he was retained; is that right?
A. That is my understanding.

Q. Okay. And on that same page there is an entry phone call with R. Faye about review of ABC One Cleaners site data 2007 to 2012. Do you remember what that conversation was about?
A. I think the question came up in some of the production that DOJ provided to the -- the plaintiffs about what documents we may have had at ATSDR and what documents either the Department of Navy provided us --
Q. Sure.
A. -- in conducting the Tarawa Terrace reports. And so that ABC Weston 2007 report came up.
Q. Okay. And then if you turn the page to the page ending 640.
A. Okay.
Q. There are a couple of entries for December 28th and 29.
A. Right.
Q. The 29th entry is, review R. Faye rebuttal report, call with R. Faye. Do you recall that conversation?
A. On the 28th?
Q. 29th.
A. 29th. I'm sorry. I don't specifically

recall that -- that phone call. I mean, I don't know what exactly I was reviewing in his report. He may have asked me my opinion of something he was writing and being that he was retained and I was retained, I probably provided an opinion.

Q. Okay. We have not received a rebuttal report from Bob Faye. One has not been disclosed. I'm just wondering if you knew why that was?

MR. DEAN: Object to the form of the question. It's confidential attorney work product and I would instruct the witness not to answer the question.

BY MR. ANWAR:

Q. Do you know if Bob Faye intends to testify in this case?

A. I've -- I'm not involved in that part of being retained as to who does and does not testify, so I do not know.

Q. Okay. Other than sort of what's reflected on these invoices, have you spoken with Bob Faye about any other aspect of your work on this case?

A. Well, just in reviewing the original ATSDR reports where he was the primary author, making sure I understood what he was writing about

or what his intent was.
Q. Sure.
A. For example, the Chapter F, fate and transport model, I wanted to clarify, you know, technically clarify something.
Q. When would that have taken -- conversation taken place?
A. Last week sometime.
Q. I also noticed from some of the entries on your invoices that you exchanged some e-mails with Jerry Ensminger; is that right?
A. If you could -- can you point me to exactly where they -- they are?
Q. I don't -- I don't -- I can look during one of the breaks --
A. Okay. Okay.
Q. -- and point you directly, but do you recall exchanging e-mails with Jerry Ensminger or talking with him during the course of your work on this case?
A. He has called me a couple of times.
Q. Okay.
MR. DEAN: I think you might have marked some of that in the first depo, if I remember correctly, just for what it's worth to

help him remember. I think you might have marked a couple that were produced.

BY MR. ANWAR:

Q. When is the last time you spoke with Mr. Ensminger?

A. Sometime this past month he called me.

Q. What was that conversation about?

A. He wanted to know my opinion of the ATSDR models. He did mention geometric bias specifically, but whether the models were, you know, accurate, did they overpredict, underpredict.

Q. Do you know why he called you in the last month about that, about whether the models were accurate?

A. No, he never provides a reason why he calls. He just calls me. I mean, in that sense.

Q. You know, just in reviewing the documents in the case, it seems like -- and you should correct me if I'm wrong -- throughout the years Mr. Ensminger has had a number of conversations with you and others on the ATSDR side about work that was being performed related to the models and the epi studies. Is that consistent with your recollection?

A. Well, Mr. Ensminger was a member of the

Camp Lejeune camp.

Q. Yeah.

A. And he probably called or talked to me in that capacity because when I was at ATSDR -- and I don't know what the situation is now -- they would have quarterly CAP meetings, okay, and it's mostly when -- if I was going to present some information or whatever, I called in his capacity as the -- as a CAP member. That's what I recall.

Q. Okay. I was just wondering if you had any insight on why he called you now. Because it seems like he probably has a pretty good understanding of the models just from the years of working with you-all. If you have any insight on why he decided to call in the last month.

MR. DEAN: Object to the form of the question.

THE WITNESS: No, I do not know why -- why he would call me, because I had not heard from him in a while. I mean...

BY MR. ANWAR:

Q. Sure. And did you-all specifically discuss geometric bias during that call?

A. Not -- not that specific verbiage, but the concept and what it means.

Q. Okay. Now --

A. Those were the values -- I need to clarify. Those were the values relating specifically to the report, not anything additional that I had done.

Q. Understood. Have you had any other conversations with Mr. Ensminger during the course of your work in this case?

A. I believe there's one e-mail where he wanted to know if I had an award certificate where we were awarded the grand prize in research from the American Academy of Environmental Engineers and Science in 2015, and I believe I did provide him with a couple of images.

Q. Sure. And if my understanding -- if my recollection from your prior deposition is correct, Mr. Ensminger is a Camp Lejeune activist, right?

MR. DEAN: Object to the form.

THE WITNESS: I assume there's different definitions for activist. I have always known him as a member of the CAP and a -- I'll just leave it at that. That's where I first met him and that's -- even when he calls today, I still think of him in terms of the Camp Lejeune CAP.

BY MR. ANWAR:

Q. And are you aware that he's a plaintiff in the lawsuit as well?
A. No, I'm not aware of anyone who's a -- who's in the lawsuit.
Q. Is Mr. Ensminger a water modeler?
A. No, he is not.
Q. Is he an epidemiologist?
A. No, he's not. Let me qualify that, to my knowledge, I guess.
Q. Sure. I also noticed in the invoices at some point during the course of your work as a retained expert, you spoke with Chris Portier. Do you recall that?
A. I don't ever recall speaking with Dr. Portier once I was retained here.
Q. Okay.
A. I spoke to him -- or he spoke to me when I was at ATSDR. That's the last -- last time, actually, I recall speaking to Dr. Portier.
Q. Who is Chris Portier?
A. Dr. Portier is a former director of the Agency for Toxic Substances and Disease Registry. I'm not sure when he started. Maybe 2010, perhaps, and retired, my understanding is, in 2013.
Q. Okay. And then I noticed on the

invoices there were some e-mails or conversations that took place with Walter Grayman; is that right?
A. That is correct.
Q. First off, let me ask you, who is Walter Grayman?
A. Walter Grayman I would consider a mentor in water distribution system modeling and probably one of the godfathers of water distribution system modeling using computational methods.
Q. And why did you speak with Walter Grayman?
A. In my capacity here or -- I don't understand --
Q. Sure.
A. -- the question.
Q. During the course of your retention --
A. Right.
Q. -- as a -- for the plaintiffs in the litigation as an expert. I noticed his name on some of the invoices. Why did you speak with him during the course of the litigation?
A. My understanding is that he was also retained as an expert witness.
Q. Okay.

A. But he is no longer that. But that was my initial understanding. So he had some questions about the water distribution system modeling because he had assisted us in conducting field studies and using the -- the model, and so that's probably why I spoke with him, about that.

Q. Do you recall any other conversations that you've had with Walter Grayman during the course of the litigation?

A. No, no.

Q. I wanted to -- we talked -- some of this is going to overlap with our discussion during the last deposition. I'm trying --

A. Okay.

Q. -- my best not to duplicate too much. We talked about, in your prior deposition, sort of when you started working on the Camp Lejeune water modeling at ATSDR and when it concluded. And I noticed in Dr. Aral's report submitted in this case, he makes a statement that over the 15-year period from 2000 to 2015, I had my team members work with essentially EDRP at ATSDR -- and, for the record, the EDRP is exposure dose reconstruction program. The statement is "from 2000 to 2015, I and my team members worked with other team members at EDRP at ATSDR to perform analysis of Tarawa Terrace, Holcomb Boulevard, Hadnot Point studies related to Camp Lejeune."

Does that time period, 2000 to 2015, is that right in terms of the work for the water modeling?

A. For Camp Lejeune?

Q. Correct.

A. No, that is not correct. We had a -- as I indicated previously, we had the cooperative agreement that ran every five years, and Georgia Tech was the cooperative agreement university partner. And so on other sites, for example, I mentioned the journal article that was published in 2004, so we would work on other sites. We did not begin working in earnest until 2003 on Camp -- Camp Lejeune, at which point, if they were still part of the cooperative agreement, which they were, that's when they would have started or we would have started to have discussions about Camp Lejeune and the approaches we should be taking and things of that nature.

Q. And that's helpful in terms of the start date. And then the end date he had in his report as 2015. I noted that the -- I think the last Hadnot Point/Holcomb Boulevard report was published in 2013. Is that consistent with your understanding?

A. The last report series was released in March 2013.

Q. Did -- did the work related to the Hadnot Point/Holcomb Boulevard modeling at ATSDR, did it conclude in March 2013 or did it go on another year until 2015?

A. The actual modeling activities and data analysis activities and report publishing concluded March 2013. I may have been asked by the epidemiologists to forward them the final modeling results after March of 2013, but I don't recall the exact date.

Q. Were you doing any work on the modeling in the ATSDR, I guess, either Tarawa Terrace or Hadnot Point/Holcomb Boulevard models, in 2015?

A. No, I was not.

Q. Okay. So the -- the time frame is just slightly off a little bit in his report, it sounds like?

A. That is correct.

Q. Okay. I just wanted to clarify that.

So you -- you worked on the ATSDR

models for Tarawa Terrace and Holcomb Boulevard/Hadnot Point -- Hadnot Point/Holcomb Boulevard for just over a decade; is that right?

A. Yes, that would be correct, although the initial work plan development probably was in early 2003 or maybe 2002, internal, internal work plan.

Q. Understood. You said 2002, 2003?

A. Yes.

Q. Okay. 11, 12-year time frame?

A. That is correct.

Q. For the 11, 12-year time frame for the work that you and your colleagues at ATSDR did related to the Tarawa Terrace and the Hadnot Point/Holcomb Boulevard models, correct?

A. That is correct.

Q. Okay. And during that period of time, you were ATSDR's project officer for the exposure dose reconstruction program, correct?

A. That is correct. I was the project officer from the beginning of the exposure dose reconstruction program, which was probably 2004 or '5.

Q. Okay. And then you were also the -- the lead or the project manager for ATSDR's water

models on Camp Lejeune, correct?
A. That is correct.
Q. Okay. Now, when you were employed during this period of time by ATSDR working on the Camp Lejeune modeling, you were a federal government employee, correct?
A. That is correct.
Q. Do you remember what grade you were sort of in the GS system in terms of employed?
A. It changed over time because I was classified under the Office of Personnel Management's research grade evaluation system.
Q. Sure.
A. So I was promoted twice from a GS-13, which is where I came into ATSDR, applied to be reclassified as -- under the research grade, and then was promoted to a GS-14 and a GS-15.
Q. When were you promoted to a GS-15?
A. I would have to look at my electronic personnel file.
Q. Sure. Were you a GS-15 by the time you were working on the Camp Lejeune water models at ATSDR?
A. Somewhere in there. Not necessarily at the beginning.

Q. Okay. I am going to hand you what I'm marking as Exhibit 8.

(DFT. EXHIBIT 8, Federal employee profile for Morris L. Maslia, was marked for identification.)

BY MR. ANWAR:

Q. I -- I looked you up on the federal government employee lookup tool, and you're welcome to look me up, too, as a federal employee. But does this document I hand you accurately reflect your GS grade and your salary while employed at ATSDR between 2004 and 2018?

A. Well, it's incorrect because I retired on December 31st, 2017.

Q. Okay. Aside from the 2018 year, for the other years, does that generally look correct?

A. I don't recall being a GS-15 all the way down to 2004 because I do recall them -- under the research grade evaluation program, what they do is, depending on the grade, but at the 13 and above they should review you every four to five years, maximum. So they would -- you -- they call in a panel and have experts and then they score you on a point basis. And then if you make above a certain -- a certain point level, then the agency has to say yes, we've got a GS-15 position available or not, okay?

So again, I just don't recall it being in 2004, but I would have to look at my own -- I know you pulled this off the -- I've got my own electronic personnel folder at home, or it was on my ATSDR LAN drive, because they wanted everybody to keep a copy of their personnel -- electronic personnel folder when they went to digital versions of it. So I could tell by those. I'm familiar with the -- whatever it is, SF-171 form that tells each year or whatever when you get promoted.

Q. Sure. Would the salary amounts, do they look roughly right?

A. They -- they -- they look, from my recollection, correct, yes.

Q. Okay. And so for that 11- or 12-year period, would it be fair sort of roughly to estimate that your total salary, cumulative salary, during that period exceeded a million dollars, correct?

A. I've never -- I've never added it up, to be quite honest about it, so I would need to add that up before...

Q. Okay. But if we added that up and I

told you it's over a million dollars, do you have any reason to dispute that?

A. No.

Q. Okay. Besides your salary as an ATSDR employee and the compensations and billings we've discussed related to your retention or your role as an expert in the litigation, have you received any other compensation related to Camp Lejeune?

A. No, I have not, nor have I ever.

Q. Now, if I remember correctly -- and you're welcome to refer to your CV as we're going through this. It's page 121 in your expert report. You started at ATSDR in 1992?

A. Let me just get there, so --

Q. Sure.

A. -- I'm on the page that you're referring to. I started at ATSDR in 1992, that's correct.

Q. And you retired in 2017, right?

A. December 31st, 2017.

Q. And as we just discussed, you worked on ATSDR's Camp -- the water modeling related to Camp Lejeune for Tarawa Terrace and Hadnot Point/Holcomb Boulevard from about 2003 to 2013, 2014?

A. Probably. I want to say through 2013.

I was being funded in part at that time by the Department of Navy, and so whatever they put in the budget for 2014, it would not have been funded by -- to my knowledge, by Camp Lejeune because the modeling was completed, okay.

Q. Okay. And give or take, for a little over -- for roughly a little over a decade, I think we said 11 or 12 years, you worked on Camp Lejeune water modeling at ATSDR, right?

A. That is correct. We did have, though, again, because I was not only project chief or scientific technical project officer for Camp Lejeune, but I was also over the exposure dose reconstruction program. We had other EDRP activities and a couple of sites that we worked in, not using Camp Lejeune money, but using the agency's other funds.

Q. Okay. You started at ATSDR in '92. You left in 2017, and you worked -- so that's, what, roughly 25 years?

A. Yes.

Q. Okay. And you worked on Camp Lejeune water modeling for close to half of that, is that right, at ATSDR?

A. Did we say 10 or 11 years, yes.

Q. Okay.
A. Maybe slightly less. Maybe slightly less, but...
Q. Understood. Was the water modeling for Camp Lejeune a significant portion of your work portfolio at ATSDR?
A. It was a substantial, but there were other sites, as I said, prior to Camp Lejeune and a couple of sites -- or a couple of analyses that were not Camp Lejeune related.
Q. Focusing on that period between 2002, 2003 to 2013, what percentage of your work would you say was related to the ATSDR's Camp Lejeune modeling?
A. I'll start after about mid-2003. I think that's when the ATSDR, I assume, got approval from either the Marine Corps or the Navy to expend the budget money on Camp Lejeune. I would say it was probably 95 percent on different aspects of Camp Lejeune.
Q. As I was looking at your -- your CV, and specifically I was looking at your list of publications, without looking each and every one up --
A. Right.

Q. -- it's on page 130.
A. Okay. Okay. I'm there.
Q. I counted about nine or ten articles that you've published related to the modeling work you did on Camp Lejeune at ATSDR; is that right?
A. That sounds about right. It would be agency reports. It would be journal articles and there were some symposia presentations.
Q. Do you have any -- well, let me ask it this way. Just ballpark, not holding you to any specific number, how many publications, symposiums, presentations, have you given related to the Camp Lejeune water modeling?
A. I would really have to go and count them up. I just don't feel answering truthfully if I just picked a number out.
Q. Would you -- I think I identified nine publications. Would you agree over ten?
A. Yes.
Q. Do you think over 20?
A. If you count some symposia presentations where we had to actually submit a manuscript, sometimes we did, and others we just did, like, PowerPoint presentations, okay?
Q. So potentially over 20?

A. Right, yes.
Q. What about over 30?
A. That may come under other activities. Like I was adjunct professor at the Emory University Rollins School of Public Health, and so I would give some case studies to my students using what was publicly released from Camp Lejeune. And I may have been asked by other ATSDR professionals who were teaching other courses on statistics or risk assessment at Emory to be a guest speaker for my -- and I would give, again, things we had already published or publicly released by the agency about Camp Lejeune.
Q. Would you agree that the work you did on the water modeling for Camp Lejeune at ATSDR was a significant part of your career at ATSDR?
A. I would say it was substantial. It would not be the complete time.
Q. And I saw on your CV that you, in 2015, received the 2015 Excellence and Environmental Energy Award, the grand prize, from the American Academy of Environmental Engineers and Scientists; is that right?
A. That is correct, sir.
Q. And was that related to the water

modeling work that you did at ATSDR on Camp Lejeune?
A. Yes, it was.
Q. What is AEEES?
A. It's a professional organization, as the name implies, of environmental engineers and other engineers and scientists, and they run a competition each year with different categories, for example, consulting small projects, government projects, and research projects.
Q. Okay.
A. And I mean, they put on webinars and things of that nature, continuing education courses.
Q. I saw the picture that you produced holding the award. You looked very happy. What did that award mean to you?
A. It meant -- it was especially meaningful not just to me, but for our entire team because an outside organization recognized the significance of our work and contribution about Camp Lejeune to the profession.
Q. Are you proud of that award?
A. Yes, I am.
Q. Would you describe it as one of the

highlights of your career?
A. Yes.
Q. How would you describe the work you've done on the Camp Lejeune water modeling at ATSDR in the context of your career?
A. I would say it was one of the similar works that I have done, just like prior to Camp Lejeune, Dover Township. Toms River, New Jersey was also a similar piece of work. It was at the U.S. Geological Survey, the work on the Floridian RASA was also a similar piece of work.
Q. Now, in your prior deposition we briefly discussed some e-mail exchanges that you had with the Bell Legal Group in a 2009/2010 time frame. Do you recall that?
A. In the September deposition?
Q. Correct.
A. I don't specifically recall that, but if it's in the verbatim transcript, then we discussed it.
Q. Okay. I'll show you one of them later.
A. Okay.
Q. And then you were retained by the Bell Legal Group in July 2022 to serve as an expert in this litigation, right?

A. That is correct.
Q. I was wondering what -- what led you or how did you decide to serve as an expert witness in this case?
A. Well, after I retired, of course, I -- I did a few consulting jobs just to keep in the profession, keep my mind fresh. And then I was approached and I felt because I had probably the most internal knowledge -- not internal ATSDR, but about the modeling I'm talking about, about what -- what we did, what the results meant, our confidence in them, and that I could advise them on those aspects of it.
Q. Are you -- how do I ask this? Is one of the factors you considered in serving as an expert in a litigation helping plaintiffs pursue their claims related to exposure to Camp Lejeune water?
A. That never -- that was never discussed with me and that was never my -- my understanding, but rather that I was a technical expert on water modeling.
Q. Do you want to help the plaintiffs in this case pursue their claims related to exposure to Camp Lejeune water?

MR. DEAN: Object to the form of the question.

THE WITNESS: That really would be a legal question. I'm not really involved in legal aspects other than being retained to explain what we did, what I did, and the meaning of the work at -- the water modeling that came from Camp Lejeune.

BY MR. ANWAR:

Q. And I guess I'm not asking you sort of in the legal sense of whether your work is being used to support the plaintiffs. I'm just asking you personally, do you want to help the plaintiffs in the litigation?

MR. DEAN: Object to the form of the question.

THE WITNESS: When we did work at ATSDR and even when I was at the USGS, we did what I would classify as science in the public's interest, okay? And so it's important to me that the public understands what we did and how we did it, and if it can help them come to a better understanding of what occurred at Camp Lejeune or Toms River, Dover Township, New Jersey, then that's a good -- good use of my time, expertise, and the taxpayer's money.

BY MR. ANWAR:

Q. So does your desire to -- or your involvement in the litigation, does that stem from a desire to explain the work that you did related to Camp Lejeune at ATSDR?

A. Yes, yes.

Q. Do you feel like your work is under attack in the litigation?

A. Not personally under attack. I believe there's been mischaracterization of the work and perhaps at different points misunderstanding of what we were tasked with or charged with doing and the reliability of the work.

Q. Do you --- is one of the motivating factors in serving as an expert for the plaintiffs, is it to defend your work?

MR. DEAN: Object to the form.

THE WITNESS: Well, I think if I'm asked a question about our work, I'm defending the -- the work, okay? So -- so but my objective is not necessarily to be hired so I can defend what we did. I would like to think that more of explaining what we did and explaining, you know, assumptions, limitations, and data analyses and things of that nature.

BY MR. ANWAR:
Q. Aside from sort of the scientific explanation portion of it or defending or explaining your work, is money a motivating factor at all serving as an expert?
A. Not at all, not at all.
Q. If the Court were to say, hey, the work that you did at ATSDR was very fine, but we don't -- we, the Court, don't believe it's appropriate for use in this -- this case, how would that make you feel?
A. Well, I would have to understand or be there when someone said -- said that. That's sort of a hypothetical. And I've never looked at the work as defending it because the Court is going to say, we don't believe it, okay? That's the best I can answer.
Q. Okay. We'll talk a little bit more about some of these other subjects later in the deposition. Did you feel like you were defending your work from the National Research Council?
MR. DEAN: Object to the form.
THE WITNESS: You mean, the results of -- of their report?
BY MR. ANWAR:

Q. I guess, did you perceive -- let me ask it differently. Did you perceive the National Research Council's comments on the ATSDR Camp Lejeune water modeling to be an attack?

MR. DEAN: Object to the form.

THE WITNESS: I believe and I believe we have explained, on a couple of occasions, internal documents as well as the published article in Groundwater, that it was a mischaracterization and misunderstanding and there was what appeared to be -- because I requested additional meetings and they would not meet with us. And I believe they made their -- part of their decision -- I didn't review the entire report, so I'm not talking about the toxicology or the epi or the rest or anything like that.

Q. Sure.

A. But they are all in conclusion that they -- there was a misunderstanding, mischaracterization, of some of the key things. So yes, I mean, it's...

Q. Yes, it was an attack, is what you're --

A. I wouldn't call it an attack, no. I would say it was a mischaracterization and misunderstanding.

Q. Okay. What about the Navy's critique of the ATSDR water modeling for Camp Lejeune? How did you perceive that?

A. I perceived that as a very usual professional discourse that you have some work, whether it's a model, data analyses or whatever, and you publish it, whether it's a peer-reviewed journal or peer-reviewed report, and the Navy had some technical comments on the report, and so we addressed them, in other words. So -- and until this day, I still perceived it as a professional exchange.

Q. What about Prabhakar Clement's -- Dr. Clement's article?

A. Right.

Q. How did you perceive that?

A. At the time it was published, which I believe is 2010, it came right after the publication of the NRC report. And again, I thought there were some misunderstandings and mischaracterizations. I do understand now that part of it was sort of philosophical. In fact, he mentioned that in his rebuttal to us. He was looking at more philosophical issues, but I felt the need to respond editorially to Dr. Clement's article.

Q. Sure. Now, in the instance of the NRC and the Navy and Dr. Clement, you did respond to each one of those, correct?

A. The -- to the NRC we wrote or I -- I oversaw an internal document, okay, and advised my management chain and leadership that we needed to respond to the NRC, I guess, agency, and they and CDC quickly invoked the 11th commandment, thou shall not critique the NRC.

Q. Why do you think that is?

A. I have no idea, but we point -- and that internal document was very -- I mean, it was very technically oriented in going -- I wouldn't say line by line, but topic by topic and explaining where we saw some issues with the NRC report. And I do know that -- I believe it was Dr. Portier, when he -- Dr. Portier in 2009 was not director of ATSDR, but when he became director, I provided him with a copy of that internal -- it's called document, okay, it wasn't a memo or anything like that. And he had a couple of topics in his letter to -- and I forget who he wrote exactly to, but about -- about our work, about the NRC report.

Q. If I'm understanding you correctly, you wanted to respond to NRC, correct?
A. Yes.
Q. Okay. And you had put together a response?
A. That is correct.
Q. But the response was kept, for whatever reason, by CDC and ATSDR, internal, correct?
A. I know by ATSDR. I don't know if it ever made it up to CDC --
Q. Okay.
A. -- that's over ATSDR, but it did make it up through my management chain, okay?
Q. And it was kept internal, correct?
A. That is my understanding.
Q. Okay. And you did respond to the Navy's comments or critiques, correct?
A. That is public information on the ATSDR website, yes.
Q. Okay. That -- there's this ATSDR report that's -- we'll look at it later, but it's sort of named response to the Navy's letter. Did you draft that response?
A. Yes.
Q. Okay. And then --

A. With assistance of team members and some epidemiologists.

Q. Understood. And the article that you published along with, I believe, Dr. Aral and some of the other ATSDR colleagues, Jason Sautner, maybe Rene, a response to Dr. Clement's article as well, correct?

A. That is correct, yes, the team. I listed all of the team. When I say team, from an agency standpoint, so that's why there are some epidemiologists that's coauthors on it as well.

Q. And when I say -- because we were talking -- just for purposes of the record, because we were talking about the 2000 Clement article, when I'm talking about Dr. Clement's article now, it's the article, I think, in the mid-2000s, 2010, 2011, focused on hindcasting, correct?

A. That is correct.

Q. Okay. Did you introduce the plaintiffs' lawyers to -- in this case to Dr. Konikow?

A. Yes, I did. When I say introduced, let me clarify. I think they were looking for a name of somebody who was nationally renowned in fate and transport modeling, and so from my days at USGS, I knew Dr. Konikow.

Q. Okay. So you connected Dr. Konikow with the Plaintiffs' Leadership, correct?

MR. DEAN: Object to the form.

THE WITNESS: I just provided contact information.

BY MR. ANWAR:

Q. Okay. Did you introduce or provide contact information to the plaintiffs' lawyers in this case for Rob -- Bob Faye?

A. Yes.

Q. When did you do that?

A. I really don't remember.

Q. Was -- was it in the last 30 days?

A. It was prior to that.

Q. Last 60 days?

A. I've been, as you said, involved in this case since July of 2022.

Q. I won't hold you to a precise date. Was it in 2025?

A. No, it was -- must have been sometime in 2024.

Q. Do you recall whether it was before or after the September 26th deposition, 2024?

A. It would have been before.

Q. Did you -- do you have Bob Faye's contact information?
A. Yes, I do.
Q. What is it?
A. I've got a phone number and an e-mail.
Q. Okay.
MR. DEAN: Hold on. I have his info as well. I don't mind -- he's a retained consulting expert. He's not been disclosed as an expert. So if you were to get his contact information, I would request that you not talk to him -- talk to Mr. Faye without me being present or on the phone.
MR. ANWAR: Okay.
MR. DEAN: If at all because he is, again, a confidential consulting expert for the PLG.
MR. ANWAR: Okay. We can discuss that separately.
MR. DEAN: Sure.
BY MR. ANWAR:
Q. Did you introduce or provide contact information for any of the other experts for the plaintiffs?
A. Just the two that you have mentioned, Dr. Konikow and Mr. Faye.

Q. In documents that we received from Dr. Konikow, there was an e-mail in there between you and Dr. Konikow. I think you were e-mailing him, and it included a line, it said "don't know if Kevin explained the politics of the case now, but it's quite eye opening to me." Do you recall that?

A. I may have said that in the e-mail. I mean, if I saw the e-mail, then we could see.

Q. Sure. What did you mean by the politics of the case?

A. Well, Camp Lejeune has always been surrounded, you know, from a political standpoint, okay, because you have different parties, meaning the Navy, the CAP, ATSDR, and so on, having different points of view, so that makes it -- and you're in public health, which is -- always has politics associated with public health. And so that's what -- and then they passed or perhaps I was aware -- I was aware of the Janey Ensminger Act, okay. That would have been political to get that passed. And I believe at the time they had already passed the PACT Act, which contained the section -- I forget the exact number for Camp -- Camp Lejeune.

So that's what I was referring --

referring to, is most of the time I know the work that -- I can't speak for Dr. Konikow, but the work that I did at, say, USGS, okay, and even most of the work that I did at ATSDR, with the exception of Dover Township, Toms River, and Camp Lejeune, were not -- did not have necessarily political aspects to them in terms of legislation being passed.

Q. Understood.

A. Things like that.

Q. I -- and we talked about this in your last deposition, and I know that you were part of a group from ATSDR that testified to Congress, correct?

A. That would have been in, like, June 12th, 2007.

Q. Okay. And that was about Camp Lejeune, correct?

A. Right.

Q. Was it a House Committee Hearing, if I remember correctly?

A. It was a Senate Subcommittee Hearing.

Q. Oh, I'm sorry.

A. And I actually was -- did not provide the testimony. I believe it was Dr. Tom Sinks. I was just there, I guess, as a -- again, a technical

expert, but I was seated at the table.
Q. Okay. Have you had any direct conversations -- have you directly had any conversations with any Congress members about Camp Lejeune?
A. No, I have not.
Q. You have a quote in your -- your e-mail signature block currently from Nobel prize physicist Richard P. Feynman. Do you know what I'm talking about?
A. Dr. Feynman, yes, yes, I do.
Q. And I believe the quote is "I would rather have questions that can't be answered than answers that can't be questioned"; is that right?
A. That is correct.
Q. Okay. Who is Richard P. Feynman?
A. He's a Nobel -- he's since deceased, but he was a very young Nobel prize winning physicist. And the laypeople probably know him for his participation on and his famous experiment on the Challenger explosion.
Q. Okay.
A. And I believe that's where he put that quote in, but I wouldn't swear -- swear to it, and, in fact, I just bought a copy of -- of a book about

-- about him.
Q. Okay. Why did you include that quote in your signature block?
A. I thought it's appropriate to everything in -- in life. It's very succinct. Don't be afraid to say you don't know the answer, but that's better than saying don't ask me the question.
Q. Would you agree that that quote is applicable to all of the work that you've done as an engineer or an environmental scientist?
A. I would say it's a more philosophical statement, okay?
Q. One that would apply to -- and you said any aspect of life, right?
MR. DEAN: Object to the form.
THE WITNESS: Well, that's how I am interpreting it, okay? I wasn't there when Dr. Feynman stated it or published it, so I don't know what was in his mind, but it seemed to me, from a philosophical standpoint, it, you know, it resinates with me just philosophically.
BY MR. ANWAR:
Q. Okay. We have been going for a little over an hour. Do you want to -- should we take

another break?

A. Sure, yes.

THE VIDEOGRAPHER: Okay. We're going off record. The time is 11:23 a.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on the record. The time is 11:32 a.m.

BY MR. ANWAR:

Q. We are back on the record from a short break. Mr. Maslia, are you okay to continue?

A. Yes, I am.

Q. Okay. And did you speak with your lawyer during the break?

A. No, I did not.

Q. Could you turn to page 145 of your expert report?

A. Yes. Okay.

Q. 145 is a -- includes on it a figure or a chart laying out the team that worked on the ATSDR water modeling for Tarawa Terrace and Hadnot Point/Holcomb Boulevard, their titles and sort of their roles; is that right?

A. That is correct.

Q. Okay. And you've included Xs. A dark green X for senior author of a report chapter. A

light green X for a contributing author of a report chapter, and then a light red O for project management and coordination; is that right?
A. That's correct.
Q. Okay. As I -- as I look at this figure, is it fair to say that you were a senior author or a contributing author or project managed and coordinated every single chapter of the Tarawa Terrace model reports and the Hadnot Point/Holcomb Boulevard model reports?
A. I was the technical or scientific project officer over all of the Camp Lejeune water modeling.
Q. Okay.
A. It's just not shown on here. You can't print three different colors on the same box, okay? So -- and then where the dark Xs are, obviously I was the senior author on that and contributed to most of the reports, but there were some individual chapters or supplements that I did not have authorship of.
Q. But you still oversaw and managed, correct?
A. Yes, yes.
Q. Coordinated, managed?

A. Yes.
Q. Okay. In coordinating and managing every chapter of the two models, Tarawa Terrace and Hadnot Point, would you have reviewed and approved every chapter on each of those reports?
A. I would have reviewed and then said it's ready to go to -- through the agency peer review and then to external -- or if any review comes back and then go out to external peer review. It's ultimately up to the agency, I guess, Office of Science and CDC Office of Science to give the final release.
Q. Understood. Would you be the one to make the decision it's ready to go to the next step of the process, the peer review process?
A. Yes.
Q. And in making that final decision, would you -- for each chapter or each report, would you have an opportunity to review and comment and suggest edits to particular chapters of either of the model reports?
A. Yes.
Q. Okay. We talked about, at the beginning of the deposition, the -- sort of the most recent calculations you've run --

A. Yes.
Q. -- with respect to geometric bias.
A. Right.
Q. As to the Tarawa Terrace model, correct?
A. Yes, yes.
Q. That was in the last month or so, correct?
A. That is correct, sir.
Q. Aside from that, do you stand by every chapter of the Tarawa Terrace model?
A. Yes.
Q. And is that also true -- do you stand by every chapter of ATSDR's Hadnot Point model?
A. Yes.
Q. Again, aside from that geometric bias discussion that we had, is there anything that you're aware of that should be changed or corrected in either the Tarawa Terrace set of model reports or the Hadnot Point/Holcomb Boulevard set of model reports?
A. There's issues brought up by the DOJ's experts that I've responded to.
Q. Okay.
A. Okay. Absorption parameters, for

example, the results, and they do not impact at all the results of the Tarawa Terrace analyses.

Q. Understood. In preparing your expert report, either the primary -- the main one or the rebuttal report, did you rerun either of the Tarawa Terrace or the Hadnot Point and Holcomb Boulevard model?

A. No.

Q. Were your reports, the main report and the rebuttal report, were they based on the ATSDR reports that are publicly available now?

A. You're talking about my expert report?

Q. Correct.

A. Yes, they were all -- whatever was publicly available on the ATSDR website, which would be all the Tarawa Terrace expert panel reports, response to the Navy, and the Hadnot Point/Holcomb Boulevard series of reports.

Q. Okay.

A. And that's what my expert report would rely on.

Q. Okay. And I think you've clarified that for me. Basically what I'm getting at is you didn't, you know, go and put MODFLOW on your computer and run the groundwater model again. You

didn't go and get MT3DMS and run the fate and transport model again, correct?
A. Not at all, no, I do not have those on my computer.
Q. And same with EPANET and the water distribution model, you didn't --
A. I did not rerun it, although I do have EPANET on my computer at home.
Q. Okay. Do you consider yourself an expert in groundwater modeling generally?
A. Yes.
Q. Any particular aspects of groundwater modeling that you consider yourself an expert or do you consider yourself an expert in all of it?
A. I would consider myself an applied researcher, so applying the available models that have been developed by others to sites, okay, and doing that as well as experience with post-calibration analyses to assess the goodness of fit of models.
Q. In terms of groundwater modeling, do you consider yourself an expert in groundwater flow modeling?
A. Yes.
Q. Do you consider yourself an expert in

contaminant fate and transport modeling?

A. I would consider myself very knowledgeable.

Q. Okay. But not an expert?

MR. DEAN: Object to the form of the question.

THE WITNESS: I mean, I'm an expert from the standpoint that I've had courses in contaminant fate and transport. I applied some and -- but I don't do it -- I did not do it routinely, but I have run contaminant fate and transport models.

BY MR. ANWAR:

Q. Do you consider yourself an expert in water distribution modeling?

A. Yes.

Q. Why do you consider yourself an expert in water distribution modeling?

A. Well, we've applied -- when I say we, at ATSDR, we applied water distribution system modeling to a couple of sites: Dover Township, Toms River, New Jersey as well as Camp Lejeune. And we were -- for the Dover Township analysis, we were actually awarded the best practice oriented paper in 2000 by the Journal of Water Resources

Planning and Management based on the work in field monitoring of the water distribution system in Toms River, New Jersey. So yes, I would consider myself an expert there.
Q. Okay. Let's turn to page 17 of your report.
A. Of my expert?
Q. Your main report, yes.
A. Expert report?
Q. Correct.
A. Page 17. Okay.
Q. Page 17 contains a summary of your opinions; is that right?
A. It has one item.
Q. Oh, I'm sorry. 17 and 18.
A. And 19.
Q. And 19. 17 through 19?
A. Yes.
Q. Starting on 17 is a section entitled "summary of your opinions" and it concludes on page 19, right?
A. Yes.
Q. Okay. I wanted to focus on opinion number three. It states, "the reconstructed simulated monthly mean contaminant concentrations

of PCE, TCE, 1-2 DCE, vinyl chloride, benzene at Tarawa Terrace, Hadnot Point and Holcomb Boulevard are contained in ATSDR report appendices A-2 for Tarawa Terrace, A-3 and A-7 for Hadnot Point, and A-8 for Holcomb Boulevard." Did I read that correctly?

A. Yes.

Q. Okay. And then opinion three goes on. It says, "these reconstructed monthly mean concentrations are also included in this report in appendixes H, I, J and K" -- well, let me -- "these reconstructed monthly mean concentrations are also included in this report in appendixes H, I, J and K, comma, are reliable and represent, within reasonable scientific and engineering certainty, the contaminant levels in selected water-supply wells and in finished water at Camp Lejeune from 1953 to 1996." Did I read that correctly?

A. That is correct.

Q. Okay.

A. The ones for Hadnot Point probably go to 2008. That's what the model runs did.

Q. Okay.

A. I'm not sure about the '96. That may have been when the wells -- all the wells -- I --

but I do recall, because we had 2008 or 2006 through 2008, a remediation rate of Hadnot Point that ran the model all the way out to 2008. So I would...

Q. When you say there that the reconstructed mean -- or reconstructed monthly mean concentrations in the ATSDR reports are reliable and represent, within reasonable scientific and engineering certainty, what do you mean by reasonable scientific and engineering certainty?

MR. DEAN: Object to the form.

THE WITNESS: When you conduct scientific and engineering analysis application and you come up with the value of -- that you believe is the most likely value and -- then there's always, you know, plus or minus a certain percent, okay, and that's accepted. That's a pragmatic engineering approximation to a modeling problem, okay? You do the best you can and see if the level of uncertainty is way beyond the information that you have in terms of giving a reliable solution or if it's within, then -- but there's always some -- some differences or errors in any of the solutions.

Q. When you say reliable there, what do you mean? Is that --

A. Reliable, to me, means that -- and I'm going to say for their ATSDR analyses, of course, that are published -- somebody could pull that off the shelf or off -- offline, I guess, now, and with the model input files, duplicate what we did, okay?

Q. In this opinion, are you stating -- are you opining that the reconstructed monthly mean concentrations in the ATSDR reports are accurate within a reasonable degree -- or reasonable scientific and engineering certainty?

A. Yes.

Q. So it's your opinion that the simulated monthly mean concentrations are accurate within reasonable scientific and engineering certainty?

A. They are the most likely values to occur.

Q. And --

A. Or to have occurred.

Q. When we're talking about reasonable scientific and engineering certainty, help me quantify that into a percentage. Are they 50 percent accurate, 75 percent accurate, 51 percent? Are they 90 percent likely to be accurate?

MR. DEAN: Object to the form of the

question. Calls for legal conclusion.

THE WITNESS: Depending on the application, not necessarily just on Camp Lejeune, but in -- generally speaking, it depends on a lot of factors. The quality of the field data. How you constructed the model. What your calibration targets may have been, or at least you try to figure them out, and so each application will have a different level of uncertainty, okay, and reliability.

BY MR. ANWAR:

Q. What do you mean by depending on the application?

A. Well, for example, we did water distribution system modeling, okay? Water distribution system modeling takes hour time steps, not monthly, but hour time steps. And we measure and we gather data because -- we personally gathered them both in -- at Dover Township and at Camp Lejeune. We had 15-minute readings per hour, okay? So that's more data. So then you have to assess that model based on the data that you have and can you accept the difference between the modeling results and the data that you -- that you have and the way you interpret the data.

In other instances you may have monthly data or sporadic data, and so the level of reliability may change. And it also depends, again, how you constructed the model. The size of the grid, how you hydrogeologically conceptualized the model. There's a lot of factors that go --go into there, so you just can't -- I don't think it's accurate to say on a blanket statement there's this uncertainty in terms of percent or not percent, you know.

Q. If the -- there is uncertainty to the simulated monthly mean contaminant concentrations, why were they -- those contaminant concentrations, I'm just wondering, why were they produced in this -- kind of this table format at the -- in multiple places in the report, but do you know what I'm referring to, at the end of Appendix A for Tarawa Terrace, for instance?

MR. DEAN: Object to the form of the question.

THE WITNESS: Can I just take a look at Appendix A?

BY MR. ANWAR:

Q. Sure. Here, we'll go ahead and mark it -- mark them both.

A. Okay. Oh, I've got a copy right here that's unmarked. That's A. No, that's not A. Here's Tarawa Terrace.

Q. Okay. I'll give you the one for the court reporter.

MR. DEAN: Just use that.

THE WITNESS: Okay. Okay.

(DFT. EXHIBIT 9, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions, Chapter A, Summary of Findings, Bates-stamped CLJA_Healtheffects-0000221172 through 0000221287, was marked for identification.)

(DFT. EXHIBIT 10, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A, Summary and Findings Bates-stamped CLJA_Healtheffects-000022136 through 0000221535, was marked for identification.)

THE WITNESS: So based on the Appendix 2 in Tarawa Terrace?

BY MR. ANWAR:

Q. I am talking about Appendix A3 and A -- A3.

A. A -- in Tarawa Terrace it's Appendix A3. It's questions and answers.

Q. Oh, I'm sorry. I have the wrong one. You're probably right. A2, yeah.

A. Okay. A2. Okay. Could you repeat the question?

Q. Sure. I guess given the uncertainty and the -- the -- the application being important, I was just wondering why were these concentrations presented in the format that they were in A2?

A. By format, what do you mean?

Q. The summary -- I mean, you -- for instance, can a person go on page A90 --

A. Okay. Hold on. A90. Okay.

Q. Stress period, 301, is for January of 1976 and the model simulated a PCE monthly mean concentration of 73.96 micrograms per liter; is that right?

A. That's directly, yes, from the model output.

Q. Sure.
A. Okay.
Q. Do you know for sure that's what the PCE concentration was in micrograms per liter in January of 1976?
A. I would say the most likely value was 74 micrograms per liter, just rounding.
Q. Okay.
A. Most likely.
Q. Didn't a moment ago you say there are sort of -- there's uncertainty associated with the model outputs and there's a range --
A. Yes.
MR. DEAN: Let him finish the question and then if I have an objection.
THE WITNESS: Okay. Okay. Oh, okay. No problem.
MR. DEAN: Can you --
BY MR. ANWAR:
Q. Didn't you say that a moment ago?
MR. DEAN: Object to the form of the question.
THE WITNESS: A moment ago I said there's -- yes, I also said there's uncertainty with the data; there's, you know, uncertainty

exists, okay?

BY MR. ANWAR:

Q. Why wasn't this numerical data presented with the uncertainty, the range, and the potential error bands for the data?

MR. DEAN: Object to the form of the question.

THE WITNESS: I believe it was in figure -- let me see if I can find the figure here. Figure -- on page A60, figure -- the figure there, A26, it's presented in terms of the 95 percent confidence.

Q. Okay. Let's turn to page -- well, let me -- let me ask some just for purposes of the record questions. When we're talking about Camp Lejeune water modeling, we're really talking about two separate water models, correct? And what I mean by that is there was a model that related to Tarawa Terrace and then there was a separate model that related to Hadnot Point and Holcomb Boulevard, correct?

A. I'd say there was an analysis related to Tarawa Terrace.

Q. Sure.

A. And then there were subsequent analyses because of the complexity of Hadnot Point and Holcomb Boulevard and the interconnection related to those areas.

Q. Was the model for the analyses for Tarawa Terrace, did that actually consist of two separate models?

A. For Tarawa Terrace? Consisted of MODFLOW and MT3DMS and then a mixing model. That would be three models.

Q. Understood. And MODFLOW is a groundwater flow model -- modeling software, correct?

A. That is correct.

Q. And MT3DMS is a contaminant fate and transport model, correct?

A. That is correct.

Q. For Tarawa Terrace, rather than running a -- sort of a water distribution model, you used the simple mixing model, correct?

A. No, that's -- that's mixing apples and oranges, okay? Let's separate off water distribution system modeling. For the groundwater flow analyses we ran MODFLOW, which generated groundwater flow velocities of different layers. That's directly imported into MT3DMS. And then we applied a flow-weighted mixing because you had different wells turning on and off. And then we used the mixing model, which was described on page A40 in equations one and two, and that was because all the wells mixed at the water treatment plant, and that was the final output to which we compared available samples that were collected at the water treatment plant.

Q. Understood. So you assumed in the Tarawa Terrace model that the -- the water from the treatment plant was the same water that the end user received, correct?

A. Yes.

Q. Now, I think that's what I was getting at. The -- now, the Tarawa Terrace analysis was completed in 2009, right?

A. The last chapter was published in 2009.

Q. Chapter A was published roughly 2007, is that...

A. In -- because of the -- excuse me. Because of the Senate Subcommittee Hearing, there was an executive summary released June the 12th, 2007.

Q. Okay.

A. And then the full Chapter A, summary of findings, was released in July of 2007. But other work had been done. Again, it was a summary document, so obviously it had results in here from -- it was just a matter of finalizing the reports.

Q. And then the Hadnot Point/Holcomb Boulevard analysis, that was completed in 2013, right?

A. March 2013, the Chapter A, summary of findings, and in that situation, rather than individual additional chapters, the agency decided to make supplements for the other contributing analyses described in the summary of findings.

Q. You would agree that when running a groundwater flow model using, for instance, MODFLOW, there is some level of uncertainty, correct?

A. Yes, yes.

Q. And when you run a fate and transport model using, for instance, MT3DMS, there is also some level of uncertainty associated with the fate and transport aspect, correct?

A. Yes, but there are different types of uncertainty, okay? In other words, there's what's referred to as scenario uncertainty, and that is your understanding or conceptualizing the system that can be an error before you ever get to the model. There's model uncertainty. For example, someone were to try to apply an analytical model, which assumes constant flow field in the groundwater, constant velocities, then that would be uncertain -- model uncertainty.

Q. And so when you're -- when you're using a groundwater flow model, a MODFLOW, and then taking the results and putting them into a fate and transport model, an MT3DMS, doesn't that certainty then accumulate because you're combining uncertainty -- uncertain results with even more uncertain results?

MR. DEAN: Object to the form of the question.

THE WITNESS: That's -- actually, if you read some papers published and all of that, it's a common mistake is to linearly add up uncertainty. It doesn't work that way, okay? It may compound it. It may get reduced or whatever, but you just can't add that you've got a 10 percent uncertainty or a 95 percent confident band on the flow model. You just can't say, okay, well, the -- the transport model has 90 percent, add the two together and call it 92 and a half. It doesn't --

it doesn't work like that.

BY MR. ANWAR:

Q. And I think you just said it could compound it, though, right?

A. You would have to look at the -- again, the specific application, the specific site that you're looking at, the specific model that you're -- you're applying.

Q. And I'm just quoting back your words. You would agree, though, it could compound it?

MR. DEAN: Object to the form of the question.

THE WITNESS: I would not necessarily say it would compound it. You would have uncertainty associated with each of the models that you applied as well as uncertainty in the data, okay, that you're calibrating to. And so that's why it's, I think, critical after you complete -- in our case it was a four-stage calibration, to try to -- or even after a third-stage, try to assess the goodness of fit of the model to data. To look at sensitivity analyses, to look at uncertainty analyses, and probabilistic uncertainty analyses to quantify that, okay?

BY MR. ANWAR:

Q. Now, let's turn to page Roman numeral three.
A. Chapter A?
Q. Chapter A, correct, of Tarawa Terrace, which is, for the record, Exhibit 9.
A. Oh, okay. I'm sorry. Roman -- the foreword?
Q. Correct. Okay. And you would agree with me, there it says, in the foreword, "the ATSDR, an agency of HHS, is conducting an epidemiological study to evaluate whether in utero and infant, up to one year of age, exposures to volatile organic compounds in contaminated drinking water at U.S. Marine Corps Base Camp Lejeune, North Carolina, were associated with specific birth defects and childhood cancers." Did I read that correctly?
A. Yes, you did.
Q. Okay. And it goes on to say "the study includes births occurring during the period 1968 to 1985 to women who were pregnant while they resided in family housing at the base." Did I read that correctly?
A. Yes, you did.
Q. Then if you go to the next paragraph,

"historical exposure data needed for the epidemiological case-control study are limited. To obtain estimates of historical exposure, ATSDR is using water modeling techniques and the process of historical reconstruction. These methods are used to quantify concentrations of particular contaminants in finished water and to compute the level and duration of human exposure to contaminated water." Did I read that correctly?

A. To contaminated drinking water.

Q. Contaminated drinking water. Thank you.

A. Yes, yes.

Q. And so you would agree with me, and I think you have before, that the Camp Lejeune water modeling for Tarawa Terrace was performed to provide data for this epidemiological study, correct?

A. It was conducted to address five questions, as I've put in my expert report. Number one was which contaminants you needed to look at. These are questions posed by the epidemiologist. You know, whether it's volatile organics, I mean, volatiles, pesticides. Another conclusion, it's a military base, so there's a numerous one. Number two, when the contaminants arrived at water-supply wells, monthly mean. And then number three, what was the concentration in the wells. Number four, what was the concentration in the water distributed throughout, in this case, Tarawa Terrace. And number five was what were the range of the values. And we interpret that, from a modeling stance, is some type of sensitivity or uncertainty analyses.

Those were -- those -- those were always from -- I guess when we first had our first kickoff meeting with the Marine Corps and Navy and all of that in October of 2003, that's what we presented to them.

Q. And that was in support of this epidemiological study that was --

A. Yes, it was in support of.

Q. Of the epi study, correct?

A. Yes.

Q. Okay. And if you turn to A98.

A. Okay. I'm there.

Q. There is a -- so A98 is a page of a question and answer section of Chapter A, Tarawa Terrace report, which is identified as Appendix A3. The question is "ATSDR's historical reconstruction analysis documents that Tarawa Terrace drinking water was contaminated with PCE that exceeded the MCL" --

A. I'm not -- I'm not following where you are. You said you were on A96?

Q. A98.

A. A98. And the --

Q. The last question --

A. Oh, okay. Okay. Okay.

Q. -- is about the results of the model, "what does this mean in terms of my family's health?"

A. Right.

Q. The response is "ATSDR's exposure assessment cannot be used to determine whether you or your family suffer -- suffered any health effects as a result of past exposure to PCE contaminated drinking water at Camp Lejeune", correct?

A. That's what it says there, yes.

Q. And you -- your -- in the chart that we looked at earlier, you're the -- the primary author of Chapter A, correct?

A. Yes.

Q. Okay. And so you wrote these words, correct?

A. I wrote these -- this section -- let me go back -- the questions and answers, okay. When I was at ATSDR they required you, if you conducted a technical analyses modeling or whether it was epi, whatever, to provide the public with a layperson's understanding, okay? So I drafted these. They were reworded by the Office of Communications and then sent back down to me to see if I agreed with their edits, which there were many. And then they were published as that appendix.

Q. Okay. And you're the primary author? You're listed first?

A. Yes.

Q. And you would stand by what's in this report today, correct?

A. Yes.

Q. Okay. Now, if you would take a look at Exhibit 10, which is Chapter A for Hadnot Point.

A. Okay. I've got a copy here. Okay. Here we go. Okay. Yes, it's unmarked.

Q. Okay. If we turn to page three again, foreword, Roman numeral three.

A. Okay.

Q. And again. There it says "ATSDR is conducting epidemiological studies to evaluate the potential health effects from exposures to volatile organic compounds such as PCE, TCE, and benzene in drinking finished water at U.S. Marine Corps Base, Camp Lejeune, North Carolina." Did I read that correctly?

A. Yes.

Q. Okay. "Historical exposure data needed for the epidemiological studies are limited. To obtain estimates of historical exposures, ATSDR is using water modeling techniques in the process of historical reconstruction to quantify concentrations of particular contaminants in finished water and to compute the level of duration of human exposure to contaminated water." Did I -- "drinking water." Did I read that correctly?

A. That is correct.

Q. Okay. And you're also the principal author of Chapter A for Hadnot Point/Holcomb Boulevard, correct?

A. That is correct.

Q. Okay. And these are your words, correct?

A. Yes.

Q. Okay. And so again, the -- the -- the model for Hadnot Point and Holcomb Boulevard were

-- was done in support of an epidemiological study, correct?

MR. DEAN: Object to the form of the question. Asked and answered, too.

THE WITNESS: It was done to address the five objectives or questions that the epidemiologists asked us to -- to address.

BY MR. ANWAR:

Q. Okay. In support of the epidemiological studies, correct?

MR. DEAN: Object to the form of the question. I'll let him answer it one more time. The same thing happened recently in another depo.

MR. ANWAR: Please --

MR. DEAN: You keep asking the same question.

MR. ANWAR: If we need to get Judge Jones on -- I'm going to ask you to stop making speaking objections and coaching the witness.

BY MR. ANWAR:

Q. Doctor, it's a yes-or-no question. The question is --

A. Well, no, it's not because you're asking me about what the epidemiologists did. And what I can tell you is I'm not an epidemiologist.

I don't know how they used the information, but I do know that they asked us to address five objectives. And one of the objectives was to provide monthly mean concentrations in drinking water that was delivered to residents, in this case it would be Hadnot Point/Holcomb Boulevard, and also express some range of confidence.

Q. And it was for the epidemiological studies? That's what it says here.

MR. DEAN: Object to the form of the question. The document speaks for itself.

THE WITNESS: That's what it says in -- in the report, but I would like to be clear that I am not an epidemiologist, so how it's being used from once we provided -- we provided -- all we provided were the monthly mean concentrations.

BY MR. ANWAR:

Q. You're not an epidemiologist, but you felt comfortable serving as a primary author in this report that says that, right?

A. I felt confident because these were water modeling reports and water modeling analyses, yes.

Q. Okay. Let's go to page A182.

A. Okay. Okay.

Q. And this is Appendix A-9, another Q and A section --
A. Yes.
Q. -- for the Hadnot Point and Holcomb Boulevard report, correct?
A. That is correct.
Q. And per the modeling results -- in terms of the modeling results, "what does this mean in terms of my family's health." It again states, "ATSDR's exposure estimates cannot be used alone to determine whether you or your family suffered any health effects as a result of past exposure to TCE contaminated drinking water at U.S. Marine Corps Base Camp Lejeune." Did I read that correctly?
A. Yes, you did.
Q. You have both Chapter As in front of you?
A. Yes.
Q. And for the Tarawa Terrace Chapter A and the Hadnot Point/Holcomb Boulevard Chapter A --
A. Excuse me, the mike fell off.
Q. Oh, no problem.
A. Okay. Am I okay? Okay. Sorry.
Q. No, it's okay. In either of the two Chapter A reports for the Tarawa Terrace analysis

or the Hadnot Point/Holcomb Boulevard analysis, can you point me to any statement in, I guess, Chapter A or any of the reports that the models were intended to be used for exposure determinations in specific individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: The purpose of these reports were to document model analyses, data, calibrations, to provide epidemiologists with mean monthly concentrations. How they intended to use it, their epidemiological studies, or how anyone else intended to use it is -- does not disqualify the model and is not a model limitation. The text that you have read both in Chapter -- Appendices Chapter A and that, that is a statement of agency policy because ATSDR's a public health agency and they do not conduct, to my knowledge, at least when I was there, individual analyses.

BY MR. ANWAR:

Q. And so --

A. Right? So that's a statement that -- but what people can do, what anyone else wants to do with -- with these models -- we had the same situation when we did Dover Township. In fact, we had consultants call ATSDR and wanted to know, well, can you estimate for us what our exposure was at, you know, 123 Main Street -- I'm making that up.

Q. So I think -- go ahead.

MR. DEAN: Let him finish his answer.

BY MR. ANWAR:

Q. I think the --

A. The answer -- so -- and the answer was from an agency policy standpoint, no.

Q. No, none of the reports say that the models were intended or should be used to determine exposure to contaminated water in specific individuals, correct?

MR. DEAN: Object to the form of the question. Can we go off the record and have you step out of the room, please, sir.

THE WITNESS: Sure.

MR. DEAN: Thank you.

THE VIDEOGRAPHER: Okay. Going off record. The time is 12:14 p.m.

(Off the record.)

THE VIDEOGRAPHER: We're going back on record. The time is 12:16 p.m.

BY MR. ANWAR:

Q. We are back on the record, Mr. Maslia. In order to expedite things a little bit, I'm going to ask you this question. It's going to be similar to at least the prior question, but it is a different question, for the record.

In any of the ATSDR modeling reports for Tarawa Terrace, Hadnot Point or Holcomb Boulevard, any of the expert panel summaries that you put together, any of the transcripts from the expert panels, 2005 and 2009, can you point me to a single statement from any of those experts at the time or in any of your reports, the numerous voluminous reports, stating that the results of the models are sufficiently reliable and accurate to be used for exposure determinations in specific individuals?

MR. DEAN: Object to the form of the question.

THE WITNESS: We express in numerous places that they are reliable, acceptable. Again, we were not asked or -- nor were we ever asked to apply them to individuals.

BY MR. ANWAR:

Q. Okay. Let's -- I'm going to show you another exhibit.

(DFT. EXHIBIT 11, Appendix 15 Bates-stamped CLJA_Healtheffects-0000061127 through 0000061136, was marked for identification.)

THE WITNESS: Okay.

BY MR. ANWAR:

Q. I'm going to represent to you -- do you recognize this document -- I've handed you what I've marked as Exhibit 11 -- Mr. Maslia?

A. It says Appendix I-5. Let me just find -- well, that's not it. Chapter I. Oh, okay. Okay. Yes, that's the sensitivity -- that's the Tarawa Terrace Chapter I report.

Q. Okay. This is an appendix to the Tarawa Terrace Chapter I report, correct?

A. Yes.

Q. Okay. And there at the -- the second paragraph in the appendix is a disclaimer, right?

A. I don't recall putting that there, but -- can I look at my full chapter on it?

Q. Sure.

A. It's not on my Chapter I.

Q. Yeah. And that's one of my questions to you. It's on ATSDR's website currently and it's been produced in the litigation. It is attached as part of a table to Chapter I, but not directly included in the reports. And on the table we discussed earlier, you're the primary author of Chapter I, correct?

A. Yes.

Q. Okay.

MR. DEAN: Let me object to the form of the question because I think the witness just said it was not attached to his -- or you may have said, I misunderstood, that this document Appendix I-15 is not a part of the report that was released, but is now on the website; is that what you said?

MR. ANWAR: It's available on the website.

THE WITNESS: I don't know anything about that. When I left ATSDR, the only things on the website were the published reports in 2017. So no, I have never seen that disclaimer.

BY MR. ANWAR:

Q. Right. Let's -- let's read through the disclaimer together.

A. Okay.

Q. It starts "the water modeling analysis results presented herein are provided as a service to the public for informational purposes. All analyses and computer simulation results have been reviewed for accuracy and completeness based on available information and current modeling assumptions."

A. It says "all data, analyses, and computer-simulations."

Q. Okay. "All data, analyses and computer-simulation results have been reviewed for accuracy and completeness based on available information and current modeling assumptions." Did I read that correctly?

A. Yes.

Q. Then it goes on to say "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Did I read that correctly?

A. Yes.

Q. "In addition, more updated information, if and when obtained, may change interpretations presented herein. For details pertaining to assumptions and limitations, the public should refer to the aforementioned reference list above." Did I read all of that correctly?

A. Yes.

Q. I most wanted -- most importantly I wanted to focus on -- it states, "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Did I read that correctly?

MR. DEAN: Well, you can answer that. I don't have an objection to that question.

THE WITNESS: Okay. Yes, you read that correctly.

BY MR. ANWAR:

Q. And is it your testimony that you've never seen this before?

A. No, it is my testimony I have never seen this before.

Q. Were you involved in any way in drafting it?

A. Not that I recall.

MR. DEAN: Object to the form of the question. He just told you he didn't know anything about it.

THE WITNESS: I don't know when it went on the website. The last time I checked, which was not recently, maybe two years ago or whatever, I don't recall seeing it.

BY MR. ANWAR:

Q. Do you know why this disclaimer is included as part of an appendix in Chapter I and not in Chapter A?

MR. DEAN: Object to the form of the question. Asked and answered.

THE WITNESS: It's not in -- in the published report, okay? It's -- so I don't know why or who put the disclaimer there or when it went on there. As I said, to my best knowledge, when I left in -- or retired in December of 2017, the only thing on the website were these complete reports. And I would not -- I don't understand why they would pull just this out and put it like that on the website. That may -- again, somebody at ATSDR must have made a decision, but I was not involved in that, nor was this ever -- the reference citation is correct, but the disclaimer I've never seen.

BY MR. ANWAR:

Q. Okay.

MR. BELL: At a good stop -- good point for a break or not?

MR. ANWAR: I have a little bit more questioning and then we can take a lunch break.

MR. BELL: Yeah, the chef out there won't ring the bell for the employees until we go get our food because y'all are the guests of the day. I'll leave it up to you.

MR. DEAN: Well, give him five more minutes if that's okay.

MR. BELL: No problem.

(DFT. EXHIBIT 12, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Disclaimer Bates-stamped CLJA_Watermodeling_01-0000938451, was marked for identification.)

BY MR. ANWAR:

Q. Okay. I am handing you what I'm marking as Exhibit 12.

A. Okay.

Q. Exhibit 12 is a redline of the disclaimer that we just looked at.

A. Okay.

Q. Would you agree with that?

MR. DEAN: Object to the form of the question.

THE WITNESS: It looks like a big difference to me, redlined.

BY MR. ANWAR:

Q. It's been redlined, correct?
A. Well, I know. I'm -- it's...
Q. And so this is a redlined version reflecting changes that were made to, I guess, the original disclaimer -- well, let me -- let me reask that question.
This is -- so the redlined language in here is what made it into the final disclaimer that we just looked at in Exhibit 11, correct?
MR. DEAN: Object to the form of the question.
THE WITNESS: No, that's the wrong sign. There's differences here. For example -- I'll just give a quick -- it says "the documents, graphs, and water modeling analyses." It says the water modeling analyses.
BY MR. ANWAR:
Q. I've got you. Okay.
A. Okay.
Q. Have you seen this before?
A. I don't recall seeing it.
Q. Okay. I will represent to you that the meta analysis indicates that ATSDR is a custodian and you're the author.
A. Okay.

Q. And it's dated May 23rd, 2007. Do you recall this document?

MR. DEAN: I -- object to the form of the question, not that we don't accept your representation, and asked and answered.

THE WITNESS: This seems to me to be two different documents because this, the one that you handed me, Exhibit 11, okay, the appendix stuff is from the Chapter I, not -- not the cover, not the cover page. The reference is correct, but not that. If you're saying -- and Chapter I probably came out in 2009. I can take a look at the date. February 2009. Okay.

BY MR. ANWAR:

Q. Do you remember --

A. The fact that it may have been in under my ATSDR land or wherever you obtained it from, I don't know how -- how these documents are obtained by DOJ. It could have been sent as an e-mail attachment or Office of Communication or even an epidemiologist, Office of the Director, anybody saying this is what we want to use, but, whatever, I -- you know, honestly do not remember these disclaimers.

Q. Okay. It is attached to an e-mail and

I will pull that e-mail during the break. We can talk through that e-mail.

A. Okay.

Q. The one that you're -- you're included on.

A. Thank you.

MR. ANWAR: Let's take a break for lunch and --

MR. DEAN: 45?

MR. ANWAR: That's fine.

THE VIDEOGRAPHER: Okay. We're going off record. The time is 12:29 p.m.

(A luncheon recess transpired.)

THE VIDEOGRAPHER: We're going back on record. The time is 1:24 p.m.

BY MR. ANWAR:

Q. Good afternoon, Mr. Maslia. We are back on the record from a lunch break. Are you okay to continue?

A. Yes, I am.

Q. Okay. Did you speak with your -- with the counsel about your testimony during the break?

A. No, I did not.

Q. Okay. Thank you. Before we went on the lunch break, we were discussing what I had marked as Exhibit 12, which is a redlined version of Exhibit 11, Exhibit 11 being a disclaimer and Exhibit 12 being the redline of that disclaimer.

A. Okay.

Q. I'm going to show you another document that I'm marking as Exhibit 13.

(DFT. EXHIBIT 13, e-mail correspondence Bates-stamped CLJA_ATSDR_BOVE-0000157167 through 0000157170, was marked for identification.)

BY MR. ANWAR:

Q. I will represent to you Exhibit 13 is an e-mail exchange from 2007 with you and Deb Tress from ATSDR and Frank Bove from ATSDR. And the e-mail includes an attachment with -- which is a redline of the disclaimer that we were discussing before the break. Take -- take a minute to look at it, but would you agree with that?

A. Agree that this is an e-mail about this -- yes.

Q. Okay. And so if we start at the beginning of the chain, it looks like you sent an e-mail on May 23rd, 2007 to Deborah Tress and the subject is disclaimer for website. And in it you write, "Deborah, I need a disclaimer that will come up when a person enters the Camp Lejeune water modeling website. Here's my attempt. Can you please review and provide correct legal verbiage? Thanks, Morris." Did I read that correctly?

A. Yes, yes.

Q. What -- what water modeling website are you referring to?

A. Thinking back to 2007, 15 years ago or whatever, I'm looking at the date. It's May 23rd. The -- neither the executive summary or the Chapter A report had come out yet because they were June 2007, is when they came out. And the only thing I can think of is someone above me, my supervisor or the division, were thinking that just like with other ATSDR documents, they wanted to put results on the website, but they wanted a disclaimer, an agency policy-type -- type disclaimer. That's the only thing I can, I mean, recall this many years back, okay?

Q. Okay. And I think this came up in your 2010 deposition. I realize that's now 15 years ago.

A. Okay.

Q. But at one point, did the ATSDR website contain a page or have a page that allowed an individual to go in and enter sort of when they were at Camp Lejeune and it produced numbers from the model?

A. Yes.

Q. Okay. Can you tell me about that?

A. Well, as part of our Tarawa Terrace analyses -- at that time it was just Tarawa Terrace. And, of course, ATSDR is focused on providing information to the public on their health, so we requested -- we were working with the U.S. Geological Survey. They had some web developer guys, so we requested an app that someone who resided at Lejeune or someone who didn't reside at Lejeune could put in dates, dates of service, and get an estimate, a quantitative estimate of exposure -- when I say exposures, concentrations of PCE.

Q. Okay.

A. Okay. And so the web application did go on the website. I'm trying to figure out how -- I think you showed me -- it was with this table, because that was Chapter I. That was the last chapter being -- I'm not saying we didn't have the numbers, but anyway, and at some point after it went on the website, I know I got a call and I'm sure my supervisor or the agency got a call from the Department of Navy that they were not pleased with it at all.

Q. The website itself?

A. You have to pull it down, yes.

Q. Okay.

A. Pull the application down off your website.

Q. What do you recall about the conversation -- about the call with the Department of the Navy?

A. Only that it gave quantitative estimates of mean concentrations, and my point -- it's the team's point -- was that it's contained in the report and it was just an easier way to present if someone didn't want to read the entire report to do it, and that's all I remember, is that there was some conversations with the Department of Navy. And then our web guys said there was something about security or whatever and the web -- that application never got put back on -- on the web. So my assumption is the agency just wanted to go with tabular values right out of the reports.

Q. Okay. We'll get back to the website.

A. Okay.

Q. I wanted to focus on the e-mail

exchange and the -- the redline disclaimer --
A. Okay.
Q. -- that was attached. So it's -- based on this first -- the first thread on the chain, it sounds like you attempted to draft the disclaimer and you sent it to Deborah Tress, correct?
MR. DEAN: Object to the form of the question. Mischaracterizes the document.
THE WITNESS: I don't know. If I recall, I was probably asked to produce the table, okay, here because someone wanted it up on the website, okay? And then someone probably said, well, we need to have a disclaimer, okay? I don't know who. I don't know who, but -- and so I attempted to draft a disclaimer not being an attorney, okay --
Q. Okay.
A. -- or agency policy person.
Q. Okay. And so the next exchange is an e-mail from Deb Tress responding to you saying, "so does the website help them estimate their own exposure to the contaminated water?" Did I read that correctly?
A. Yes.
Q. And then you respond to that further up

in the chain. You say, "yes, but they cannot modify our numbers. It just provides results of modeling based on the dates they enter to a website and they can also download a graph and table as a PDF." Did I read that correctly?

A. Yes, that's what I just said about getting the tables from the report, okay?

Q. And now going further up on the chain to the first page of the exhibit, Deb Tress's response to you on May 23, 2007 says, "how about this? I'm not totally clear how this is being presented, so please edit as needed. I'm not that" -- it says considered, but I think I might be concerned "with liability by ATSDR for the use of the tool, so I took out that type of language."

A. Okay.

Q. "Thanks". Did I read that correctly?

A. Yes.

Q. Okay. And then you forward that on to Frank Bove, correct?

A. That is correct.

Q. And that's the first e-mail on the page, the top of the chain. It says, "Frank, attached is a disclaimer that will appear on the water modeling website. It's been edited by Deb

Tress. Let me know if you agree to it and then I will send to our web gurus." Did I read that correctly?

A. That is correct.

Q. Okay. So earlier you indicated you -- you at least couldn't recall having seen this disclaimer before?

A. That is correct, yes.

Q. But based on this e-mail -- this is your e-mail address and you would have received the disclaimer, correct?

A. Yes, yes.

Q. Okay.

A. That's -- I mean, as I said, it was a lot of things going on around May 2007 with the prep for the subcommittee hearing and trying to get reports approved by the Office of Science and the Office of Director and stuff and...

MR. DEAN: So for the record, so we just clarify that Bates stamp numbers ends in one -- Bove 167 and goes through 170. I haven't gone to look, but I presume the document attached is what you're saying is the document that is attached that -- that he sent to Frank Bove?

MR. ANWAR: The last document on this

chain --

MR. DEAN: 170.

MR. ANWAR: -- 170 is the attachment to that e-mail thread.

MR. DEAN: Okay. Thank you.

BY MR. ANWAR:

Q. You didn't recall it earlier, but you would have received it and you were involved in the drafting process, correct?

A. It's got my e-mail address on it and, again, it looks like Office of General Counsel, Deborah Tress, edited it, okay?

Q. Okay.

A. And probably -- and sent it back to me and then I -- I didn't accept or reject the redline. It's blue on here, but that's fine. I just sent it on, as you can see by the title of the attachment, is disclaimer underscore MLMOGC reviewed.

Q. Okay.

A. Okay. So that's -- I forwarded it on to Dr. Bove.

Q. Okay. And Exhibit 11, which we discussed before the break, was the Chapter I, Appendix I-5 document. Do you recall that?

A. It's the table from Appendix I-5.
Q. Yes.
A. Again, the final version of the report -- the numbers are the same, but the final version of the complete report was not published until February of 2009, so this must have been -- I can -- I can only surmise that once this was published in 2009, they went back and replaced the original tables. Same numbers, but original tables, okay? We had completed the Monte Carlo simulation, but we had not had the Chapter I report approved, okay? So it's, you know, I guess I'm confused as to -- because the e-mail is dated 2007.
Q. Yeah.
A. The report is not -- typically we would get a report approved and then if we wanted to pull a table or a PDF or a figure or whatever from it, we would do it that way. So it's the same table. I've checked the numbers, or spot-checked the numbers, and it's the same -- same table. So maybe it was -- the report wasn't drafted when we went ahead and put that, you know, forwarded that to Dr. Bove.
Q. Do you have any idea why the disclaimer didn't make it into Chapter I itself, the full

report?

A. No, that's -- that's a mystery to me. I will say to give credit to ATSDR leadership and management, they did believe in the peer review and expert review panels that we put together, and every report went through at least two peer reviews, one internal and one external, and so I think that's why none of the reports really -- with the -- we'll get to Hadnot Point in a minute, but none of the reports contained any disclaimers like -- like you're showing here. So I don't know what prompted the disclaimer, but...

Q. Well, I will -- I will represent to you that -- and you're, obviously, welcome to go look for it yourself. The Appendix I disclaimer is still included on the website as part --

A. On the website.

Q. -- of the table -- as part of a table document. In the disclaimer where it says "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system" --

A. Are you referring to the redline or blue line -- I mean, blue line or redline?

Q. On Exhibit 11.

A. Okay. I'm sorry. Okay. Okay. Go ahead.

Q. The final version that's on the website now.

A. Okay.

Q. In the middle of the disclaimer, it says, "the results, however, may not reflect the actual exposure of specific individuals to contaminants in the water system." Do you agree with that statement?

MR. DEAN: Object to the form of the question.

THE WITNESS: I would say it has to say that because what we're presenting is a Monte Carlo simulation result, so you've got the calibrated value, the probability at 2.5 percent, the probability at 50 percent, and the probability at 97.5 percent. So your exposure may be someplace in the middle there in between those ranges. So from that standpoint, that's a correct statement because, you know, a person's individual exposure could be within that range anywhere.

Q. Okay.

A. And can I just qualify something?

Q. Go ahead.

A. When I use the words from my standpoint of exposure, I'm talking about the estimated value of the contaminated drinking water. I'm not referring to exposure like ingestion, inhalation, thermal exposure, okay? I'm just -- so I'm using the word exposure in that sense.

Q. You're using exposure in -- in the sense of drinking water?

A. Drinking water. Drinking water. But the definition of exposure -- exposure assessment is you have to really look at which pathway or multiple pathways, okay, someone may -- may have been or may be exposed.

Q. Understood. Let's turn back to your rebuttal report, which is Exhibit 6.

A. This is 5.

Q. I know, a lot of documents.

A. Four. I've got a copy here, if that's okay.

MR. DEAN: Yeah.

THE WITNESS: The tabs are just typographical edits. Not technical, typographical.

BY MR. ANWAR:

Q. That's your version of --

A. Yeah, that's my version of my response

report.

Q. Okay. Your rebuttal report?

A. Yes.

Q. Which is -- I've marked as Exhibit 6.

A. Yeah, it's here someplace.

Q. Do you have any, like, markings or writing in that?

A. I only corrected -- due to the Maslia-genetic OCD, you know, like, I referenced date is incorrect, but nothing technical. No technical changes or technical reinterpretations on here.

Q. Okay. Just like a typo?

A. Yes, yes, yes.

Q. Okay. Let's -- let's turn to page 27.

A. Okay. Okay.

Q. Page 27, at the bottom of it, contains a section in your rebuttal report, Section 4.3, excuse me, volatilization of VOCs during water treatment process, correct?

A. Yes.

Q. And this is a response to the opinions of DOJ's expert Remy Hennet about VOC losses that would have occurred during the water treatment and distribution process at Tarawa Terrace and Hadnot

Point, correct?
A. It would have occurred only during the water treatment process. It's not possible for it to occur during the distribution because you're dealing with closed pressurized pipes.
Q. Okay. You would agree during the water treatment process, correct?
A. Well, that's -- yeah, that's -- yes.
Q. So I don't want to necessarily read this line by line.
A. Okay.
Q. Unless you want to direct me to a specific portion, but I'll start more generally.
A. Okay.
Q. For much of this it appears that you are restating Dr. David Sabatini's opinion on how VOC losses are calculated and the extent of the VOC losses that would have occurred; is that right?
A. That is correct.
Q. Okay. And do you defer to Mr. -- Dr. Sabatini on those opinions?
A. Yes, the calculations that he did, the interpretations that he did, I defer to him. That's his area of expertise.
Q. Okay. You're not doing any independent

calculations on VOC losses, correct?
A. No, I'm not.
Q. And you're not doing any independent interpretation of those calculations of VOC losses, correct?
A. I'm doing comparisons.
Q. You're comparing Dr. Hennet's opinion with Dr. Sabatini's opinion, correct?
A. And -- and the Marine Corps' consultant, AH Environmental.
Q. Okay.
A. And our experts who served on the expert panels.
Q. Determining VOC losses or calculating them, that's not your expertise, correct?
A. That is correct.
Q. Okay. So turning to page 30 in your report.
A. Okay.
Q. Actually, it might be 29. Sorry about that.
A. Okay.
Q. Okay. I misspoke again. I'm sorry. It's page 31.
A. 31?

Q. Yeah.
A. Okay. I'm there.
Q. Okay. So in the -- in the second paragraph there, the first large paragraph, you go on to discuss -- it says, "additionally, in contrast to Remy Hennet's contention that ATSDR ignored or did not account for VOC losses during storage treatment and distribution"...
A. I'm there. I'm following.
Q. "This issue, including the results of the AH Environmental Consultants report, was discussed in detail with the expert panels convened by ATSDR in 2005 and 2009." Did I read that correctly?
A. Yes, yes, you did.
Q. Okay. And a little further down it says, "excerpts from the verbatim transcript are provided in Appendix A", and you're talking about the expert panel. "The consensus was there was negligible volatilization, at most 10 percent, from the spiractors." And -- so -- and then you quote, "so although we said it's probably negligible and I agree with Tom's number here, at 90 percent what's going in is coming out on the other end." Did I read that correctly?

A. Yes, and then it references Appendix A at the end of the sentence.
Q. Correct.
A. Okay. To be clear, that's not my quotation.
Q. Correct. That's from the expert panel, correct?
A. Yes.
Q. And that's Dr. Pommerenk?
A. Yes.
Q. Okay. And the last sentence there is, "in light of the conclusions of AH Environmental Consultants, 2004, and the recommendations of its expert panels, ATSDR made the decision to consider any potential VOC losses from storage, treatment and distribution as negligible." Did I read that correctly?
A. Yes.
Q. And I believe you reference in it in your report, but I'll pull out the actual document as well.
A. In which report? The expert report?
Q. It's in your expert report, but let me -- I'm going to pull out the -- the AHE report for you. Hang on a second.

(DFT. EXHIBIT 14, ATSDR Support Estimation of VOC Removal report from AH Environmental Consultants Inc., Bates-stamped CLJA_Watermodeling_010000071446 through 0000071512, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 14. Exhibit 14 is the 2004 environmental -- or AH Environmental Consultants report, correct?

A. That is correct.

Q. It's the one that you reference in your rebuttal report, correct?

A. Yes.

Q. If you turn to page 4-4.

A. Which page? Oh, report page four?

Q. Report page 4-4. Thank you.

A. Okay.

Q. At the top of the page there it states, "based on these observations, there is some uncertainty in removal estimates from the effluent pipes. Additional uncertainties are introduced by varying head losses in the pipes caused by calcium carbonate scale built-up and manual clearing -- cleaning. However, it is estimated that PCE and TCE removals due to aeration at the spiractor effluent pipes are likely to be no larger than 15 percent." Did I -- Did I read that correctly?

A. Yes, yes.

Q. So AHE's report determined up to or no larger than 15 percent, correct?

MR. DEAN: Object to the form of the question.

BY MR. ANWAR:

Q. And let me -- let me repeat the question. This AHE report determined that PCE and TCE losses or VOC loss due to aeration at the spiractor effluent pipes are likely to be no larger than -- no, to be -- than 15 percent?

A. That's what it states.

Q. Okay.

A. That's what the report states.

Q. And looking back at page 31 of your rebuttal report, that last -- that paragraph we were just looking at, the last sentence is, "so in light of the conclusions of the AHE consultants, 2004, and the recommendations of the expert panels, ATSDR made the decision to consider any potential VOC losses from storage, treatment, and distribution as negligible." Did I read that correctly?

A. Yes.
Q. Whether it's 10 percent VOC losses or up to 15 percent VOC losses, is it your opinion that 10 or 15 percent is negligible -- a negligible percent of losses?
A. Yes, compared with the differences, for example, in water sampling or the quality sampling, the uncertainties associated with well scheduling operations. And you've got to look at, you know, everything, not just isolate on -- on the water treatment plant, but considering everything 10 percent -- percent, we assumed and we were, I believe, justified in assuming it was negligible, okay? That is an -- the approach we took was a pragmatic engineering approximation through a modeling issue.
Q. For purposes of determining exposure in an individual, is a 10 or 15 percent VOC loss -- would you consider that to be negligible?
A. You would have to speak with the epidemiologist or toxicologist, okay? I couldn't say on an individual level, okay?
(DFT. EXHIBIT 15, Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa

Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions Response to the Department of the Navy's Letter on: Assessment of ATSDR Water Modeling for Tarawa Terrace, Bates-stamped CLJA_Watermodeling_01_09_0000033263 through 0000033326, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 15.

A. Okay. Response. Okay.

Q. And I wanted to direct your attention to page six, I believe, of the report.

A. Okay. The pages, I don't believe, are numbered.

Q. I think they're on the top left. Well, and let me --

A. Can you give me a Bates number because this doesn't have a report page number.

Q. Before I begin, let me -- let me start by asking you a few questions.

A. Sure.

Q. This is the ATSDR response to the Department of Navy's letter or their critiques on the Tarawa Terrace modeling, correct?

A. That's -- yes, this is --

Q. And it's entitled, on the first page there, response to the Department of Navy -- to the Department of the Navy's letter on quote -- colon, assessment of ATSDR water modeling for Tarawa Terrace, correct?

A. That's correct.

Q. Okay. Did you write this response?

A. Again, other reports, I wrote parts of it and I coordinated other people's response. I may have asked them for input and if they could respond to a certain section or not, but I coordinated the overall report.

Q. Okay. So in coordinating it, similar to the other reports that you oversaw and coordinated, would you have reviewed and had an opportunity to review the -- to comment on the report?

A. Yes.

Q. And ultimately, what was decided, would you have had an opportunity to sign off on the report?

A. It would have come from me in going up through the clearance process, report clearance process of the agency, okay? And so I would have been the one that put it into the clearance process at the first stage once I was satisfied with the report.

Q. So you would have -- you would have approved it and then pushed it up the chain, correct?

A. Yes.

Q. Okay.

A. Well, technically a report is only approved by either the Office of the Director or the Office of Science at CDC, okay? An author cannot approve an agency report. They can submit it, they can comment on it and all of that, but it's only those two, Office of Director and Office of Science at CDC, when I was there.

Q. And perhaps "approve" is a bad term because it may be a term of art --

A. Right.

Q. -- within an agency, but you would have had an opportunity to review, comment and sign up -- sign off on it and then send it up the chain to be approved, correct?

A. Yes, that is correct.

Q. Okay. So on the page with the Bates ending in 33272, if you could turn there.

A. Yeah, yeah. 272?
Q. Correct.
A. Okay. I'm there, 33272.
Q. Okay. And then the page before, 33271, it's a Department of Navy comment statement 7.1 and it's an excerpt from their letter. It says, "however, all comparisons did not fall within the calibration range. At the water treatment plant, 12 percent of the simulated PCE concentrations failed the calibration standard at the water supply wells, a majority, 53 percent, of the simulated concentrations fell outside the calibration standard."
A. Correct.
Q. Did I read that correctly?
A. Yes.
Q. Okay. And so then ATSDR responds. And if you turn the page, as part of the response on the last page there it states, "to address the issue of the intended use of the water modeling results by the current ATSDR epidemiological study, the DON, Department of Navy, should be advised that a successful epidemiological study places little emphasis on the actual or absolute estimate of concentration and, rather, emphasizes the relative

level of exposure. That is, exposed individuals are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to the, quote, true measured PCE concentration." Did I read that correctly?

A. Yes.

Q. Were you involved in -- did you -- did you write that section?

A. No, I did not.

Q. Okay. But you reviewed it and you signed off on the response before you sent it off to the appropriate --

A. I did not. It seems to me, looking at the language or the verbiage in that last paragraph, that that was written by an epidemiologist, and what I would have done as we were preparing this report -- as I said, we had a team. I may have forwarded it to the epidemiologists of the study and asked them specifically would they review it and care to add anything to it.

Q. But you oversaw the response and you reviewed it?

A. Yes.

Q. And you signed off and sent it up the chain to be approved, correct?
A. That is -- that is correct.
Q. Okay. And so as I understand it, as I'm reading this, it's -- and this is coming as part of a response to a concern, so maybe you wrote about -- raised about the accuracy of the model based on the calibration. As far as -- it sounds like for purposes of the epidemiological study that was being conducted in which the modeling was supporting, the absolute concentration values produced by the model didn't matter; would you agree with that?
MR. DEAN: Object to the form.
THE WITNESS: Well, it doesn't say didn't matter. It says little emphasis is placed on it.
BY MR. ANWAR:
Q. Okay.
A. And again, it's from -- I would interpret this, because I know I did not write this section, that that's -- you really need to ask an epidemiologist on the epidemiological interpretation of that.
Q. What it says is that that is

successful -- that the -- the intended use of the water modeling results by the current epidemiological study places little emphasis on the actual absolute estimate of concentration and rather emphasizes the relative level of exposure, right?

A. That's what it says.

Q. All right. And then it says, "that is, exposed individuals, in effect -- are, in effect, ranked by exposure level and maintain their rank order of exposure level regardless of how far off the estimated concentration is to the true measured PCE concentration", correct?

A. That's what that -- that sentence that you just read says.

Q. Okay. So if in that context for the -- of the water modeling and what was happening at the time, when you-all were -- so let's turn back to the discussion in your rebuttal report about the VOC losses --

A. Okay.

Q. -- and ATSDR's characterization of 10 or 15 percent of VOC losses as negligible. If ATSDR was performing an epidemiological study that was ranking exposure level and maintaining the rank order of individuals, does it matter -- it doesn't matter whether the VOC losses are 10 percent, 15 percent, 25 percent, does it?

A. It's an epidemiology question or toxicology or a combination of both, okay? Again, in the response, again, I can tell that's not the way I write. It was written by an epidemiologist in there and I just -- I'm not comfortable answering an interpretation from one or the other, okay?

Q. The point I'm getting at is that whatever the concentration level, you know, we're talking about is produced by the model, let's say 100, across the board for individuals, the same amount is coming off the top for the VOC losses, so 10 percent, 15 percent, it doesn't change the rank of the order -- the rank of individuals for purposes of the epi study, right?

MR. DEAN: Object to the form of the question.

THE WITNESS: Again, that's an epidemiological analysis. I've never done one of those. I've never ranked, okay, so I don't know what assumptions they are using to put into there. I know they are using the mean monthly concentrations that we reconstructed, but that's as far as I can go.

BY MR. ANWAR:

Q. ATSDR made the decision -- treated VOC losses as negligible because the water modeling was supporting an epi study, right?

A. No.

MR. DEAN: Object to the form of the question.

THE WITNESS: One has nothing to do with the other. I think we're comparing apples and oranges here. The VOC potential volatilization was geared towards our water modeling and taking the results of the simple mixing model and then putting it through the water treatment process. We did not model the water treatment process and, you know, distributing the -- the water to wherever, locations within Camp -- Camp Lejeune.

If -- back up. Based on -- again, I'm referring to the AH report, our experts. We had one of our distribution system experts, and it was our conclusion that 10 percent, 15 percent, was well within engineering applications. That is typically done in -- in engineering applications. You go from theory -- from contaminant fate and transport equation, groundwater flow, and then you have to make some assumptions, okay, some simplifying assumptions or pragmatic --

SIRI: I'm sorry. I didn't quite catch that. Can you please say that again?

BY MR. ANWAR:

Q. Siri wants you to repeat it.

A. Okay. I didn't know someone was listening, but -- and so that -- that's what our focus is. Our focus was never on how the epidemiology were going to interpret or use the results other than that the most likely estimates were mean monthly concentrations.

Q. When you're building a model and you're -- you're starting with the conceptual model, isn't part of the -- developing the conceptual model understanding what the purpose and the model will be used for?

A. No, the purpose is to get -- in terms of, if we can get specific, a groundwater flow model, for example, your conceptual model would be how does water move through the different aquifers or different layers. And contaminant transport, if there's a contaminant source or sources, how do those contaminants then mix or move with groundwater, and then how are they mixed with the different wells that may or may not intercept contaminated water, and then how they're distributed, okay?

And so your groundwater flow has specific equations with some parameters that you have to make assumptions on. The contaminant fate and transport has equations that we have to make some engineering approximations or simplifications, and the treatment process we -- we said after looking also at the data, the data, the sampling data that was provided by whoever did the lab analyses that came -- provided to us by our points of contact at Camp Lejeune, but somebody did the analyses, that there was very little negligible indication of any kind of VOC loss from the untreated, where all the raw water went in, to the treated. And that's -- I put that in -- is this the rebuttal report? I put that in the rebuttal report. We had some sampling data that showed that.

Q. I guess one of the things I -- and this is just me, like, leveling --

A. Right.

Q. -- and not, you know, taking off the

lawyer hat. One of the things I sort of struggle with is this idea that when the modeling was being performed, that the purpose for which the model was being used is somehow divorced from the decisions that were made with respect to building the actual model. And I'm saying candidly, like, reading the e-mails, the documents --

A. Right.

Q. -- it's all over the paperwork and the documents at the time that the modeling was built to support the epi study. And I think -- it sounds like, to me, you're saying that when you're building the model, you just had no idea what they were doing with the -- the model results.

MR. DEAN: Object to the form of the question. You can answer.

THE WITNESS: As I said before, if you look at the start of the project, the start, they asked us -- they saw what we did with Toms River, New Jersey and came to us and said, well, can you do the same thing with Camp Lejeune, meaning monthly concentrations or monthly -- yeah, monthly water concentrations. And so that's where we started and there were, again, the five objectives that I've stated previously, and that's how we designed the model, is to be able to reconstruct concentrations to meet those five objectives and to, you know, express some reliability, uncertainty associated with them.

How the epidemiology side or toxicology side of -- of the agency would then take those and what analyses they would do, as I said, we were blinded to that, okay? I could never tell you -- to this day, I do not know who was classified as a case, who was a controlled, where they lived, what -- how they served, when they served or anything like that. Because in developing these -- the models for historical reconstruction, they should be, as I termed it, robust, meaning anyone, not just the epidemiologists, anyone should be able to take the results of your model and apply them as they see fit given the uncertainties, the limitations of modeling.

BY MR. ANWAR:

Q. Frank Bove was the epidemiologist performing the studies, correct?

A. He was the senior epidemiologist. There was also -- now it's Dr. Perri Ruckart.

Q. Okay.

A. Those are the two people I interacted with.

Q. Dr. Bove and Dr. Ruckart, correct?

A. Yes.

Q. And if you were developing the model, you were certainly communicating with Dr. Bove, correct?

A. There were e-mails, but not -- he was not questioning us and what assumptions we were making. They would more communicate with us on two aspects. One, there's a CAP meeting and we need an update on the modeling and, two, when are we going to have some final results that we can use for the epi study, okay?

Q. Okay. You were communicating with Dr. Bove when building the model, though, correct?

MR. DEAN: Object to the form of the question.

THE WITNESS: When you say building, are you talking about calibrating the model or doing the conceptual groundwater flow model and what type of code we were going to use?

BY MR. ANWAR:

Q. Any aspect of developing either of the Tarawa Terrace model or the Hadnot Point/Holcomb Boulevard model. During the course of it, you were

discussing what Dr. Bove's needs were, correct?
MR. DEAN: Object to the form of the question. Mischaracterizes his prior testimony.
THE WITNESS: We communicated about what results they would need, the epidemiologists would need, and could we provide them. They indicated that they would need, at one point, trimester information. So if we could give them monthly, that would -- they would be comfortable with -- with monthly values.
BY MR. ANWAR:
Q. Was Dr. Bove permitted the opportunity to weigh in on modeling decisions? So, for instance, parameter inputs that you decided on and assumptions that were made?
A. I may have copied him if I sent out a group e-mail, if we were discussing modeling things, but he would not come back and say, no, you should use, you know, 100 or 30 or whatever parameter. We never had those kinds of discussions. He left that strictly to the water modeling team.
Q. So turning back to your rebuttal report.
A. Okay.

Q. I think it's page 31.
A. Okay.
Q. There -- actually, I may have told you the wrong page again. Give me one second. Okay. It's page 30, actually. I'm sorry.
A. Okay.
Q. At the top of that page it starts, "in addition, Remy Hennet's assertion that" --
A. Wait. Page 30.
Q. 30 of your rebuttal.
A. This says rebuttal.
Q. It's the first full sentence.
A. Oh, okay. I see it. Okay.
Q. It states, "in addition Remy Hennet's assertion that ATSDR did not account for such VOC losses is incorrect." And then it goes on, "first ATSDR analyzed sampling data of water from both pretreatment and posttreatment." And then you list in a table sampling data for the Hadnot Point water treatment system?
A. Correct.
Q. And the rest of that is a discussion about the sampling data from the Hadnot Point water treatment system. I don't see anywhere in that paragraph any discussion about Tarawa Terrace. And

it's true that the Tarawa Terrace model didn't account for VOC losses at all, right?
A. No, we said they were negligible at each treatment facility. It's just that at Hadnot Point we actually had sampling data, okay? A pair and a triplet, okay? And, for example, for July 27th, 1982 for TCE, we have -- the untreated water is 19 micrograms per liter and that same day -- I can't say what time it was taken at, but we've got treated water at 21 micrograms per liter, allowing for measurement error. It appears to me that there is no VOC loss and that is in sampling data that -- and so, again, you can calculate using equations, but the sampling data showed no VOC loss.
Again, on here there is -- at the top of page 31 it says "at the Tarawa Terrace water treatment plant there's triplet measured data taken on July 28th, 1982." And in this -- in this one it's classified as finished, untreated, and treated water. So 104 micrograms per liter finished water, 76 untreated, and 82 treated water, okay?
Q. Those --
A. Now, again, you have variations like this in water -- water samples, but it does not

seem to me that there are any VOC losses.
Q. So we'll turn to the sampling data as it relates to Hadnot Point --
A. Okay.
Q. -- because that discussion is all about Hadnot Point, correct?
A. No, no, I just said this is Tarawa Terrace. I just -- the triplet is data from Tarawa Terrace. The TTWTP is our acronym for that.
Q. What page are you looking?
A. Page 31 at the top.
Q. Now, when you were comparing the sampling data to determine no VOC losses, so for both Hadnot Point and Holcomb Boulevard, did you take into account whether or not the -- the wells, the contaminated wells, for those two treatment systems had been pumping?
A. We do not have information on sampling data, I believe, on any of the sampling data, whether the wells were pumping or not -- not pumping. We may be able to make some judgments based on before and after if it's at the same -- same -- same well, whether the well was pumping or not, but we had no information on the pumping status of the well, but that would not have -- you

would not have lost any VOCs in the well because it's not that you have air space in there. The well is screened down through the aquifer, okay? It's completely filled with water.

Q. Well, you're -- you're basing the conclusion at the top of page 31 as it relates to Tarawa Terrace, and I think for Hadnot Point as well, you're comparing finished water samples versus untreated water samples, and you're reaching the conclusion, it seems to me, that in comparing those, just the -- the sampling results, there were no VOC losses, right?

A. Well, the data indicate that and then taking that in addition to what our expert panel said, maybe 10 percent or so, that leans you towards the minimum for the negligible losses because I would expect if there were VOC losses, and let's say 10 percent, I would expect to see that in the sampling data to be reduced for the sampling data from the untreated water, which is probably the raw water tank where all the wells mix in together, go through the treatment process, and then they put it into a treated water tank either elevated or underground. I would have expected to see some losses.

Furthermore, I might add, in the period January 28th through February 8th, 1984, there was an eight-day period when they had to shut down the Holcomb Boulevard water treatment plant. Holcomb Boulevard was never served with -- did not -- the treatment plant was -- never had contaminated water, but when they shut down during that eight-day period, the distribution system going into Holcomb Boulevard received contaminated Hadnot Point water. And if you just look at some of the values, and I put the ranges in there. I believe there's a CLW document that lists them all the way from 24.1 to over 1100. So again, I'm going to ask again, where are the losses?

Q. So for instance, for Tarawa Terrace, the -- the source or the primary contaminated well was TT26, right?

A. That -- that was the main well, yes.

Q. And there's statements in the reports, and we'll look at them, that -- but would you agree that when TT26 was pumping, the -- the contaminant concentration levels were higher?

A. Yes.

Q. And when TT26 was not pumping, the contaminant concentration levels decreased, and I

think you stated in your expert panel that -- in one of the expert panels that the concentration levels went down to almost zero?
A. Well, that's shown in our Chapter A report, too. When they shut the well down for maintenance, okay, so it was not pumping, the concentrations at the water treatment plant went down to near -- near zero, and that also is what proved to us that TT26 was the driving force or the driving well in that whole -- whole system.
Q. So the only point I'm trying to make with respect to comparing finished samples from finished water versus untreated water at Tarawa Terrace and at Hadnot Point, I mean, simply -- context matters. Simply comparing samples from untreated water and finished water doesn't tell you whether the well was pumping, whether the contaminants were increasing, whether the well -- whether the well had stopped pumping and the contaminants were decreasing, you can't make a determination on VOC losses solely by comparing a finished water sample and an untreated water sample?
MR. DEAN: Object to the form of the question. Compound. Complex.

BY MR. ANWAR:

Q. You can answer.

A. Okay. I think you are confusing -- and I don't mean that as a personal attack.

Q. Sure. No offense taken.

A. Confusing different mechanisms and different aspects of the entire process of delivering, obtaining water from the aquifer to the delivery point, okay? The samples -- there's some samples at TT26, okay, that's at the well, and that -- that says nothing about -- and honestly, that says nothing about the treatment process. The treatment process occurs after all the wells mix in in the entry to the water treatment plant, okay?

So if I take a sample, and let's say untreated water, which will be the raw water tank, okay, and I get a -- a value, a concentration, and then I take a similar sample and I'm assuming they are using the same testing methodology at the treated end, which would be on the other side of the spiractors, the other side, and I don't see any -- any losses, any changes, decreases in concentration, excuse me, can I -- then what I am saying is it's a good assumption, a good engineering assumption, that even -- whatever losses there are are so negligible that we're not able to measure them. Or the people that measured them, the same -- the ATSDR did not actually measure those -- those samples, okay? And that's, again -- and everything that we do in modeling and interpretations and all of that, it's sort of a weight of evidence approach.

Q. Sure.

A. Okay? So we've got the AH report. We've got our expert panel. We've got -- these members actually did water distribution system testing at various -- not at Camp Lejeune, but at various locations, and we've got sampling data. So you've got to take it all -- all together, okay?

Q. I just have a few more questions on this topic --

A. Sure.

Q. -- and then we'll take a break.

A. Okay.

Q. Now, using Tarawa Terrace again as the example, TT26 was the main well that was contaminated, correct?

A. That is -- that is correct. There was some contamination at TT23, which is referred to as the TT new well. It only ran for about nine months maybe. When it was put in, it was put in to a contaminated aquifer, okay, so that's why its concentrations are high immediately. But again, TT26 was the major contributor.

Q. TT26 and TT23 weren't the only wells providing water in Tarawa Terrace, right?

A. That is correct.

Q. And the wells at Camp Lejeune, including Tarawa Terrace, were cycled, right, in terms of the usage?

A. They recycled, yes, yes.

Q. And so simply comparing a finished water sample versus an untreated water sample doesn't tell you anything about which well the water was coming from, right?

A. Well, we knew that based --

MR. DEAN: Object to the form.

THE WITNESS: We knew that based on the modeling, okay, the contaminant fate and transport model. The output of the contaminant fate and transport model were the concentrations at specific wells, okay? And you have to look in the model output and you can see which wells were turned on or off during which month. And then we had, again, a simple mixing model.

BY MR. ANWAR:
Q. And --
A. And the key is the simple mixing model mixed all -- all the wells together, okay, for conservation of mass and continuity. And so when we get a monthly concentration out of the mixing model, okay, that's what we said went into the water treatment plant.
Q. In -- in comparing finished water samples and untreated water samples for purposes of your rebuttal report in offering opinions about VOC losses --
A. Right.
Q. -- at Hadnot Point and Tarawa Terrace, did you go back and look to see what time frame the samples came from, whether the wells -- which wells were turned on and off, what information was available?
A. Let's see what this is. I looked at the treatment process, okay, because that's -- that was the focal point of those claiming there were major VOC losses versus negligible. And so I looked -- you have to look at the treatment process, okay? The treatment process starts at the mixing of all the wells into the raw water tank.

And the assumption, engineering assumption, is that there's instantaneous mixing, and we prove that in the Chapter I report because we run parallel models. We run the full-blown EPANET model, which is water distribution, and we run the mixing model. And after a week or ten days, they are equivalent to the -- out to the four decimal places. So that means you have -- the mixing model in addition to what our expert panel told us, all the wells were mixing at the water treatment plant in the raw water tank and there was instantaneous mixing compared to our monthly concentration needs.

Q. Okay. I think my last question on this, so just taking the Tarawa Terrace example here in your report at the top of page 31 where you're comparing the 104 microgram per liter unfinished water versus the 76 microgram per liter in untreated water and the 82 microgram per liter in treated water --

A. Right.

Q. -- I don't see it anywhere in your report, but -- and so I think you would agree that you don't know what percentage of water in the untreated, treated, and finished water samples at Tarawa Terrace came from TT26, right?

MR. DEAN: Object to the form.

THE WITNESS: You -- you could -- you could actually compute that because the process to get the mixing model results would be is you take the well's capacity for a given month, how much it's pumping, what the concentration is -- let me back up. Hold on. Get the chapter right. It's easier for me to explain the Chapter A here. Here. Okay. It's -- it's a model here. Okay. Page A40 in Chapter A, equations one and two. Concentration of PCE in finished water, okay? So we have all of the information. You see it's summing over however many wells were pumping versus whether they are contaminated or not. So, yes, we do know, but the assumption was -- in agreement with what our expert panel recommended -- is that you could assume instantaneous was a CSTR, continuously stirred tank reactor model, for the mixing model. And so the minute the wells hit the raw water tank, they all mixed. And to us instantly was anything less -- a good portion less than a month. And that's shown in the Chapter I report. I can tell you exactly where in a minute.

Q. Why don't we go ahead and take a break if you're --

A. Okay.

THE VIDEOGRAPHER: Okay. We're going off. Record the time is 2:33 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 2:43 p.m.

THE WITNESS: Is it possible to qualify or continue with where we left off?

BY MR. ANWAR:

Q. Sure. Did you have something you wanted to --

A. Yes.

Q. -- correct or --

A. I would like you to turn to the Hadnot Point/Holcomb Boulevard Chapter A report.

Q. Sure. What page are you --

A. Page A38, Figure A15.

Q. A38, A15.

A. Yes.

Q. Okay.

A. Okay. This is the same mixing model that we talked about at the Tarawa Terrace. You'll notice the equations on page -- the next, page A1 and A2 are the same equations one and two in Tarawa Terrace report in Chapter A.

Q. Okay.
A. What I want to point out to is -- and this is a conceptual or a schematic. If you look at the distribution network of pipes on the left-hand part of the Figure A -- mixing model approach is the title of that section.
Q. Okay.
A. You'll see that there are little -- towards the right there's HPWTP, that tank represents HP, and you've got contaminated, meaning red, or uncontaminated, blue, symbols there mixing into the -- into the HPWTP. Now, we did not do step-by-step treatment process. What the assumption is, and a correct assumption, an approximation, is that they all instantaneously mixed in the raw water tank. Once they mixed in the raw water tank, if, in fact, there's this massive VOC loss, you would see it in the samples, and we didn't. And so our assumption was that there was negligible losses within the treatment process, and so what -- the concentration in the tank through the mixing model is the same as the contamination anywhere throughout the distribution system.
Q. Okay. But you're talking sort of --

you're talking in the context of model -- still the model, right?

A. That's exactly correct, yes.

Q. And at the end of the day, a model is an approximation of reality, right?

A. Yes.

Q. There is no way to perfectly replicate reality, right?

A. No, a model is an approximation. Some are closer approximations and some are -- are not as close, but it is an approximation. But at the end of the day, if we are going to test the model out, I'm speaking generically now of the model, then that's where we go and gather some field information or sampling information and see if it, in fact, proves or supports -- that's probably a better word -- supports the assumptions that we made using this model.

Q. The pumping data for Tarawa Terrace and TT26, the wells in Tarawa Terrace and TT26 in particular, that was limited, right?

A. The pumping data? We had -- we had monthly data. We had some early on in the -- early, early '50s or '40s. We had some annual pumpage data. And then in -- I believe from about

-- for Hadnot Point from about 1998 through 2008, we had daily pumping values.

Q. You said from 1998 to 2008?

A. That's my recollection, yes, we had daily -- daily values.

Q. Well -- and those values are sort of outside the time period we're -- we're interested in, right?

A. No. Again, you've got the epidemiological study, which goes from '68 to '85, but we're using -- and I'm going to limit this right now to groundwater flow and contaminant fate and transport models; those are boundary-valued problems. So you've got to take them out or start them from a period of known water level, a period of known concentration, and run them out until you get back to a period of known information.

We -- at Hadnot Point we had some known information because they were doing remediation pumping so that the models there went out all the way to 2008 because it was another set of data in addition to the 1980s data that could get -- build confidence, substantial confidence, in the modeling results. So the models went out or started based on hydrogeologic and modeling concepts and frametimed where -- and part of the model went through the epidemiologic study period, the two -- in other words, the epidemiology did not control when we started or ended the model.

Q. 1998 is after 1987, right?

A. Yes.

Q. And --

A. If you're interested in building confidence in your model and testing out the goodness of fit of your calibration, if you've got another set of information past the epidemiology -- again, the epidemiology doesn't impact how we're calibrating or developing the model -- then you want to use that.

Q. I guess more broadly speaking, you know, we can debate the points of the actual modeling, which, you know, you're an expert on it and I'm not. But if ATSDR's modeling accounted for VOC losses, why was it necessary to make a statement that the VOC losses were -- were negligible and, you know, why was it necessary to make that -- that determination?

A. Okay. Because you needed to somehow quantify, I felt, what he meant by negligible. He does not say zero. He said negligible, okay? And

I'm speaking again in terms of pragmatic engineering applications doing modeling; you make these kinds of assumptions, okay? He also had wanted to make sure someone -- when we say negligible, if they read the expert panel and saw Dr. Pommerenk, who is, I believe, AH consultant for the Marine Corps who sat on our expert panel saying, well, less than 10 percent, then someone reading our reports would say, okay, negligible 10 percent -- even if there's VOC losses, there's somewhere less in that -- in that range, and now I'm looking at sampling data and it doesn't appear to be from the sampling data any -- even 10 percent loss anywhere, so negligible is a good approximation.

Q. You -- and coming out of the expert panel, you-all landed on 10 percent, right?

A. That's what the expert panel said, okay? And that's when we got together either in a team meeting, not part of the expert panel, but, you know, subsequent, because the expert panel made many recommendations, which we typically either generally followed, and we, you know, we would just say, oh, well, it's 10 percent, that's negligible compared to the variation and all the other parameters. Sampling data, aquifer properties, and things of that -- well operations, things of that nature. So we were confident with the -- had confidence in assuming negligible VOC losses.

Q. And the AEE report said up to 15 percent, right?

A. Yes.

Q. And so when -- when we're talking about negligible in terms of the decision ATSDR made in determining VOC losses were negligible, we're talking about between 10 and 15 percent, right?

MR. DEAN: Object to the form of the question. Mischaracterizes the prior testimony.

THE WITNESS: I would say it was 10 percent because the representative of AH Consulting Dr. Pommernek, who was also representing the Department of Navy, U.S. Marine Corps on the expert panel then -- then said, well, you know, I'll give you that 90 -- there's a 90 percent passthrough, so that's 10 percent. And then we also had other water distribution system experts on there and -- like Dr. Walski, Dr. Grayman, Dr. Clark, and they indicated in their experience that there would be even less than 10 percent negligible.

Q. Okay.

A. And they have done analyses with other water distribution systems like Tucson, Arizona, Redlands, California and so on.

Q. Let's turn to Exhibit 10, which is Chapter A for Hadnot Point and Holcomb Boulevard.

A. Okay. Oh, I've got it open right here. Okay.

Q. And let's turn to page A1.

A. Okay.

Q. So just -- just so the record is clear, we're now discussing the analysis for Hadnot Point/Holcomb Boulevard, right?

A. That is correct, summary of findings.

Q. And footnote number seven on the first page states, "for this study, finished water is defined as groundwater that has undergone treatment at a water treatment plant and was subsequently delivered to a family housing unit or other facility. Throughout this report and the Hadnot Point/Holcomb Boulevard report series, the term finished water is used in place of terms such as finished drinking water, drinking water, treated water or tap water." Did I read that correctly?

A. Yes.

Q. So ATSDR modeled -- ATSDR said it

modeled water that had undergone treatment at a -- at a water treatment plant at Hadnot Point, correct?

A. That's not what that says, or that's not what I interpret that to say. What that is is trying to define what finished water is, okay? There are different names. Some people would say potable water, okay? It's not the same as potable water. It's not the same as groundwater. It's treated water, but that statement does not say we modeled the treatment process. And I've -- I've never maintained that we modeled the treatment process.

Q. Okay.

A. And our expert panel in 2005 also said that the treatment process did not have to be modeled.

Q. Let's turn to page A33.

A. Okay. Okay. I'm there.

Q. Looking at number nine.

A. Okay.

Q. It states, "reconstructed simulated monthly mean concentrations of PCE, TCE, 1-2-DCE, and vinyl chloride and benzene for finished water at the Hadnot Point water treatment plant were determined by using a materials balance model simple" --

A. Materials mass balance.

Q. Excuse me. "Materials mass balance model, simple mixing, to compute the flow-weighted average concentration of the aforementioned contaminants. This computational method is based on the principals of continuity and conservation of mass, Masters 1998. The use of the materials mass balance method is justified because all raw water from water supply wells within the Hadnot Point water treatment plant service area was mixed at the Hadnot Point water treatment plant prior to treatment and distribution." And then it says, "details of this method are described in a subsequent section of the report." Did I -- did I read all that correctly?

A. Yes.

Q. Would you agree that what ATSDR called finished water at the Hadnot Point water treatment plant was based on a material mass balance model, simple mixing, to compute flow-weighted average concentrations of contaminants?

A. Yes.

Q. And agree that mass -- a mass balance

-- agree it was a mass balance model based on continuity and conservation of mass?

A. Yeah, that's what equations A1 and A2 in this report and equations one and two in the Tarawa Terrace Chapter A report -- the first equation is continuity. The second one is conservation of mass.

Q. Agree that continuity and conservation of mass means the simple mixing model assumed that mass of all contaminants entering the water treatment plant were conserved through the water treatment plant?

A. Yes.

Q. Okay. And they continued, correct?

A. What do you mean?

MR. DEAN: Objection to form.

BY MR. ANWAR:

Q. It assumed that they continued the --

A. You mean the flow continued?

Q. The mass of the contaminants.

A. I'm not following you. Are you asking did the concentration from one -- once it's mixed at the raw water tank is the same as the concentration in the finished water tank?

Q. I think you answered my question.

Let's -- would you agree ATSDR modeled influent to the water treatment plant as having the same contaminant concentrations as the effluent from the water treatment plant?

A. No, we modeled -- the influent, to me, by definition, would be the different wells coming into the raw water treatment tank. If you look at the water distribution system utility maps, you'll -- you'll see that the raw water from wells were typically piped over to the raw water tank through concrete pipes, okay, underground pipes. So once all the wells fed into there, in the raw water tank, I assumed there was instantaneous mixing, as the mixing model does, okay, and then that -- that would equal the finished water concentration.

Q. Okay. Let's look at A62.

A. What? I'm sorry?

Q. A62.

A. On HP report?

Q. Yes.

A. Page 62. Okay. Okay.

Q. Looking -- focusing on Table A18, you would agree that Table 18 shows, among other things, measured TCE concentrations at the Hadnot Point water treatment plant?

A. Yes.
Q. Looking at TCE, you would agree there are only a few measurements each of treated and untreated water?
A. Yes.
Q. Agree the data is insufficient to conclude no treatment losses, right?
MR. DEAN: Object to form.
BY MR. ANWAR:
Q. You can answer.
A. Okay. Using the data that we have, you always want more data as a modeler, okay, always. That's -- okay. So if you're asking me as a modeler would I want more data than this, yes, but we were working with the data that we had and that was presented to us. And given this data, I see, again, July 27th, treated -- or let me see the exact wording, untreated and treated, footnote five and six, they are approximately the same value. That's the data I referenced in my rebuttal report. So you use that data because that's what we have.
Q. Direct me to that again.
A. On page A62, if you go to 7/27/82, the first listing has a footnote five which says untreated. The second listing, 7/27/1982, under

TCE, it says 21.

Q. You said 7/27/1982?

A. Yes.

Q. TCE. And then the listing underneath it, you're saying is --

A. It gives the treatment status.

Q. And your -- your opinion is that the model indirectly accounted for treatment losses based on those two points of data?

A. Based on those two points. Based on, also, the January 28th through February 4th, 1985 shutdown of the Holcomb Boulevard treatment plant where we just saw huge slugs of TCE within the Holcomb Boulevard treatment system -- not treatment, but distribution system. So again, we used a weight of evidence approach. And then, again, referring back to the expert panel report that said, well, we did 10 percent, we -- we said that justified the assumption of negligible.

Q. For the samples that you're -- that we're discussing, the 7/27/1928 for TCE.

A. Yes, uh-huh.

Q. ATSDR didn't know if HP651 was pumping on that day, right?

A. We could go back to the reconstructed

-- reconstructed pumping schedule and -- and figure out if it was pumping or not. I would have to look -- I would have to look at our pumping schedule.
Q. Okay. But that's a reconstructed pumping schedule, correct?
A. It's still the only thing close to reality that we have.
Q. But it's not reality, right?
MR. DEAN: Object to form.
THE WITNESS: It's what we used to reconstruct and then compare these values to -- to that. So it was -- it was pumping in the model.
BY MR. ANWAR:
Q. For -- in the absence of pumping data for Tarawa Terrace, at least --
A. Right.
Q. -- ATSDR assumed that a well was pumping unless you had evidence affirmatively disproving that it was pumping, correct?
A. That is correct. And we then tested that out through an uncertainty analysis by varying the pumping through a Monte Carlo-type uncertainty analysis, but the calibrated model assumed continuous pumping unless it was shut down for maintenance purposes.

Q. And with respect to the samples that we've been discussing, the July 27, 1982, ATSDR didn't know if HP651 was pumping the day before either, right?
A. No, there's no indication as to the status of the water supply wells feeding the raw water tank. These are taken at the treatment plant, not at the wells, if I'm -- yes, these are taken at the treatment plant. So the wells have already mixed, on, off, whatever.
Q. When you say no indication, what do you mean?
A. There's no -- this table here is from the water treatment plant, okay?
Q. Yeah.
A. So it does not contain an indication as to which wells were on, which wells were contaminated, which wells were on and not contaminated, and which wells were off, okay? This -- this particular table, okay? This is a result of applying the -- a mixing model, a flow-weighted mixing model.
Q. When you say this is the result, what do you mean "this?"
A. Well, if you look under the

reconstructed column, the middle column there.
Q. Yeah.
A. Okay. That's what -- once we got the concentrations out of the model for each of the Hadnot Point wells --
Q. Yeah.
A. -- and we can tell which ones were operating, which ones were not and have a zero there, and then we knew what the reconstructed concentration is, so then we would tabulate those into an Excel spreadsheet, do the flow-weighted mixing in the Excel spreadsheet.
Q. And, you know, I'm talking about not the reconstructed schedule, but about real-world data?
A. I understand that, but, again, as I think we've discussed real early on, if my recollection is correct, these are one point in time samples, okay? And we are -- we are doing monthly simulations, monthly results. So that's, you know, just -- you need to keep that in mind when you're looking at data versus modeling results.
Q. Agree -- you would agree that you don't know the percentage of water in those samples that

came from HP651?

A. Not in the -- not in the samples, but I would know -- I would have to tabulate it, but I would know in the reconstructed column.

Q. But the reconstructed column is a simulation, right?

A. That's our best estimate, most likely estimate.

Q. Okay. And that's because you don't know the real-world data on whether -- what percentage of water in those samples came from HP651?

A. Not from the sampling data. However, you do have the previous table, I think, or somewhere in here, it's early on, there is a table -- let's see. Here you go. Page A48.

Q. So I wanted to actually change topics a little bit.

A. Oh, sure. Okay.

Q. Shift gears a little bit. You would agree that it takes time for water to get through the -- the water treatment plant, right?

A. Compared to the groundwater system, it's instantaneous. I'm talking about hours or maybe even minutes compared to days or months or longer than that, you know. That's -- I think, as I said previously, water distribution system models use an hour time step, and you typically would measure pressures. If you had any concentrations, you would measure those at, say, at 15-minute intervals, so you're talking about a much more rapid process.

Q. Similar to our discussion on TT26 for Hadnot Point, you would agree that whether -- whether HP651 was pumping had a significant impact on the concentration of TCE entering the Hadnot Point water treatment plant, right?

A. Yes.

Q. And you would agree that when HP651 stops pumping or stopped pumping, concentration of TCE entering the Hadnot Point water treatment plant would go down very quickly?

MR. DEAN: Object to the form.

THE WITNESS: Well, we could look at the graph on page A63 in Chapter A here, Figure A27. And you do see up and down with -- of TCE at the water treatment plant, which is indicative of cycling on and off of HP651. But unlike TT26, the only time it goes to zero or close to zero is after they completely turned the well -- the well off.

Q. But when HP651 stops pumping, concentration of TCE entering the HP -- the Hadnot Point water treatment plant goes down, right?

A. It -- it gets reduced, but because there were so many -- there were other wells pumping and contributing to the water treatment plant and supplied -- supplied water, some of those other wells, if they were contaminated, would -- would, you know, add to the concentration at the water treatment plant.

Q. You would agree that when HP651 stops pumping, at that very moment water coming out of the Hadnot Point water treatment plant entered into it with TCE concentrations from when HP651 was pumping, correct?

A. Could you repeat the question again? I'm sorry. I didn't follow.

Q. Sure. So when -- when HP651 stops pumping, the water that was pumping into the Hadnot Point water treatment plant doesn't immediately go away, right?

A. That is correct.

Q. That water that had been pumping from HP651 continues through the water treatment plant, correct?

A. Yes. Again, the pipes are pressurized and water is flowing full, okay? A storage tank is not pressurized like the distribution pipeline, but it's full, and so it's not that you have no water stopped at 651 and then the raw water tank has no more water in it. It's still filled with the previous day's concentration, and if 651 was not pumping on a particular day, you would still have contaminated water in that raw water tank.

Q. And so carrying that through to conclusion, if 651 stopped pumping and that water -- but the water that had been pumping from 651 into the Hadnot Point water treatment plant entered into it and then continued to be distributed, the finished water sample from -- from that water that pumped through 651 -- or excuse me, from the 651 water that had pumped through the Hadnot Point water treatment plant would reflect that contaminated water, right?

MR. DEAN: Object to form.

THE WITNESS: Okay. Could you clarify that?

BY MR. ANWAR:

Q. Sure. So a moment ago you agreed with me that when HP651 stops pumping, at that precise

moment the water that had been pumping into the water treatment plant at Hadnot Point doesn't go away, right?
A. That is correct.
Q. It -- that water that had been pumping from 651 remains in the water treatment plant, correct?
A. Yes, the water that's there the previous day when HP651 was pumping, let's say -- for argument's sake let's say it's still there, okay, but over a day's period it probably moved through the treatment process.
Q. And a moment ago we -- we discussed that ATSDR treated or used a mixing model for purposes of finished water, correct?
A. That is correct.
Q. And so -- well, let's -- let's -- stepping away from the model, that water in the Hadnot Point treatment plant from 651, that doesn't immediately disappear, that still ends up in the finished water, correct?
A. That is correct.
Q. Okay. And then 651 is now stopped and other wells are pumping water to it, correct?
A. They are compensating for the loss of

the volume of the well, okay? Because at the end of the day, when we were there in 2004 and historically, having spoken with past operators, they had to keep their tanks, finished water tanks nearly filled for fire protection, okay, so they -- you would have had to compensate for HP651 with other -- other wells.

Q. And those other wells pumping into the HP treatment plant could include wells that weren't contaminated, right?

A. That is correct.

Q. So in that case, if you were to take an untreated sample and compare it to the treated sample from the -- the HP651 water that went through the system, the treated water would be higher, likely, than the -- the untreated water sample taken at the water treatment plant?

A. Again, I think we need to view this in terms of the historical reconstruction that we did on a monthly basis. Even though -- even though the distribution system does the EPANET model, you can do hourly calculations, meaning you can do daily calculations. The output from the contaminant fate and transport model and the mixing model are valid on a monthly basis. So over a month, you would have seen 651 come back on.

Q. But again, we're talking about the model simulation world and not the real world?

A. But that's what we did at ATSDR. I mean, that's -- that's the whole concept of historical reconstruction or modeling in general, is that we used models and applied models where we may not have information, real data, and you build confidence by the calibration process to use -- use those models. We took, at ATSDR, the sampling data that was provided to us by the Marine Corps, Department of Navy or other -- other water quality labs and that's the data that -- that we had.

Q. I'm going to hand you what I'm marking as --

MR. ANWAR: I'm sorry. Can you remind me, is this 15? I forgot to write one down. 16.

(DFT. EXHIBIT 16, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A-Supplement 2, Development and Application of a Methodology to

Characterize Present-Day and Historical Water Supply Well Operations, was marked for identification.)

BY MR. ANWAR:

Q. Did I actually hand you the exhibit?

A. No.

Q. Sir, do you have the exhibit?

A. No, you didn't tell me what 16 was.

Q. Sorry. I just put the sticker on it and I lost my train of thought. I'll just put another sticker on it.

Okay. I'm handing you what I've marked as Exhibit 16.

A. Supplement 2. Okay.

Q. Can you turn to page -- so for starters, this is part of the Hadnot Point/Holcomb Boulevard analysis, correct?

A. Yes, it's Supplement 2 of Chapter A.

Q. Okay. And the title is "development and application of a methodology to characterize present-day and historical water-supply well operations", correct?

A. That is correct.

Q. Okay. If you could turn to page S2.2.

A. 2.2. Okay. 2.2. Okay. Background?

Q. Yeah.
A. Okay.
Q. And so at the top of that page on the right-hand side --
A. Right.
Q. -- paragraph starting "detailed daily data."
A. Let me just take a look. Okay. I'm there.
Q. Okay. So it starts by stating, "detailed daily data pertaining to the pumping schedule of the wells are available subsequent to January 1998", correct?
A. That's -- yes, that's what we previously discussed.
Q. Sure. And then "prior to 1998, data pertaining to wells operation are limited or unavailable", correct?
A. That is correct.
Q. And then it goes on to state, "similarly, daily water treatment plant raw water samples are available" --
A. Raw water volumes.
Q. Volumes. Excuse me, are -- let me reread that.

A. Okay.
Q. "Prior to, similarly, daily water treatment plant raw water volumes are available after December 1994", correct?
A. That is correct.
Q. "And then between 1980 and 1994, monthly raw water volumes are available. Yearly volumes are available for some times -- for some years prior to 1980. A trendline was used to estimate raw water flows for years prior to 1980 when no data exist. Monthly raw water flow percentages were then calculated using known monthly data for the period 1980 to 2004. These values are used to estimate monthly raw water flows prior to 1980. This methodology is based on two assumptions: Similar characteristics of the operational patterns of the wells and water treatment plants for the periods of time before and after January 1998 and, two, the quality between total water volume delivered to the water treatment plant from the operating wells and the water treatment plant raw water volume data at all times." Did I read that correctly?
A. Yes, you did.
Q. Okay. Agree -- you'd agree that prior

-- based on this, prior to 1998, data pertaining to well operations was limited or unavailable?

A. Yes, that's what that says.

Q. Agree that according to this, that there were daily water treatment plant raw water volumes available after 19 -- after December 1994, correct?

A. Yes.

Q. Agree there were monthly raw water volumes available for 1980 to 1994, right?

A. Yes.

Q. And then there were some yearly volumes prior to 1980, right?

A. That is correct.

Q. ATSDR had to estimate pumping schedules due to the lack of this data, right?

A. We had to estimate pumping schedules to get the operational -- I'm equating operational and pumping schedules to be able to code them in -- on a monthly basis to the -- to the model, to the groundwater flow and contaminant fate and transport.

Q. And so if we go on to the next paragraph, data availability.

A. Okay.

Q. "Four types of data sources pertinent to water supply well operation -- operational records and water treatment plant raw water records are used in this supplement." It says "these are daily operational records, January 1998 to June 2008. Number two, Camp Lejeune historic drinking water consolidated document repository records. Number three, Camp Lejeune water documents. Number four, U.S. Geological Survey. Using these data sources, operational chronologies for 1996" -- excuse me.

A. Wait.

Q. "Using these data sources operational chronologies for 96 wells supplying groundwater, in parentheses, raw water, to the Hadnot Point water treatment plant and Holcomb Boulevard water treatment plant were developed." Did I read that correctly?

A. Yes, yes.

Q. You would agree that ATSDR didn't use pumping data from the '80s, but used data from pumping schedules after 1998 to estimate pumping schedules during 1953 to 1987?

A. The way the methodology that's described in Supplement 2, there was a training period and then a predictive period. So the training period typically went from 1998 to 2008 because that was known information on a daily basis. And once we obtained the characteristics of the operating wells based on that, then we could go out and where we either had partial data or missing data, use the prediction from there and apply the prediction to the data gaps.

Q. So for Hadnot Point/Holcomb Boulevard analysis and the model, you used predictions based on pumping schedules after 1998, correct, to -- to let me ask that again.

So based -- for Hadnot Point/Holcomb Boulevard you used pumping schedules from after 1998 and predicted backwards the pumping schedules during 1953 to 1987, right?

MR. DEAN: Object -- object to the form.

THE WITNESS: Again, it says -- I think it was up -- yeah, we also used -- for data we're missing a trendline, which is an accepted statistical approach in engineering. And the algorithm developed by who is now Dr. Telci, the first author on here. At the time he was with Georgia Tech, used the training period for periods of known water supply operations and then used the predictive period for when we had to predict the operations. So you have a combination of both training and prediction.

BY MR. ANWAR:

Q. And that's training and prediction, but that's -- that's both simulated pumping schedules, correct?

A. No, well, the training was based on daily data, okay, and all we're interested in is monthly.

Q. The training was based on pumping schedule data after 1998, correct?

A. Yes, yes.

Q. And then the simulated is the pumping schedule from 1953 to 1987, right?

A. It would go through '98, actually. I mean, for -- Hadnot Point/Holcomb Boulevard didn't come online until '72, so you have different periods there, but, yes, it would -- that's the predictive period, is where you had either limited -- because you might have a month information here and there and stuff like that, but that's -- or unknown information that you would use the predictive values that came out for each well, each certain well.

Q. Let's turn to page S12.

A. Okay. Okay.

MR. DEAN: S2.12 or just S12?

MR. ANWAR: I'm sorry. It's S2.12.

MR. DEAN: Okay.

MR. ANWAR: I've been staring at these documents too long.

BY MR. ANWAR:

Q. And at the top of the left-hand --

A. Right.

Q. -- page it says, historical reconstruction period, 1942 to 2007, prediction process, correct?

A. Right.

Q. And this is the -- the training and the -- this -- this paragraph in this section is addressing the training and the prediction process you were just describing, correct?

A. I believe it is. This shows the start of prediction process. There should be another flow chart somewhere, I seem to recall.

Q. I wanted to just ask you about some of the language in the first paragraph.

A. Okay. Sure, sure. Go ahead.

Q. It says, "similar to the training process, the prediction process, PP, is structured as a series of calculations and checking steps. The results of the steps were placed in separate sheets of a Microsoft Excel workbook." And then that last sentence, "because some wells did not physically exist during the training period, surrogate wells were selected to represent these untrained wells." Did I read that correctly?
A. Yes, yes.
Q. And so you would agree in the training process for reconstructing historical well pumping schedules, ATSDR used surrogate wells for wells that were untrained?
A. No, for wells that -- wells that did not physically exist, okay? If you look at Figure S2.2 on page S2.4.
Q. 2.4?
A. Yes. It's a full-page figure.
Q. Okay. Oh, I see. It's 2.4 --
A. S2.4, Figure S2.2.
Q. Okay. Yeah, I'm looking at 2.40. Go ahead.
A. Okay. For example, you can take an example here, let's just look at -- coming down,

HP604, okay? It stops operations at about 1960, but then you've got HP637. So HP604 may be -- or HP637 may be a surrogate well because HP604 no longer exists. And I think we list the -- somewhere in here there's a table -- oh, there you go. The surrogate wells, okay. Table S2.2 on page S2.13, there's a list.

Q. Okay. So --

A. And looking at those wells and looking at that figure, you can see which wells were surrogate for wells that were no longer operating.

Q. On S2.13.

A. Yes.

Q. Table S2.2.

A. Right.

Q. Just looking at that, the surrogate wells include -- let me double-check. Surrogate wells were used for HP651, HP634, HP602, HP603 and HP608, right?

A. 608, yes.

Q. You would agree that ATSDR modeled reconstructed pumping schedules for these wells -- strike that.

Okay. You would agree that ATSDR modeled reconstructed pumping schedules for these wells based on 1998 to 2008 pumping schedules for different wells, correct?

A. Say that -- say that again.

Q. Sure. So a moment ago we talked -- you know, we -- we went through a list of the wells, 651, 634, 602, 603, 608, for which surrogate wells were -- were used, right?

A. Yes.

Q. And to determine the pumping schedule for these wells, 651, 634, 602, 603, 608, ATSDR reconstructed the pumping schedule for surrogate -- based on surrogate wells from 1998 to 2008, correct?

A. Yes.

Q. Okay.

A. That was the training period.

Q. Let's go back to Exhibit 10, which is Chapter A for Hadnot Point/Holcomb Boulevard.

A. Okay. I'm right here. Yes.

Q. Give me a second and I will catch up with you. Turn to page A84, please.

A. Okay. A84. Okay. Where it says "trichloroethylene source release date sensitivity analysis?"

Q. Correct.

A. Okay.
Q. So this is a discussion in Chapter A for Hadnot Point/Holcomb Boulevard about TCE's source release date and the sensitivity analysis that was performed, correct?
A. Yes.
Q. Okay. So I wanted to start by reading from that first paragraph on the left.
A. Okay.
Q. Which starts, "historical records delineating the timing and volume of inadvertent releases of solvents during routine -- routine operations from leaking" -- it says "UST". Those are underground storage tanks, right?
A. That's correct.
Q. Okay. "From leaking UST systems or from disposal solvent waste, spent dry cleaning filters or other materials, were not available for the Hadnot Point/Holcomb Boulevard study area." Did I read that correctly?
A. Yes.
Q. "For modeling purposes, a median source release date of nine years from the date of the underground storage tank system installation or site development, in the case of the HPLF area",

which is a Hadnot Point landfill area, "was used in the contaminant fate and transport models." Did I read that correctly?

A. Yes.

Q. "This source release date formulation is consistent with empirical data indicating that the median time frame for leak development in underground storage tank systems, typically in piping and joint components, is nine years from installation date." And there's a source to an EPA document and another cite source. Did I read that correctly?

A. That is correct.

Q. Okay. Then it goes on to state, "UST systems were not the source of contaminants in the Hadnot Point landfill area. However, given the lack of historical information, a similar source release time frame, in this case seven years from site development, was applied to the Hadnot Point landfill area sources within the model." Did I read that correctly?

A. Yes.

Q. Would you -- you'd agree, based on this paragraph, that historical records delineating or providing information about the time and volume of solvent contaminant releases from underground storage tank systems, disposal of solvent waste, spent dry cleaning filters or other materials wasn't available for the Hadnot Point area?

A. That is correct. And that is why we went to external references or other references like the ones that we -- we cited, the EPA report '6/'87 and the Gangadharan, et al., '87. I think they discussed something like over 12,000 tanks that they analyzed that -- and so we -- we felt that was a good source of information to use.

Q. ATSDR -- still based on this paragraph, you would agree ATSDR, the Hadnot Point/Holcomb Boulevard model, assumed all underground storage tank systems began releasing contaminants nine years after the system was installed, right?

A. It's -- typically it was the piping joints, okay? I think we say in there the actual tank did not necessarily leak, but it was at the pipe joints because of the construction methods back then in the '40s and '50s and '60s, unlike today where you have to have a concrete pad, solid, and then you put the tank on. They just dug the hole, put the tank on, then when they -- and connected the pipes. And when the tank filled up, then the pipes flexed, and that's where you got the leakage.

Q. So it -- ATSDR, the Hadnot Point/Holcomb Boulevard model assumed that the piping joints for underground storage systems began releasing contaminants nine years after the systems --

A. Yes, based -- based --

Q. -- were installed?

A. -- on the references that we cited.

Q. Okay. And as you indicated, based on references, that was based on an EPA study on underground storage tank system leaks, that following nine years was the median time frame for leak development?

A. Yes.

Q. ATSDR assumed contaminant sources in Hadnot -- in the Hadnot Point landfill started seven years --

A. Yes.

Q. -- after site development, right?

A. Yes.

Q. Okay.

A. That's because the landfill, to our knowledge, was unlined and it was not tanks. It was just disposal of landfill material, contaminated landfill material.

Q. And it was necessary to make these assumptions about sort of the contaminant start dates because the information of when the underground storage tanks and the Hadnot Point landfill began releasing contaminants, that's not available, right?

A. You're talking about the Hadnot Point industrial area or the landfill?

Q. Well, let's -- let's break them up.

A. Okay.

Q. So the assumption was made about underground storage tanks systems beginning to release contaminants nine years after the system was installed, right?

A. Yes, that would be the Hadnot Point industrial area.

Q. And -- but that's because -- and that assumption was made because the data available precisely identifying or pinning down when the underground storage tanks began releasing contaminants does not exist?

A. That is correct.

Q. Okay. And the same is true for the --

the Hadnot Point landfill assumption, correct?
A. Right. And we used a shorter time period, again, because there were not underground storage tanks, per se. It was a landfill, most likely unlined, okay, and not individual tanks, but just waste thrown or disposed of into the landfill. So we assumed it would have a, you know, two-year, short period until it started leaking for the modeling purposes.
Q. But -- okay. Understood. But in terms of real-world data, in terms of the actual data, precisely pinning down when the Hadnot Point landfill started releasing contaminants, that doesn't exist, right?
A. Not to my knowledge, but that, again, is part of the model -- model calibration process, okay? That makes the source, then, a calibration parameter both in terms of strength and in terms of duration.
Q. Okay. And if -- turning to the next page, A85.
A. Yes.
Q. That's the calibration you're -- you're referencing, right?
A. That's a sensitivity -- you're in the

sensitivity analysis section, which is part of the uncertainty analysis. We wanted to see the impact of varying, again, the source release date.

Q. And that's what I meant. So this -- as I read the sensitivity analysis, you varied the release source -- the source release date from a period of -- let's see -- minus nine years, meaning nine years before the calibrated source release date, to plus nine years, meaning nine years after the calibrated release source date, correct?

A. That is correct.

Q. And in all of these scenarios, nine years before the release -- calibrated source release date, the model was still able to -- well, strike that.

Well, can you remind me, what was the calibrated source release date?

A. Hold on. Let me see. I have to go back to off the top of my head. Well, the model started in 1942 for Hadnot Point.

Q. Sure.

A. Hadnot Point landfill industrial, 1942, I believe. So nine -- nine years after that would be 1951, so that would be the calibrated.

Q. Okay. I've got you. Let's -- looking

-- returning back to the sensitivity analysis.
A. Okay.
Q. As -- you agree that this shows the effect of the calibrated model of varying the start date of contaminant sources, right?
A. Yes. What it does not show, as any sensitivity analysis, it doesn't show whether that's realistic or not. These are numerical, okay? In other words, it just shows numerically how the concentrations would shift forward or backwards depending on the release date.
Q. In all of these scenarios, nine years earlier than the calibrated source release date --
A. Right.
Q. -- five years earlier than the calibrated source release date, the actual calibrated source release date, which I see there, it appears to be 1951, 1952?
A. Yeah, that's what we said, yeah.
Q. Yeah. Five years after the calibrated release source date --
A. Right.
Q. -- nine years --
A. Right.
Q. -- after the calibrated release source

date, they all seem to converge during the period of the epidemiological study. Do you see that?
A. Yes.
Q. And so based on the sensitivity analysis, it's possible any one of these ranges could have been the release source date?
A. No, because we assumed, as we did with Tarawa Terrace, that we had a -- the calibrated parameters would be your most likely to have occurred, okay? And then these others are just seeing the impact on -- on the model, I mean, that's, you know, a five-year or nine-year change is a pretty major, major change --
Q. Don't these --
A. -- of the release date, okay, so -- but the most likely one is the calibrated one. I think that's important to understand.
Q. I understand that the -- the most likely is the -- you know, it's your opinion the most likely --
A. Yes.
Q. -- is the calibrated?
A. Yes.
Q. But doesn't the sensitivity analysis show that plus or minus nine years or five years

from the calibrated source release date, that it's possible?

A. It's a possibility.

MR. DEAN: Object to the form.

THE WITNESS: It's a possibility, but, again, that's -- typically, when you're conducting sensitivity analyses and uncertainty analyses, you want to get an understanding of how the system is reacting to changes in -- in this case, it's a single parameter.

Q. I'm going to mark another exhibit.

(DFT. EXHIBIT 17, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter C: Occurrence of Selected Contaminants in Groundwater at Installation Restoration Program Sites, was marked for identification.)

BY MR. ANWAR:

Q. I'm handing you what I'm marking as Exhibit 17.

A. Chapter C. Okay.

Q. This is Chapter C for the Hadnot Point/Holcomb Boulevard analysis, correct?
A. That's correct.
Q. I would like you to turn to C98.
A. C98. Okay. Well, okay. Let's -- let me rearrange the clip so I can...
Q. What's that?
A. Let me rearrange the clip.
Q. Sure.
A. Okay. C98. Okay. Table C8.
Q. Yes, Table C8. And Table C8 is entitled -- or titled "summary of analysis for benzene, toluene, ethylbenzene and total xylene and water samples collected at Hadnot Point water supply wells, Camp Lejeune", right?
A. Right.
Q. Okay. I wanted -- directing your attention to HP602.
A. Okay.
Q. It has concentrations there for one, two, three, four, five, six, seven, eight dates there between 1984 to 1981, correct?
A. Yes, with two below detection limits.
Q. Correct, so two below detection limits for HP602?

A. Yes.
Q. And then the other five above detection limits with some value?
A. No, there's six.
Q. Oh, there's six. Excuse me.
The other six are above the detection limit with some value and they are all ranging from 1984 to 1991, correct?
A. That is correct.
Q. And it appears five of the samples, the -- for benzene there at HP602 are from '84?
A. Is that a question? I'm sorry.
Q. Yeah, is that right?
A. Okay. I've got one from '84, one, two, three, four. Four above detection limits are from 1984.
Q. Okay. And then there's one from '85, one from '86, then one from '91, correct?
A. Yes, that's correct.
Q. And then if we go down to HP608.
A. Okay.
Q. There are four samples between '84 and '86, correct?
A. Yes.
Q. And one appears to be below the

detection limit?

A. Right.

Q. Okay. You would agree that this table, it summarizes the measurements of benzene at the Hadnot Point water supply -- water supply wells, right?

A. Yes.

Q. And agree that benzene -- you would agree that benzene at the Hadnot Point source wells found only benzene above the detection limit at HP602 and HP608, correct?

A. 608, yes. Let me -- 608, that's correct, and then -- yes, above -- yeah, above the detection levels, yes.

Q. And the samples at 602, the concentration levels of benzene and the samples at 602 are much higher than the samples at 608, right?

A. Yes.

Q. For instance, the highest sample there, at 602, is 720 micrograms per liter, right?

A. Yes.

Q. And the highest sample at 608 appears to be four micrograms per liter?

A. Yeah, yes.

Q. Okay. So you would agree that the

driving source of benzene contamination at the Hadnot Point water treatment plant was HP602, right?
A. I would actually like to look at my graphs here because we really need to look at -- okay. Benzene. HP602, yes.
Q. That was the --
A. Yes.
Q. -- driving source of benzene contamination for that Hadnot Point water treatment plant, right?
A. That's -- that's the measured data that we have, so yes.
Q. Okay.
A. Based -- based on the measured data.
Q. Okay.
A. And the -- and the supply list.
Q. Let's turn back to -- I'm jumping around a little bit -- Chapter A for Hadnot Point, which is Exhibit 10.
A. For Hadnot Point? Yeah, I've got it right here.
Q. Actually it's Supplement 1 for --
A. Okay. I don't have Supplement 1. I've got Supplement 2 that you gave me.

Q. Okay. Let me mark it, then.

THE VIDEOGRAPHER: Sir, I'm going to need to change the media when you get to a stopping point.

MR. ANWAR: Sure. Let's stop right now.

THE VIDEOGRAPHER: All right. Going of record. The time is 3:59 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time the 4:10 p.m.

BY MR. ANWAR:

Q. We are back on the record from a short break, Mr. Maslia. Are you okay to continue?

A. Yes.

Q. Okay. Did you speak with your counsel outside or during the break?

A. No, I did not.

Q. Okay. Thank you.

I'm handing you what I'm marking as Exhibit 18.

(DFT. EXHIBIT 18, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the

Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina, Chapter A-Supplement 1, Descriptions and Characterizations of Data Pertinent to Water-Supply Well Capacities, Histories, and Operations, was marked for identification.)

BY MR. ANWAR:

Q. Okay. This is Chapter A, Supplement 1 for the Holcomb Boulevard/Hadnot Point analysis -- or the Hadnot Point/Holcomb Boulevard analysis.

A. Right, that's correct.

Q. And it's titled "descriptions and characterizations of data pertinent to water-supply well capacities, histories and operations", right?

A. Yes.

Q. Okay. If you could turn to page S117.

A. Okay. I'm there.

Q. S117 is a figure for well HP602, right?

A. It's a table, yes.

Q. Table. You'd agree that this table shows what ATSDR concluded about HP602 operating history and capacity history, right?

A. Yes.

Q. Okay. You'd agree that well HP602 had

a relatively small capacity, right?
A. I would say -- I would say it'd probably have an average capacity. I mean, there's some -- like 69 goes down to 50 or 30, it looks like. They then redeveloped the well. So I would say it's average. It's average capacity.
Q. If you compare it to HP well 608 on page S126.
A. HP608. Okay.
Q. Would you agree that the capacity for well HP602 was less than, generally speaking, the capacity for well HP608?
A. Yes.
Q. And focusing back on HR602 on S117.
A. Okay.
Q. Would you agree that the capacity fluctuated significantly?
A. Yes, it fluctuated.
Q. Okay. And it fluctuated in a range from 30 GPM on September 4th, 1969 --
A. Right.
Q. -- to 154 GPM on October 24, 1984, right?
A. Yes.
Q. Looking at the table for HP602, you

would agree that HP602 was out of service multiple times, correct?

MR. DEAN: Object to the form.

THE WITNESS: No, it's only out of service one, two, three -- three times.

BY MR. ANWAR:

Q. I see -- it was out of service April of 1979?

A. Yes, that's one. Oh, out four times. Out.

Q. It was out of service in October of 1981?

MR. DEAN: Which well? 60 --

THE WITNESS: 602.

MR. DEAN: Okay.

BY MR. ANWAR:

Q. You agree with that?

A. Yes, yes -- well, no, it says out. Again, these records are directly from either the water utility at Camp Lejeune or the well driller or whatever. So it says out. It does not say out of service. I don't know if that means -- if that means it was just out on that date or whatever, but the rest of them say out of service.

Q. Okay. It was -- it says out of service

on October 1981, correct?
A. Yes.
Q. So there's an October 1981 that says, quote, out, and then the following entry on the table is October 1981, out of service, right?
A. Yes, to me indicates we had, at least on that one, a multiple record or two different sources of records.
Q. And then November 30th, 1984, it was out of service as well, right?
A. Yes.
Q. So it was out of service at least three times, correct?
A. Yes.
Q. And then as of November 30th, 1984, it was permanently closed or terminated, right?
A. Well, service was terminated and then abandonment would be in '94, permanently closed.
Q. What -- what do you understand the distinction to be between service terminated and abandoned?
A. Service terminated would indicate they just stopped using it, but it might still be available for emergency purposes, whereas, abandonment would mean that they would, I would

say, pull the well screen out, pull the pump out, and maybe they seal it up with bentonite, concrete, the hole up.

Q. Okay.

A. That's the difference. There's an example for -- at Tarawa Terrace for TT23 that -- it says it was out of service, but, in fact, we have records that show during April of '85 they actually used it because they were short of water, okay? So unless it's abandoned, the well casing pulled and then concrete up -- that's what service terminated means to me, is that it's not being used.

Q. Okay. Based on the information in the table, which I assume comes from the available data, HP602 wasn't used after November 30th, 1984, right?

A. That's what that indicates.

Q. Okay.

A. We have no -- no data between -- or there's -- yeah, no data listed in the table between -- after November 30th, 1984 and June 1994. So just looking at those two pieces of data, it's terminated in '84 and then abandoned in '94. There's no indication on here as to whether it was

used for emergency purposes or other things like that.
Q. Okay.
A. Which is always a possibility with a well that's not abandoned.
Q. Turning the page back to S16 -- excuse me, S126. Looking at the table on HP608.
A. Yes. Okay.
MR. DEAN: S?
THE WITNESS: 26. 1.26.
MR. DEAN: I guess I don't have that one.
THE WITNESS: Is this Supplement 1?
BY MR. ANWAR:
Q. You'd agree that ATSDA -- ATSDR determined capacity of HP608 ranged from 115 GPM to 230 GPM?
A. Yes.
Q. And as we discussed a few moments ago, compared to 60 -- HP602 --
A. Wait. Hold on just a second. It continues on page S127. It's got a capacity of 226 on 1983 -- March 21st, 1984.
Q. I see that. So my question was, do you agree that the range for -- ATSDR determined the

capacity of HP608 to be in the range of 115 GPM on the low end and 230 GPM on the high end?

A. Yes.

Q. And --

A. I just wanted to make sure we had the full table in front of us.

Q. No, I appreciate that. Compared to -- and we discussed a moment ago, and you're welcome to turn back to look if you would like, but for HP602 the range was 30 GPM to 154 GPM?

A. Yeah, that's correct.

Q. Okay. You agree that the table on -- for HP608 on page S127 shows that service was terminated for HP608 on December 6, 1984, correct?

A. Yes, that's what it states.

Q. Okay. I would like to turn back to Chapter C.

A. Chapter C. Okay.

Q. For the Hadnot Point/Holcomb Boulevard analysis.

A. Yes. Okay. Chapter C.

Q. If I could direct you to page 108.

A. 108. Okay.

Q. Page C108, there's a Table C12 on it, right?

A. Yes.
Q. Okay. So there are three entries there, November 19, 1985, where benzene was detected at 2500 micrograms per liter, right?
A. Yes.
Q. And then there's an entry December 10, 1985 where benzene was detected, 38 micrograms per liter, right?
A. Yes.
Q. And then there is an entry just below it, December 18, 1985, where benzene was detected, one microgram per liter, right?
A. That's correct.
Q. Okay. Outside of those three entries in November 1985 and December 1985, according to this table, benzene was never detected above the detection limit at the Hadnot Point water treatment plant, right?
MR. DEAN: Object to the form.
THE WITNESS: Based on the sample data? We're talking about the data in this table?
BY MR. ANWAR:
Q. Yeah.
A. With the exception of those three readings that you cited, everything else was below

the detection limit.

Q. And just for the record, the -- we're looking at Table C12. It's entitled "summary of analyses for benzene, tolune, ethylbenzene and total xylene in water samples collected at the Hadnot Point water treatment plant at Camp Lejeune", right?

A. Yes.

Q. Okay. So these are samples collected at the Hadnot Point water treatment plant?

A. Right.

Q. Okay. And so a moment ago -- so for -- still focusing on C12 on -- Table C12 on November 19, 1985, December 10, 1985, and December 1985. Do you see that?

A. Yes.

Q. A moment ago we looked at tables with the operating and pumping histories for HP602 and HP608. Do you recall that?

A. Yes.

Q. So at the time of these three detections for benzene, HP602 and HP608 were shut down, right?

MR. DEAN: Object to the form.

THE WITNESS: I need to -- let's see.

Supplement 1, I'm guessing, yeah.

BY MR. ANWAR:

Q. Yeah, and if you want to --

A. Share the dates.

Q. -- go look over it, it was -- the 608 is on S126 and 27.

A. Okay. November 19th, '85. November 19th, '85.

Q. HP608 --

A. Yes, yes, it was not, according to this table, not operating, not in service.

Q. Yeah. And according to the table, it was terminated in December, December 6th, 1984, right?

A. Right.

Q. So almost -- it had been shut down for almost a year --

A. Right.

Q. -- by the time the benzene was detected --

A. Uh-huh.

Q. -- at the Hadnot Point water treatment plant, right?

A. That's correct.

Q. Okay. Then 602, which is page 17,

S117.

A. Okay. I'm there.

Q. And we discussed this service was terminated November 30th, 1984?

A. Yes.

Q. And it, likewise, had been shut down almost a year by the time benzene was detected at -- above detection limits at the --

A. Right.

Q. Or strike that.

It too -- the HP602 was -- also had been shut down in November 30th, 1984, which was about a year after benzene was detected at the Hadnot Point water treatment plant, correct?

A. No, we've got '85 at the water treatment plant. Is that what you're speaking with, the benzene detections at the water treatment plant?

Q. Correct.

A. That was in November '85 and it says service terminated November 30, 1984.

Q. So almost a year had passed, right?

A. Yes.

Q. Okay. Would you agree that -- well, strike that. Let me ask it this way. Residual benzene from HP602 or HP608 used -- before December 1984 was not the source of benzene in the November and December 1985 samples we just looked at, right?

MR. DEAN: Object to the form.

THE WITNESS: Again, this well says service terminated. There's always the possibility that they were operated and not recorded as operated. I'm saying we observed at that Tarawa Terrace, but -- and for the 2500 part per billion, if you go to the Chapter C report, it might be in this report also, we noted that the base chemist, Elizabeth Betz, noted on that one that it was not representative, okay? She did not say -- the samples don't say that that's not a valid sample. It said it was just not representative.

And we actually had a phone interview with her and there's some documentation, with Elizabeth Betz, to ask her did that mean that sample was, you know, not valid and all of that. I asked the question and she answered to me that, no, she just meant that benzene sample -- especially benzene samples would go up and down, up and down until there was no regularity to the concentrations.

BY MR. ANWAR:

Q. Well, in that conversation, was she referring to the 2500 micrograms per liter?

A. I specifically asked her about that, yes.

Q. And your understanding is -- from her is that that sample from Hadnot Point water treatment plant was not representative?

A. Yes, but I asked her -- that's marked on the JTC lab reports. It's not -- and it's also marked in our Chapter C.

Q. Sure.

A. Just to be clear. And I asked her what was meant or what was her understanding of not representative, and she said that -- and it's recorded in the notes or meeting notes that we had with her, phone conference, that she meant that there was just -- the benzene sampling data would go up and down, up and down by a large amount, and so that's why it was not representative. She did not say -- I asked her and she said she -- because I asked if she meant that she would consider that sample or, you know, or it was an erroneous sample, and she definitely said, no, she just -- her meaning was that it was -- the sampling data went high and low, high and low.

Q. As you sit here today, you don't have any reason to believe that the residual -- residual benzene from HP602 or HP608 used before December 1984 was the source of benzene samples in November, December 1985?

A. We really did not do a residual analysis and, as you know, benzene is a floater. It floats on top of water, so like salad dressing with oil and vinegar. When you shake it up, maybe stir it up, and then it separates out. So we really did not do a residual analysis to see you know, that specificity.

Q. But you don't have any definitive data demonstrating that it was residual benzene from HP602 or HP608 used before December 1984 that was the source of this November, December 1985 benzene samples?

A. Well, we've got our reconstructed values at the water treatment plant.

Q. Well, and we don't need to look at those.

A. Okay.

Q. I'm just talking in terms of the real-world data, not in terms of the model right now.

A. Okay. So again, ask your question again.

Q. Just some terms of real-world data, you don't -- there isn't any real-world data available or that exists demonstrating that HP602 -- residual benzene from HP602 or HP 608 used before December 1984, which is when those two wells closed, was the source of the November/December 1985 measurements in the Hadnot Point water treatment plant?

A. I do not have data for those wells after they went out of service.

Q. Now, Tarawa Terrace, if I remember correctly, ATSDR didn't use nondetects in the geometric bias; is that right?

A. What's published in the published title, yes, that's correct, we did not ignore the data. They're published in the table, but when we went to compute the geometric bias, we did not include the nondetects because there's a whole area of analysis about nondetects value -- what value should you include or what value should you assign or not assign and things of that nature.

Q. And in the published data you didn't --

ATSDR didn't use nondetects in the geometric bias, which was used to assess calibration, right?

A. That is correct.

Q. Okay.

A. But we did publish it in the tables accompanying -- accompanying that, okay, for both the wells and -- supply wells and the treatment plant.

Q. And as I understand it, from the very beginning of our conversation today, it sounds like you've done some additional work with respect to geometric mean -- or geometric bias?

A. Yes.

Q. Okay. And was that only for Tarawa Terrace?

A. It was for Tarawa Terrace and I'd have to look at my notes. I might have done it for the Hadnot Point water treatment plant.

Q. That would be reflected in your notes?

A. Yes.

Q. And do you intend to offer that opinion if called to testify at trial?

A. That we -- that I reassessed the computation?

Q. Yes.

A. Yes. Well, I mean, I will defer to the attorneys on that, but I have notes that I'll turn over to the attorneys.

Q. Okay. How --

MR. DEAN: Well, I mean, you should answer his question fully because you can update and amend your opinions pursuant to the rules in the deposition if he asked. So if you've completed your answer, fine. If you didn't, finish answering his question.

THE WITNESS: No. I mean, I looked again, as we discussed earlier today, after reading Dr. Konikow's report, and he discussed the issue of using duplicate samples or triplicate samples within the same day or same month when the model results only provide you one value per month. So then I went back and recomputed using that approach. So if we had two samples in a month, then I would take an average. If you had three, I would take an average, so I would compare one to one.

Q. Okay. I have to find my place again. Okay. How did ATSDR assess calibration of the Hadnot Point mixing model for benzene with only -- or primarily nondetect data points?

A. Let me get to Chapter C and in table -- on Table A18 on page A62, we've got supply well.

Q. Is this on Chapter A or Chapter --

A. Chapter A. I'm on Chapter A, yes. Chapter A of Hadnot Point.

Q. Okay. What -- what page were you looking at?

A. I was on page A62. Okay. I misspoke. That was the water treatment plant, okay? We had measured data and then we had reconstructed data. So I may have computed a geometric mean just, like, on scratch paper, but I did not publish it as part of the Chapter A for Hadnot Point/Holcomb Boulevard report.

Q. Why did you treat that differently than for Tarawa Terrace?

A. I really don't -- don't know. I know we were under a timeline crunch to get it out and it just may have been that it was not -- that I looked at -- I just looked at visually the values, reconstructed versus measured, and said, you know, that was, you know, provided a good fit. And also looked at the wells on page -- well, they're graphs and stuff like that, but also there's a table earlier on. Somewhere there's a table. And just said that I was satisfied with -- with the -- with the fit or the goodness of fit of the calibrated results with the available water treatment plant data.

It was also -- with Tarawa Terrace we had just PCE, okay, one constituent. Whereas here we had multiple constituents and I may have -- I said, well, maybe we need to look into each one individually or something like that. It was a little more complex computation, and so it did not end up in -- in the published report.

Q. Would you agree that not assessing geometric bias affects uncertainty and reliability for the Hadnot Point model?

A. Not necessarily because, again, geometric bias just gives me an estimate; is the model way over or way under or it's in the ballpark, okay? And again, I'm looking at the plot. A graphic is just as good as a geometric bias. A geometric bias is putting a quantitative estimate on a graphic, okay? Had this graphic, and so it was just a computation that was not done for this -- this analysis. You can go back and -- and do it. I mean, as I said, I've got my notes.

Q. Okay. If you could turn back to

Chapter C on page C106.
A. 106?
Q. Yeah.
A. 106. Okay. I've got it.
Q. On C106 there's a Table C11, right?
A. Yes.
Q. It states, "summary analyses for PCE, TCE, 1-1-DCE, trans-1-2-DCE, 1-2-DCE" -- it says, "1-2-DCE, total 1-2-DCE, and vinyl chloride in water samples collected at the Hadnot Point water treatment plant, Camp Lejeune", correct?
A. Yes.
Q. Okay. I just wanted to ask you a few questions about this.
A. Sure.
Q. You'd agree that this table summarizes measured PCE and degradation product observations at the Hadnot Point water treatment plant?
A. Yes.
Q. You'd agree that vinyl chloride was never detected above the reporting limit at Hadnot Point water treatment plant?
A. There's -- on February '85 the value -- estimated value of 2.9.
Q. Where are you looking? February --

A. C11, February 5th, 1985 all the way across the last column. It says 2.9J.

Q. Okay. Aside from that one time, would you agree that vinyl chloride was not detected above the detection limit?

A. Let me make sure this goes -- is this the same -- Table C10, C11. You're just talking about Table C11, right?

Q. Correct.

A. Yes, that would be --

Q. You would agree that aside from that -- that one time in -- on February 5th, 1985, that vinyl chloride was never detected above the detection limit?

A. Yes.

Q. And this is for that Hadnot Point water treatment plant, right?

A. That's correct.

Q. Okay. And then you would agree that DCE was rarely detected above the detection limit at the Hadnot Point water treatment plant?

MR. DEAN: Object to the form.

THE WITNESS: No, where there's a trans-DCE, 1-2-DCE on February 5th, again, 1985, of 150 micrograms per liter.

BY MR. ANWAR:
Q. So that's that one time?
A. Yes.
Q. Would you agree, aside from that one time, that DCE was not detected above the reporting limit at the Hadnot Point water treatment plant?
MR. DEAN: Object to the form.
THE WITNESS: Yes.
BY MR. ANWAR:
Q. Okay. Let -- jumping around. Let's turn back to Chapter A for Hadnot Point/Holcomb Boulevard.
A. Okay. Okay.
Q. I would like to direct your attention to A46.
A. Page A46?
Q. Correct.
A. Okay.
Q. There are a series of graphs there entitled Figure A18, correct?
A. A18, yes.
Q. And A18 is titled "reconstructed or simulated and measured concentrations of TCE at selected water supply wells within the Hadnot Point industrial area." Did I read that correct?

A. Yes.
Q. Okay. And the wells reflected on these graphs are HP602, HP608, HP634, and then there's well HP601 and, slash, HP660, correct?
A. That is correct.
Q. Would you agree that these -- this figure shows calibrated model values at HP well 601, 602, 608 and 634?
A. They show the -- yes, the red line is the simulated values.
Q. Okay.
A. Or reconstructed values, and the black dots are the measured.
Q. So the -- for instance, at HP602 there are one, two, three, four, five, six measured values reflected on the graph, right?
A. Yes.
Q. For HP601 it looks like there are three measured values on the graph, right?
A. Yes, they are measured for HP660, which was the replacement well.
Q. For 601, right?
A. Yes.
Q. For HP608, it looks like there are four values reflected on the graph?

A. Yes.
Q. And for HP634 it looks like there is one value reflected on the graph?
A. Yes.
Q. Those are the measured values we're talking about, correct?
A. That is correct.
Q. And then the -- that red -- the red line is what the model is simulating as estimated concentrations?
A. Yes, that's correct.
Q. These graphs show some measured values, but they show none of the nondetect values, correct?
A. That's correct.
Q. And you would agree that if we turn to -- you might keep this page open --
A. Okay.
Q. -- but also turn to Chapter C, C95.
A. Right. C95?
Q. Correct.
A. Okay. I'm there. Table C7.
Q. Yes.
A. Okay.
Q. C7, "summary of analyses, PCE, TCE, DCE

and vinyl chloride for water samples collected at Hadnot Point water treatment plant", right?

A. Right.

Q. Okay. For HP634 there, there are four values below the nondetect limit, right -- or excuse me, there are four -- four nondetects?

A. In Table C9 -- I mean, on Table C7?

Q. Yes.

A. For 634 there's -- yes, that's correct.

Q. And if you go back and look at A46, there's one measured value reflected there, right?

A. That's correct.

Q. But those -- those four nondetects are not reflected?

A. That's correct. The issue with trying to graphically represent nondetects gets back to what value are you going to use. If we use the detection limit, then someone can argue, well, you don't know that definitively because it was nondetect. If you want to use half the detection limit, again, that's just an estimate. There are some other complex methods where people -- Dennis Helsel and others who have worked in the nondetect area, that you can estimate and quantify the nondetects, but for our purposes we used the graphics in the reports as -- and companions to the tables. So if someone wanted to see what all the values were, they could go to the -- to the table and see that we had nondetects and we also had above detection limits.

Q. Okay. Let's -- let's look at -- and let me mark it. Let's switch gears a little bit.

A. Okay.

Q. I'm going to hand you what I'm marking as Exhibit 19.

(DFT. EXHIBIT 19, Analyses and Historical Reconstruction of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water Within the Service Areas of the Hadnot Point and Holcomb Boulevard Water Treatment Plants and Vicinities, U.S. Marine Corps Base Camp Lejeune, North Carolina Chapter A-Supplement 6, Characterization and Simulation of Fate and Transport of Selected Volatile Organic Compounds in the vicinities of the Hadnot Point Industrial Area and Landfill, was marked for identification.)

THE WITNESS: Okay.

BY MR. ANWAR:

Q. Here you go.

A. Supplement 6. Okay.

Q. Exhibit 19 is a Hadnot Point/Holcomb Boulevard Chapter A-Supplement 6, right?
A. That is correct.
Q. Okay. And it's titled "characterization and simulation of fate and transport of selected volatile organic compounds in the vicinities of the Hadnot Point industrial area and landfill", right?
A. That is correct.
Q. Okay. Can I have you turn to page S645?
A. Okay. 645. Okay.
Q. And S645 includes a discussion of -- it's entitled discussion and limitations, correct?
A. That is correct.
Q. And that's of the Hadnot Point/Holcomb Boulevard analysis and model, correct?
A. Yes, yes.
Q. Okay. Looking over on the right-hand side, second paragraph, it starts, "for contaminant fate and transport modeling reported herein, however, insufficient water quality data existed to conduct a statistical analysis for assessment of model calibration fit. In addition, specific data pertinent to the timing of initial deposition of

contaminants to the ground or subsurface chronologies of waste disposal operations such as dates and times when contaminants were deposited in the Hadnot Point landfill or descriptions of the temporal variation of contaminant concentrations in the subsurface generally are not available."

Did I read that all correctly?

A. Yes.

Q. Okay. And then it goes on, "determining these types of source identification and characterization data became part of the historical reconstruction, whereby the contaminant fate and transport model was used to test source locations, varying concentrations, and beginning and ending dates for leakage and migration of source contaminants to the subsurface and the underlying groundwater flow system." Did I read that correctly?

A. That's correct.

Q. Okay. So then the next starts, "conducting a robust uncertainty analysis using Monte Carlo analysis requires simulating thousands of realizations. When using available computational equipment, the Hadnot Point industrial area and the Hadnot Point landfill models have a simulation time of about six to eight hours for each simulation. The lengthy simulation times and the substantial data limitations therefore make a comprehensive uncertainty analysis computationally prohibitive based on available resources and time limitations. Thus, the ranges of values presented in the sensitivity analysis section of this report assess a limited number of input and output model parameters. The results, in other words, range of concentration presented in the sensitivity analysis reported herein, should not be considered or interpreted as the results of a robust and comprehensive uncertainty analysis, but do provide insight into parameter sensitivity and uncertainty in a qualitative sense."

Did I read that all correctly?

A. Yes.

Q. Based on the two paragraphs we just read together, you would agree that ATSDR did not conduct a statistical analysis to assess model calibration and fit at Hadnot Point because there wasn't sufficient water quality data, right?

MR. DEAN: Object to the form of the question and misstates and mischaracterizes the document.

THE WITNESS: I'm just seeing where we said that on this -- I'm sure I'm --

MR. BELL: Are y'all allowed to have candy bars?

MR. ANWAR: Sure.

MR. BELL: I know it's late in the day. Someone said, well, don't give him anymore.

THE WITNESS: Yeah, it's -- as it states in the report, insufficient water quality data and the statistical analysis for assessment of model calibration is not -- was not conducted, okay? I believe they were referring to -- this was the -- this was the groundwater flow -- the contaminant fate and transport groundwater model, not necessarily the mixing model and -- at the Hadnot Point water treatment plant, okay? That may have been able to have been computed.

BY MR. ANWAR:

Q. But you agree statistical analysis to assess model calibration fit wasn't conducted because -- because there was insufficient water quality data, right?

A. Yes, that's what it says.

Q. Okay. And in this paragraph, when it's referencing water quality data, you would agree that means measurements of contaminant concentrations, right?

MR. DEAN: Object to the form.

THE WITNESS: That's what I would interpret it to mean.

BY MR. ANWAR:

Q. Okay. So earlier, just, I think, a few minutes ago, we talked about geometric bias at the Hadnot Point mixing model?

A. Right.

Q. Would you agree this says one wasn't done?

A. Again, I'm looking at -- this is strictly a groundwater contaminant fate and transport. It would have been done or could have been done in the summary chapter, Chapter A, but I do not see it there, so it was not conducted.

Q. One was --

A. It was not computed. Let me just -- it was not computed like it was computed for Tarawa Terrace.

Q. One wasn't computed for the fate and transport model for Hadnot Point, correct?

A. One was not computed for the water

supply wells at Tarawa Terrace -- let's go back. We computed geometric bias for the water supply wells and then we also computed a geometric bias for the water treatment plant, okay? So Supplement 6 is strictly the groundwater flow model, so there was not one conducted -- computed for the supply wells at Hadnot Point and Holcomb Boulevard.

Q. Okay. I just want to make sure. There was not one computed for the supply wells, correct?

A. That is correct.

Q. And would you agree there was not one conducted for fate and transport?

MR. DEAN: Object to the form.

THE WITNESS: That would -- that would be the supply wells.

BY MR. ANWAR:

Q. Okay. I've got you.

A. Okay. The fate and transport model, you would pull out the concentrations at the well locations.

Q. Okay. That's what I wanted to make sure I understood. Thank you.

And so now kind of looking back at the paragraphs we just read.

A. Okay. Hold on. Go back there.

MR. DEAN: Page 45, 645. I think that's where...

THE WITNESS: Yeah, I'm there.

BY MR. ANWAR:

Q. It says, you'd agree, "that specific data pertinent to the timing of initial deposition of contaminants to the ground or subsurface chronologies of waste disposal operations such as dates and times when contaminants were deposited in the Hadnot Point landfill or descriptions of the temporal variation of contaminant concentrations in the subsurface generally were not available at Hadnot Point", right?

A. That's what it says, yes.

Q. Okay. And you agree that historical -- quote, historical reconstruction, as used in the paragraphs, had to include testing source locations, varying concentrations, and beginning and ending dates for leakage and migration of source contaminants to the subsurface and the underlying groundwater flow system?

A. That would be the calibration process.

Q. You'd agree that a comprehensive uncertainty analysis wasn't done at Hadnot Point because, as it states in the paragraph, "lengthy

simulation times and substantial data limitations were computationally prohibited" --
A. Yes.
Q. "Prohibitive."
A. Yes, that's what it says.
Q. ATSDR did a sensitivity analysis, but it said, results should not be considered or interpreted as results of a robust and comprehensive uncertainty analysis, correct?
A. Yes.
MR. DEAN: Object to the form.
BY MR. ANWAR:
Q. And your answer was yes, right?
A. Yes, I'm confirming what -- you read it from the report.
Q. It's the last sentence of the last paragraph. So ATSDR did a sensitivity analysis, but said its results should not be considered or interpreted as the results of a robust and comprehensive uncertainty analysis, right?
MR. DEAN: We can stipulate you read that sentence correctly.
BY MR. ANWAR:
Q. And you agree with that, right?
MR. DEAN: Object to the form.

THE WITNESS: It can be considered qualitative. That's what we say in here, okay? We did conduct sensitivity analyses.

BY MR. ANWAR:

Q. Let's jump ahead -- or let's jump to -- back to Supplement 6 -- or we are on Supplement 6.

A. Yes.

Q. So let's turn to page 44, S6.44.

A. 44, okay.

Q. So the page before.

A. Okay.

Q. On page S6 there is a Figure S6.23, correct?

A. Yes.

Q. And the figure is titled "variations in reconstructed simulated finished water concentrations of TCE derived using a Latin hypercube sampling methodology on water-supply well monthly operational schedules for Hadnot Point/Holcomb Boulevard study area", correct?

A. Yes.

Q. Okay. This is the -- the -- the figure for the uncertainty analysis on the Hadnot Point/Holcomb Boulevard model, right?

A. Yes, at the water treatment plant.

Q. Okay. At the water treatment plant.
And agree that the results of this uncertainty analysis at the Hadnot Point water treatment plant where reconstructed monthly well operations -- okay. Let me ask that again.
You agree that the results of the uncertainty analysis here were -- for reconstructed monthly well operations schedules were varied?
A. Yes.
Q. And this -- this reflects the -- the water-supply well monthly operational schedules, correct?
A. Yes.
Q. It's an uncertainty analysis about the water-supply well monthly operational schedules, correct?
A. That is correct.
Q. Okay. And the uncertainty analysis shows -- the uncertainty analysis was varied, right?
MR. DEAN: Object to the form.
THE WITNESS: I'm not sure I understand what you mean by the uncertainty analyses was varied.
BY MR. ANWAR:

Q. The results of the uncertainty analysis were varied, correct?
MR. DEAN: Object to the form.
THE WITNESS: The results were not varied.
BY MR. ANWAR:
Q. I thought a moment ago you agreed they were varied.
MR. DEAN: Object to the form.
THE WITNESS: You asked me about the water-supply wells.
BY MR. ANWAR:
Q. Okay.
A. That's the parameter that was varied.
Q. Okay. Understood. Ah, yeah. And you'd agree -- so let me -- just so the record is clean, agree this -- the -- this uncertainty analysis at Hadnot Point is where reconstructed monthly well operations schedules were varied, correct?
A. Yes.
Q. Okay. Thank you. And you agree that the results of this uncertainty analysis suggests that changes in pumping schedules produce very different modeled monthly mean contaminant

concentrations, right?

MR. DEAN: Object to the form.

THE WITNESS: There's variation from the mean to the high or low.

BY MR. ANWAR:

Q. There's significant variation, right?

MR. DEAN: Object to the form.

THE WITNESS: I don't know if I would call it significant. If you compare it to the data spread, it's not -- it's greater than at Tarawa Terrace.

BY MR. ANWAR:

Q. You agree it is greater than Tarawa Terrace, right?

A. Yes, but we still considered it to meet our modeling objectives.

Q. You'd agree this was a Monte Carlo simulation like in Tarawa Terrace, but unlike Tarawa Terrace, only the one input parameter, well pumping schedule, was varied, correct?

A. It was a Latin hypercube sampling, which is a variant of Monte Carlo simulation when Monte Carlo simulation becomes computationally prohibitive. So it is a Monte Carlo, but it's Latin hypercube sampling.

Q. A moment ago we were talking about the degree of variation. Would you agree that the variation is hundreds of micrograms per liter?
A. Once -- you're talking about the reconstructed results or the sampling data?
Q. The -- the reconstructed results.
A. Once HP651 kicks in, yes, after July -- I think June or July of '72.
Q. That's where you see the -- on the figure, Figure S623, dot 23, it spike up, correct?
A. Yes.
Q. Now, looking at this Figure S6.23, you would agree the gray line show all of the Monte Carlo simulations drawn on the same chart?
MR. DEAN: Object to the form of the question.
THE WITNESS: They -- they show all the Latin hypercube sampling results on -- on this graph.
BY MR. ANWAR:
Q. Why not show the 95 percent realization balance like ATSDR did for Tarawa Terrace?
A. It was not -- with Latin hypercube you -- you had -- in this case we used ten equal subdivision or sampling points, okay? That's the

definition of Latin hypercube, is you have an equal probability within each sampling domain, which we had ten. And so it was just not possible to compute a confidence limit, but -- using -- using that approach.

Q. Okay.

A. But it did give us both a quantitative, in terms of high/low, and qualitative feeling of the model results at the water treatment plant.

Q. Got it. I think we are in the home stretch, about 40 minutes left, probably 40, 45. Why don't we take a quick five or five or ten. I would like to take a look at my notes and --

A. Okay. Sure.

MR. ANWAR: Thank you.

THE VIDEOGRAPHER: Going off record. The time is 5:10 p.m.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 5:23 p.m.

BY MR. ANWAR:

Q. We are back on the record from a short break. Mr. Maslia, are you okay to continue?

A. Yes, I am.

Q. Did you speak to your lawyers during

the break?

A. No, I did not.

Q. Okay. I may bounce around a little bit. I wanted to ask you a few questions about your rebuttal report, your opinions in your rebuttal report. Dr. Spiliotopoulos pointed out, for the Tarawa Terrace model, that the KD values and the bulk density values for the calculation of the retardation factor contained errors. Do you recall that?

A. He pointed out that the bulk density did.

Q. Okay. And my -- my understanding of your opinions about that are essentially that you don't dispute the error, but it doesn't, in your opinion, change the analysis much; is that right?

A. It's not so much of an error. What was used originally was the wet bulk density, and it was pointed out to us in 2009, by one of the experts on the Hadnot Point/Holcomb Boulevard panel when we had sent the Tarawa Terrace report, that we had a wet bulk density. So we went back and changed that value and, of course, you've got to understand is that in the contaminant fate and transport equations, bulk density and distribution coefficient are not included. What's included is retardation factor, okay? And we originally had a retardation factor of 2.93. So if we adjusted the bulk density to drop down, that means we could adjust KD up. They are compensating, okay, because they are calibration -- KD is a calibration parameter.

Q. Sure.

A. And that resulted in the exact same retardation factor of 2.93, and it resulted in identical to the decimal place concentrations that we had published in the Chapter A report.

Q. Okay. And thank you for -- for explaining that. The -- if I'm understanding your testimony correctly, it's not so much that the -- the difference of opinion about bulk density or the error, as Dr. Spiliotopoulos has described it, doesn't exist; it's that it's offsetting such that it doesn't impact the retardation factor?

A. That is correct.

Q. Okay.

A. Our retardation factor was consistent -- it was identical to what it was in the published report, okay, but it was also very consistent with existing literature values as well for PCE in this type of terrain.

Q. Now, the retardation factors -- excuse me, the bulk density and the KD value used for Hadnot Point and Holcomb Boulevard model or analysis is different than the one for the Tarawa Terrace model, is that --

A. I would like to just compare the two so we're --

Q. Sure.

A. -- comparing apples to apples here. So let get me to Hadnot Point. Okay. There's -- I'm looking at page A41 for the Hadnot Point report. Ah, here you go. So you asked about bulk density.

Q. Yeah, the -- let's start with bulk density.

A. Well, yes, but, again, as I said, we corrected the one that was in Chapter A once we realized that was a wet bulk density. The corrected value came very close to 46,700 grams per cubic foot.

Q. Okay.

A. Which is what we used in the Hadnot Point.

Q. But the values for the actual calculation -- for the actual -- how you calculated the retardation factor between Tarawa Terrace and for Hadnot Point, can you direct me to the page that you're looking?

A. Okay. I'm on page A41 of the Hadnot Point/Holcomb Boulevard report.

Q. Sure.

A. And then also page A29 of the Tarawa Terrace report.

Q. Okay. Okay. Let's come back to that.

A. Okay.

Q. I'm going to mark what is, I think, Exhibit 20 now.

(DFT. EXHIBIT 20, letter dated February 21, 2007 from Morris Maslia to Dr. Leonard F. Konikow Bates-stamped CL_PLG-Expert_Konikow_0000000006 through 0000000021, was marked for identification.)

BY MR. ANWAR:

Q. Here you go. This -- the first page of Exhibit 20 is dated February 21, 2007, correct?

A. Yes.

Q. And it is a letter from you to Dr. Leonard Konikow enclosing feedback to comments that Dr. Konikow had raised about the Tarawa Terrace analysis, correct?

A. Yes, he was a peer-reviewer, external peer-reviewer --
Q. Okay.
A. -- on that particular chapter for Tarawa Terrace.
Q. Now, these -- these responses to Dr. Konikow's concerns or what are identified as major concerns were drafted by Bob Faye, correct?
A. Yes.
Q. Did you have a chance to review these before they were sent out?
A. I -- I reviewed it. It's been a while since I've seen these, but I did -- did review it.
Q. Would you have discussed the responses with Bob Faye before they were sent back to Dr. Konikow?
A. Not necessarily discussed it. If I had an issue with the response, I may have talked to him.
Q. Okay.
A. And asked him, but I typically -- my approach was not to micromanage the modelers, right? So since Bob Faye was the primary author on Chapter F, I assume that's what this chapter is -- yes, then I would allow him to develop the

responses. And, of course, he was a subcontractor to ATSDR through Eastern Research Group, so that's -- that's who he would send the responses to and they would provide me with a copy.

Q. Okay. So on -- let's call it the page ending in Bates label 08.

A. Okay. Okay.

Q. Actually, let's go to 09.

A. Okay.

THE WITNESS: Do you need a copy? Do you need a copy?

MR. DEAN: I have one.

THE WITNESS: Oh, okay. Okay.

BY MR. ANWAR:

Q. Number three, Dr. Konikow raised as a major concern, "the reliability of the estimate of the biodegradation rate constant based on the assumption that concentration declines" -- excuse me. Let me read that again.

Number three of Dr. Konikow's major concerns reads, "the reliability of the estimate of the biodegradation rate constant based on the assumption that concentration declines observed at one location over a period of several -- several years can be explained solely by biodegradation."

Did I read that correctly?
A. Yes, you read that correctly.
Q. Okay. And it looks like Bob Faye's response there was "the author never claimed that the biodegradation rate computer using field data was reliable or the sole reason for the observed decline in PCE concentration." Did I read that correctly?
A. Yes.
Q. Okay. Do -- do you agree with that statement?
A. That's Mr. Faye's opinion as the person who did the -- the model in response to Dr. Konikow's question or comment, but, you know, what is generally being said is that some of these transport parameters, like biodegradation rate, that's very limited field -- field data, and so, you know, there could be any possibilities for the decline in the concentration. And I think that's what Dr. Konikow was raising as well.
Q. And the next sentence says, "rather, the computed rate was presented as an approximate value useful to begin model calibration." Did I read that correctly?
A. Yes. And I would agree with that.

Q. So if you go on, the rest of it reads, "well TT26 is located on a direct migration, slash, advective pathway from the PCE source at ABC One-Hour Cleaners." Did I read that correctly?

A. Yes.

Q. Do you agree with that?

A. Yes.

Q. Okay. And then it says, "to the extent that migration of PCE mass towards and away from supply well TT26 occurred at about equal rates during 1985 to 1991, the computed degradation rate of 0.00053 per day approximates a long-term average degradation rate." Did I read that correctly?

A. Yes.

Q. It goes on to say, "on the other hand, if a significant quantity of the PCE degraded in the vicinity of supply well TT26 was replaced by advection, then the degradation rate computed using equation three is probably a minimum rate," correct?

A. Yes, that's what you read.

Q. Okay. And do you agree with that?

A. I agree with that concept, yes. He's basically saying we had two data points at TT26 in '85 and '91, and so that's what was used to compute

the initial -- to start model calibration.
Q. And then it goes on to say, "the report does not state or indicate that the decline in PCE mass at supply well TT23 is due entirely to biodegradation rate -- biodegradation. Rather, the report indicates that the computed first-order degradation rate is an estimate used as a basis to begin model calibration," correct?
A. Yes. It's important to understand that the value that we ended up for the calibrated rate, which is five times ten to the minus four per day, 0.0005, compares extremely favorably with the values that Dr. Clement came up with in his model for his paper.
Q. That who came up with?
A. Dr. Clement.
Q. Okay. And you're talking about the Dover Air Force Base model?
A. Yes, yes, very similar lithology. We did have a gravel zone in there, but, again, he came up with -- I think it was somewhere around one to four times ten to the minus four. I would have to look at the paper and see.
Q. That's okay.
A. But that's, you know...

Q. I wanted to turn your attention to the Bates page ending now in 15.

A. Yeah, could I just make sure I gave you the right numbers?

Q. Sure.

A. Here we go. Okay. Here you go. The estimated -- the field estimated apparent reaction rates range from 3.5 to seven times ten to the minus four per day for PCE, and we're smack dab in the middle with five times ten to the minus four.

Q. Let's turn to the page ending in 15.

A. Okay.

Q. There is a comment about -- towards the bottom of -- about mass loading. Starting page 59, it says, "mass loading, disagree, see my comments under major concerns item five. The reviewer seems to assign a high degree of accuracy and credibility to the PCE mass computation that is unwarranted." Did I read that correctly?

A. Yes.

Q. And then it says, "as explained previously, the computation of PCE mass was highly interpretive and somewhat subjective process frequently based on questionable data." Did I read that correctly?

A. Yes.

Q. Do you agree with that?

A. Not necessarily. We had data from ABC Dry Cleaners, PCE data, and we used a technique that was published in Groundwater journal that's documented in the Chapter E and the Chapter F -- F report in -- the key fact takeaway, and I mentioned this in -- I believe it was my expert report, is that the mass computed using the field data and the mass determined from the MT3DMS model were the same order of magnitude, which gave us -- it's almost another calibration check, okay?

Q. The comment goes on to say, "field data applied to the PCE mass computation were limited both spatially and vertically," right?

A. Right.

Q. And that's a true statement, right?

A. That is. They were limited, but they were still field data available.

Q. And then, "the computation was accomplished regardless of data limitations to provide an estimate of a minimum mass loading rate to begin model calibration." Did I read that correctly?

A. Yes.

Q. Okay. Now, for the Tarawa Terrace model, ATSDR assumed mass loading on January 1, 1953, correct?
A. That is correct.
Q. And I think, was it -- without pulling up the report, was it 1300 -- or no, 1200?
A. That was the calibrated value, is 1200. We started at 200. And again, that is a calibration parameter that you're free to adjust during the model calibration process. We're adjusting, you know, conductivity. You're adjusting reaction rate. You're adjusting a number of parameters. And so it was adjusted and the best fit value came up to, I believe, 1200 grams per day.
Q. Okay. And I understand that DOJ's expert has offered a -- well, let me -- let me ask you this: You reviewed Dr. Spiliotopoulos's report, correct?
A. Yes.
Q. Okay. And you saw that his opinion that the -- the later start date for ABC Cleaners, correct?
A. Right, correct.
Q. Of July 1954, correct?

A. That is correct.
Q. Okay. And in the ATSDR Tarawa Terrace model, the start date was assumed to be January 1, 1953, correct?
A. That is correct.
Q. And on day one, the calibrated mass loading rate is 1200 micrograms per liter, correct?
A. No, grams per day.
Q. Per day. I'm sorry.
A. Yeah, grams. The way it was input to the model as a source loading rate, so it would be grams per day.
Q. Thank you for that. It was assumed to be a constant 1200 micrograms per day, correct?
A. The calibrated value.
Q. For Tarawa Terrace?
A. Yes.
Q. Okay. In the real world, if contaminants on the surface were to start leaking, would they immediately reach the aquifer?
A. They would within, in this case, probably a couple of years.
Q. So in -- in -- for Tarawa Terrace it's your opinion that whenever ABC Cleaners released PCE into the -- onto the ground, it would have

taken a couple of years for it to reach the aquifer?

A. To reach any of the supply wells pumping. In other words, it would have gone vertically horizontal and, of course, the -- say TT26 is pumping, is putting tremendous gradient, vertical gradient, down right near to the well, so it would have fallen horizontal and then vertically down into the well -- a well casing or a well screen and been pulled -- pulled up. And the assumption was, again, the engineering assumption, that it started on January 1st, 1953 when ABC Cleaners started operations.

Q. Okay. So you assumed the constant -- the calibrated constant mass loading rate on day one, but you agree in the real world it may have taken a couple of years for contaminants from ABC Cleaner to actually get to the supply wells, correct?

A. It may have, but we did not do -- you would have to do an unsaturated zone modeling or analysis to actually quantify that.

Q. Why did you-all decide to assume a constant mass loading rate on day one?

A. Because if we did not assume a constant value, that would be, to me, indicative that we must have had some additional data to say that, you know, it was a certain rate this day, a different rate in another day, and so on. So we did not have that information, so in keeping with accepted model calibration practice, we assumed the constant rate that we computed -- we computed initial, which was a minimum value, and then through the calibration process increased it using calibration to check results for the available contaminant concentration data at the wells.

(DFT. EXHIBIT 21, e-mail correspondence Bates-stamped CLJA_Watermodeling_05-0000021184 through 0000021188, was marked for identification.)

BY MR. ANWAR:

Q.   I'm handing you what I'm marking as Exhibit 21.

A.   Okay.

Q.   I hope that's right, 21. We were just talking about mass loading with respect to Tarawa Terrace. I would like to shift gears to -- to sort of mass loading with respect to Hadnot Point/Holcomb Boulevard.

A.   Okay.

Q.   And this is an e-mail from Barbara

Anderson to you dated -- the first e-mail -- well, I guess the chain, both of them, are dated September 26th, 2011, correct?

A. It's September 26, 2011, yes.

Q. Okay. And this e-mail is discussing mass loading of benzene, correct, or, I guess, LNAPL, light non-aqueous phase liquid?

A. I believe this is discussing the LNAPL that's dissolved because -- it says LNAPL on it, so I'll leave it at that right now.

Q. The third paragraph states, "the first scenario is a simple step function. The second scenario incorporates some information we have about the Hadnot Point fuel farm area and conceptualizes the source strength LNAPL area as increasing over time. In reality, the LNAPL footprint grew and spread as the UST system leaks and releases progressed. At some point in time the LNAPL footprint grew to be the size that -- that GT calculated from the free product data, 1988 to 1999, but it was not that size from the beginning start date. This is shown in scenario two."

Did I read that correctly?

A. Yes.

Q. And do you agree with Barbara Anderson that in reality the LNAPL footprint grew and spread as the underground storage tank system leaks and releases progressed?

A. Conceptually, yes, I would agree with that.

Q. And scenario two shows a -- the leaks and releases progressing over time, correct?

A. That is correct.

Q. Whereas, the scenario one is a step function that shows immediate mass loading or release right away, correct?

A. That is correct.

Q. And for the Hadnot Point/Holcomb Boulevard model as it relates to LNAPL, ATSDR used scenario one, correct?

A. I would have to go back and read -- the LNAPL was rather complicated because we had the folks at the multi-environmental simulations lab at Georgia Tech looking at the volume and then the movement within the saturated zone to the water table. And then we had the other people, like Barbara and Mr. Elliott Jones, who did the fate and transport part, looking at it moving the water table.

So I would have to go back and -- and

look at how each one characterized the mass loading rate or the source -- source rate and -- but I know Barbara was our data analyst, and I think the task here was to look at two different conceptualizations for how mass loading at the Hadnot Point industrial area and fuel farm could have occurred.

Q. Okay. And scenario two is more realistic, right, in the real world?

MR. DEAN: Object to the form.

THE WITNESS: Again, that's -- I think that's an data analysis engineering call as to what it could be.

BY MR. ANWAR:

Q. Okay.

A. You know, where it's almost -- you'd have to run a sensitivity analyses on here and see which one provided you closer agreement.

Q. Okay. As you, Mr. Maslia, sit here today, are you planning to amend or supplement your expert report in the case?

A. Well, we mentioned about the geometric bias. I don't know if that amends my report or -- and we included that extra paper reference --

Q. Okay.

A. -- from Clement, so that definitely, I think, should be in there. And, you know, I don't have any intentions of any major changes based on additional modeling that I'm -- I'm doing. I'm not planning on doing any.
Q. When you say no intent on major changes --
A. Right.
Q. -- are you planning to -- and when I say supplemental disclosure, are you planning to provide, like, another written document with additional or updated opinions --
MR. DEAN: So --
BY MR. ANWAR:
Q. -- major or minor?
MR. DEAN: Let me -- let me take over here and answer for the witness, if it's okay. And that is, as you know, DOJ recently belatedly produced a bunch of photos from Dr. Hennet without any sort of a disclosure of what it is. So we can't respond to our experts until we sort of know some explanation as to what that is. So that could potentially, depending on Mr. Hennet's deposition, trigger something from him, but he nor any of our experts at this time can answer your question about

additional thoughts or opinions or whatever. And, of course, there's been some correspondence about this. Mr. Bain has sent a letter and we've responded. So we just -- he's reserving that right as to that stuff.

MR. ANWAR: Okay. Well, we will wait to see -- we'll wait to receive the documents related to the geometric bias and we will reserve our right to keep the deposition open or to reopen it. And I think I only have a few minutes left, so thank you for your time. I'll reserve those final minutes. Thank you for your time today.

THE WITNESS: Okay. Thank you.

MR. DEAN: Okay. Let's go off the record, if it's okay, for maybe about ten minutes. Take a break. Let me get my thoughts together. I've got some questions. They won't be long, but I've got a few questions.

THE VIDEOGRAPHER: Okay. Going off record. The time is 5:56.

(A recess transpired.)

THE VIDEOGRAPHER: Okay. We are going back on record. The time is 6:15 p.m.

EXAMINATION

BY MR. DEAN:

Q. All right. Mr. Maslia, I just have a few questions, so I don't think we'll be long, okay?

A. Okay.

Q. Oh, there we go. So earlier you were shown Exhibit 9, which is the Chapter A Tarawa Terrace report, and I want to ask you if you can look at your version and turn to page -- I believe it's A -- excuse me. You were shown Chapter C.

A. Hadnot Point?

Q. Hadnot Point, page C98. So it looks like it's Chapter C.

A. Yeah, I'm trying to find...

Q. Can you tell me what that exhibit number was?

MS. SILVERSTEIN: 17.

THE WITNESS: I've got Exhibit 17.

BY MR. DEAN:

Q. Okay. So take a look at Exhibit 17; put it in front of you.

MR. ANWAR: What page are you on?

MR. DEAN: Page C98.

THE WITNESS: Okay. C98. Okay. I'm at C98.

BY MR. DEAN:

Q. Do you remember Mr. Anwar asking you quite a few questions about the sampling for benzene at Hadnot -- or HP602?

A. Yes, I do.

Q. Okay. And y'all went over -- spent quite a while on reviewing those different sampling results. Do you remember that?

A. Yes.

Q. Now, can I have exhibit number --

MR. DEAN: Do we just want to continue the same number sequence?

MR. ANWAR: Whatever you want, yes.

(DFT. EXHIBIT 22, Appendix A5 Bates-stamped CLJA_Watermodeling_010000942748 through 0000942750, was marked for identification.)

BY MR. DEAN:

Q. I'm just going to use this just to shortcut it. I believe it's the end of -- this is Appendix I-5, Exhibit 22.

A. Okay. That's from the Chapter A report for Hadnot Point/Holcomb Boulevard.

Q. Correct. Now, you -- you were also asked some questions about the same time -- y'all were having a discussion about when the well was on and when was well was off. Do you remember that?

A. Yes.

Q. Okay. Can you explain to me as it concerns those sampling that was done post-turning off of the well, what the significance would be for those test results as it concerns the existence of the continuing contamination?

MR. DEAN: Object to the form.

THE WITNESS: Well, what these plots show, show early time, '51, the contamination in '68, the wells are pumping. November '84, the wells are pumping and shut off. And then it shows the plume -- this is the benzene plume, I believe, yes, benzene. It still shows it migrating under the hydraulic gradient, which is heading east to northwest, okay?

Q. Okay. And what is the significance of that with regard to the validity of any of the either calibration or contaminant testing concentrations after the well was shut off?

MR. DEAN: Object to the form.

THE WITNESS: What that indicates to me, and I think we had this discussion, is even though the tables that we have based on information provided by the Marine Corps for the Navy shows a well shut off, if you're still observing benzene concentrations in the water treatment plant, there had to be some wells pumping, okay? Maybe not continuously, but the plume is still moving past the well. I'm looking at well -- well 602 there, and even in 2008 there's still a plume over there. So if that well was ever turned on again, even though it says out of service, you would -- it would -- you would get benzene.

Q. Sorry.

A. This is similar to what we observed at Tarawa Terrace with TT26, and even though they shut down TT26, the plume kept moving.

Q. Okay. And were samples taken for concentrations in the area of the wells after those wells were shut down?

A. Were they?

Q. Yes.

A. I would have to look and see on the Chapter C report.

Q. Now, the Prabhakar Clement article that was previously -- I believe it was marked as an exhibit, the 2000 paper.

A. Yes, that one.

Q. Okay. Exhibit 1.

A. Okay.

Q. When did you locate that paper?
A. I would say within the last six months.
Q. When you were giving your 2010 deposition and responding to a question from the plaintiff's lawyer in that case -- well, strike that.
Before I go there, who was defending you during that 2010 deposition?
A. Mr. Adam Bain from the Department of Justice.
Q. Okay. And did you meet with him and prepare for that deposition in -- in -- either by phone or in person?
A. I met with him in the afternoon along with attorneys for CDC's Office of General Counsel on the 29th, the day before, for a few hours in the afternoon.
Q. Okay.
A. And since I had never been deposed before, he went over the ground rules and --
Q. And during that meeting or any other conversations y'all had, did Mr. Bain ever question the validity of your work at -- for which you were about to testify to?
A. No, he did not.

Q. Now, you -- he asked -- excuse me, not he. The plaintiff's lawyer in that case asked a question to which you responded something -- I'm using the word mob, do you remember that?

A. Yes.

Q. Referring to the work or some of the work that was done here. Were you aware at -- in 2010, or had you seen Dr. Clement's paper at that time?

A. I had not seen this particular journal article.

Q. All right. I'm going to show you Exhibit 23.

(DFT. EXHIBIT 23, Author's reply by T. Prabhakar Clement from Ground Water, January-February 2012 Bates-stamped CLJA_Watermodeling_010000092109 through 0000092111, was marked for identification.)

MR. ANWAR: And I'm just going to note for the record that conversations that took place when you were an employee of ATSDR and the Department of Justice are privileged.

THE WITNESS: Okay.

MR. DEAN: And I'm not sure I agree, but I don't think it matters, just for the record.

You know what, I don't think I have an extra copy of this. I'll show it to you. I don't have an extra copy of it.

MR. ANWAR: I have a copy.

MR. DEAN: It's the response to...

BY MR. DEAN:

Q. So I'm going to show you Exhibit No. 23. And can you tell me what that document is?

A. This looks like Dr. Clement's response to our editorial review or editorial comment on his 2010 paper about hindcasting.

Q. And can you read the first -- let me see. I think it's just the first full sentence.

A. I believe I've got a copy if you want me to just use my copy and then...

Q. Yes, it's -- it's actually the first full sentence. It's a rather long sentence, but...

A. Yeah, I got --

Q. You can just use this one.

A. Oh, okay. Okay. Okay.

Q. Can you read into the record --

A. The first full sentence?

Q. Yes, sir. Now, let's give it a little context. What is Dr. Clement responding to?

A. Dr. Clement published an article in

Groundwater, in the same journal, I believe it was in 2010, about basically hindcasting, historical reconstruction to us, when is enough enough, and used the Camp Lejeune project as a case study or an example.

Q. Okay. And who is Dr. Clement as it concerns his relationship with any of the Camp Lejeune work? What -- what role, if any, did he play at any point in time with regard to Camp Lejeune work?

A. Dr. Clement was the hydrogeologist and modeler expert on the National Research Council that assessed ATSDR's Camp Lejeune work.

Q. So when people refer to the 2009 NRC report, he was the water modeler that was -- served as one of those panel members?

A. He was the only water modeler.

Q. Okay. So later on he must have written an article in 2010 about additional information about Camp Lejeune?

A. Yes.

Q. Okay. And can you read into the record what he said in his response to ATSDR's response?

A. Okay. In the response to our editorial.

Q. Yes.
A. Okay. "The goal of my article was not to review the Camp Lejeune, in parentheses, CLJ, modeling studies." Do you want me to continue?
Q. You can -- you can read the next line.
A. Okay. "Rather it was to use the CLJ problem as an example to highlight issues related to model complexities and to speak -- and to spark an open debate on when, where, and why we should limit model complexity."
Q. Okay. Now, you spent a lot of time, both you and Mr. Anwar, using a word, "uncertainty?"
A. Yes.
Q. Okay. And of course, lawyers and the general public may use the word "uncertainty" differently than water modelers; is that correct?
A. Yes.
Q. So what -- when you were referring -- using the word with -- uncertainty in responding to questions that used the word "uncertainty", can you explain to the Court and jury what is an uncertainty -- what is uncertainty definition or an uncertainty analysis as you're using it in this deposition?

A. I'm using it in this deposition and the modeling analyses.
Q. Is uncertainty unusual in water modeling work?
A. Not at all.
Q. And explain that to the Court, sir.
A. Again, that -- that was -- I'll say that was one of our primary concerns and disagreement with the NRC report because it -- it described the uncertainty about data about modeling. We never disagreed that there was uncertainty. An example being you have a sample measurement and, you know, you can have a lower value or a higher value. And so the uncertainty would be that range in there in terms of numerical analysis, like Monte Carlo gives you upper band, a mean, and a lower band. And so that band is the uncertainty or the confidence, okay? So when we're talking about uncertainty, we're also talking about the confidence that we have in the results.
Q. Okay. And you expect to see the word "uncertainty" in any -- everyday garden variety of water modeling project?
MR. DEAN: Object to form.
THE WITNESS: They should. If you look

at some of the earlier modeling procedures or protocols of models -- when I say earlier, prior to 1980, prior to 19 -- you might see sensitivity analysis and that's part of uncertainty analysis, but good modeling practice would include both sensitivity analysis and an uncertainty analysis.

BY MR. DEAN:

Q. All right. Let's go to one other area real quick. I don't know the exhibit number. It's the e-mail related to the disclaimer.

A. Oh, okay. Here, 11.

Q. Okay.

MS. SILVERSTEIN: The e-mail is Exhibit 13.

THE WITNESS: Here you go. 13.

BY MR. DEAN:

Q. 13, yes.

A. The exhibit is 12.

Q. Yeah, the disclaimer. So with regard to Exhibits 12 and 13 having to do with this issue that arose, it appears, in May of 2007, do you remember having a conversation of questions back and forth with Mr. Anwar?

A. Yes, I do.

Q. Okay. And -- but I didn't hear him

ask, nor did I -- or maybe I missed it, but did you -- did someone reach out to you and complain or did some -- something come to you from another department or agency upset about what was being posted on the website that generated the need for a disclaimer on the website?

MR. DEAN: Object to form.

THE WITNESS: I recall that it was conveyed to me in the source sent to me, the Department of Navy, where or who -- I'm not sure, it could have been a representative at Camp Lejeune that -- my point of contact, but the message was that the Navy was upset about anyone being able to access values on the ATSDR website.

Q. And calculate for their own benefit specific numbers?

A. Yes, yes, yes.

Q. Okay. So up until the time, based on your information from a source that it's the Navy that made this complaint, there was not any consideration for the need for a waiver; is that fair?

MR. DEAN: Object to form.

THE WITNESS: We -- we did not have that in our protocol so to speak --

BY MR. DEAN:

Q. Sure.

A. -- that we needed to put up a disclaimer.

Q. It still today doesn't show up in the written published reports, bound, produced reports, other than on the website?

A. No, no, it does not appear in the reports.

Q. And when you were communicating with the lawyer about a form of a disclaimer, Ms. Deborah Tress in May 2007, do you know whether or not she was communicating with Adam Bain and the Department of Justice at the same time with regard to this disclaimer?

MR. DEAN: Object to form.

THE WITNESS: I do not know. We were just told --

BY MR. DEAN:

Q. And for the record, Ms. Deborah, Debbie, Tress, she's a lawyer, in-house lawyer, employed by the federal government working for the ATSDR CDC in-house counsel?

A. At the time of that e-mail, she was the CDC in the CC Office of the General Counsel and we were told she would be the one handling any Camp Lejeune-type issues.

Q. Okay.

A. From a legal standpoint.

Q. So late this afternoon, probably in the last hour or so, you answered some questions with regard to timing of contaminants to Tarawa Terrace TT26. Do you remember that?

A. Yes.

Q. And I believe it is Alex Spiliotopoulos's report where he has some suggestions and a graph where he has the contaminants going -- instead of going through the water column, dropping into the ground -- are you familiar with what I'm referring to?

A. Yes, I am.

Q. Okay. How is the most reasonable way in which you expect contaminants that get into the water column -- are they going to continue in the water table or are they going to drop in the ground, is my first question?

A. Well, they're going to go along a pathway, a horizontal pathway. And as I put in my rebuttal report and Dr. Konikow explained, they'll -- they'll go horizontally almost until they reach the well, and that's because you've got a cone of depression around the well as the well is pumping, and then go very rapidly vertically into the -- into the well.

Q. And scientifically, why does -- why -- why is that? Why does that occur, in your opinion?

A. Because the groundwater is -- velocity is flowing with the gradient. So the gradient is decreasing or the water level is decreasing as you approach the well.

Q. Okay. And is the contaminants -- is the -- traveling in the water table versus reaching the well itself, is one faster than the other?

A. Yes, the -- the last, let's call it, the few -- few feet or where the cone of depression of the well is going to much more rapidly pull in any contaminants, and the time is going to be much more shortened because of the high velocities at the well and within the cone of depression.

Q. I'm sorry. My dog is -- they can't find my -- my wife can't find my dog, so I told her where he was at.

Okay. Let's give this back.

A. Okay.

Q. Between the time -- when did you --

remind me when you retired?

A. December 31st, 2017.

Q. Okay. When you retired on January the -- January of 2018 until the unfortunate time when I gave you a call in '22, did you do any work on Camp Lejeune during that time frame?

A. No, I did not.

Q. Okay.

A. Nor did I speak to anyone.

Q. Okay. Let me ask a -- the timing question, let me ask one last different way. For purposes of the timing of contaminants to reach the aquifer, is that different from the time for it to reach the water table?

A. Well, conceptually, the aquifer in Tarawa Terrace that we modeled starts at the water table, okay? And we didn't look at -- we didn't on MODFLOW, MT3DMS, did not look above the water table. It was maybe about 10 feet, 15 feet of saturated zone. And so we looked at everything -- all our models assume it's at the water table, and that the timed travel through the unsaturated zone, so typically down vertically, would be minimal.

MR. DEAN: All right. I believe that's all the questions I have. Thank you.

MR. ANWAR: I just have a couple of follow-up questions in my --
THE WITNESS: Sure.
MR. ANWAR: -- few remaining minutes.

EXAMINATION

BY MR. ANWAR:
Q. Mr. Dean showed you, I think, what was marked as Exhibit 22.
A. Yes.
Q. If you would like to take a look. My only question about this is Exhibit 22 is the depiction of plumes at Hadnot Point -- the contaminant plume at Hadnot Point, correct?
A. Yes, yes, yes. It's the -- you're talking about benzene?
Q. For the benzene plume, correct?
A. Yes, yes. Let's see, what -- what page you're on?
Q. It's A146.
A. A146. Okay. Okay. I'm there.
Q. My only question about it is that what we're seeing here is a visual depiction of the reconstructed plume based on the model, right?
A. That is correct.
Q. Okay. I'm going to mark one exhibit.

(DFT. EXHIBIT 24, e-mail correspondence Bates-stamped CLJA_ATSDR_BOVE-0000108607 and 0000108608, was marked for identification.)

BY MR. ANWAR:

Q. I'll hand it to you, Exhibit 23. 24. I'm sorry. Let me fix that. I can't count. I will represent to you this is an e-mail exchange that starts between you and Dr. Clement and then that you forward on to the ATSDR team in February of 2008. Would you agree with that?

A. Yes.

Q. Okay. And in the -- the e-mail exchange -- the e-mail from Clement, Dr. Clement, to you at the bottom of the chain, he's offering some -- some -- his sort of feedback and some compliments about the work that you-all did with respect to the Tarawa Terrace analysis, correct?

A. It does not specifically say Tarawa Terrace. However, given the date of that, it would have been Tarawa Terrace because we would not have probably even started on Hadnot Point.

Q. Sure. And the subject says sensitivity analysis on well --

A. Oh, okay. Okay.

Q. -- TT26, right?

A. Okay. Yes.
Q. Okay. And he says, "yesterday I read most of your report and I found them to be very thoughtfully organized. It is a complex problem, but you guys did the best possible job a modeler can. They are lucky to have you guys as a modeling team. Thanks for your support." Did I read that right?
A. Yes.
Q. Okay. And then you forward it to your team and you say, "look at the second paragraph from Dr. Clement, a member of the National Research Council committee on contamination of drinking water at Camp Lejeune. It's nice to get words of praise from unbiased and technically competent colleagues about our abilities and work." Did I read that correctly?
A. Yes.
Q. Okay. And I understand that subsequently the NRC report was published, correct, in 2009?
A. That's correct, that's correct.
Q. And after the NRC report, Dr. Clement published his -- his article on hindcasting, and then you-all -- you and Dr. Aral and the ATSDR team

had a response, and then he published sort of a response to your response, correct?
A. Right, that's correct.
Q. Okay.
A. That's typically what's done in the journal article type.
Q. Sure. Do you -- in your view, as you sit here today, is Dr. Clement still an unbiased and technically competent colleague?
MR. DEAN: Object to the form.
THE WITNESS: Yes, I never -- I never said he was biased. We always said it was the NRC report, the final -- the final report. Again, I think we discussed this in my previous deposition, that that is what really caught the entire team by surprise because we were providing information and data to Dr. Clement. I think we also provided it to Dr. Knuckles and some other people.
Q. Sure.
A. And the feedback was this is, you know, great -- great stuff, great job and all of that. And the report -- and especially the -- I guess, what is it, the public summary or whatever, really just took a 180-degree opposite turn.
Q. Okay.

A. Okay.

MR. ANWAR: Those are all the questions I have. Thank you.

EXAMINATION

BY MR. DEAN:

Q. Mr. Maslia, he's -- I'm just focusing on Exhibit 24, and Mr. Anwar is pointing out the -- your use of the word "unbiased" --

A. Right.

Q. -- with respect to the reference to Dr. Clement on February 21st, 2008. Do you see that?

A. Yes, I do.

Q. At the time that e-mail was sent and words that you're issuing, the NRC report had not been issued yet, right?

A. Yes, you're correct.

Q. And it had not been issued until July -- I think it's July 2009.

A. June 2009.

Q. June 2009. Have you now read Susan Martel's deposition and all of the exhibits that are attached to it?

A. Yes.

Q. And do you have an opinion as to

whether or not the NRC was, in fact, biased or unbiased in the issuance of that final report?

A. The NRC report, I believe, contained numerous -- numerous -- it contained -- it contained mistakes, mischaracterizations, and it appeared to us to be -- and I'm talking about the project team, including the epidemiologists and whatever toxicologist, that it was a biased report.

MR. DEAN: Thank you. I have no further questions.

MR. ANWAR: Nothing from me. Thank you.

THE WITNESS: Thank you.

THE VIDEOGRAPHER: Okay. Then we're going off record the time is 6:49 p.m. This concludes today's deposition.

(The witness, after having been advised of his right to read and sign this transcript, does not waive that right.)

CERTIFICATE OF REPORTER

I, Lauren A. Balogh, Registered Professional Reporter and Notary Public for the State of South Carolina at Large, do hereby certify that the foregoing transcript is a true, accurate, and complete record.

I further certify that I am neither related to nor counsel for any party to the cause pending or interested in the events thereof.

Witness my hand, I have hereunto affixed my official seal this 18th day of March, 2025 at Myrtle Beach, Horry County, South Carolina.

____

Lauren A. Balogh
My Commission expires
March 19, 2030

I N D E X

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EXHIBIT 15

Rebuttal to Reports of Dr. Alex Spiliotopoulos and Dr. Remy J.-C. Hennet

Leonard F. Konikow

January 13, 2025

Qualifications:

I received a PhD in Geosciences from Penn State University in 1973, specializing in hydrogeology and groundwater modeling. I worked as a research hydrologist for the U.S. Geological Survey for about 42 years, and was the Editor-in-Chief of *Groundwater* journal for four years (2020-2023). At the USGS, I was mostly involved in the development, documentation, and application of groundwater flow models and groundwater solute-transport models. I was elected to the National Academy of Engineering in 2015. I am a Fellow of the American Geophysical Union and the Geological Society of America, which also presented me with their Meinzer Award for publications that have significantly advanced the science of hydrogeology. I have served on several Expert Peer Review Panels during my career, including those for ATSDR's Camp Lejeune groundwater modeling studies in 2005 and in 2009.

My curriculum vitae is included with this report as **Attachment A**, and a list of the publications I authored in the previous 10 years is included as **Attachment B**. I am being compensated at an hourly rate of $400 for my work on this litigation. I have not testified at a deposition or trial in the last 4 years.

Introduction:

ATSDR prepared reports describing models developed to simulate groundwater flow and contaminant transport at two areas of Camp Lejeune, North Carolina: Tarawa Terrace (TT) and Hadnot Point/Holcomb Boulevard (HPHB). Their use of the models was innovative in the sense that instead of a typical use of a groundwater model to predict future behavior, they used the model to "predict" how the system evolved in the past (before concentration observations were made) from a known state (an initial condition), in which no contaminants were present, to a contaminated aquifer with a mapped distribution in the early to mid-1980s when contamination was observed at a number of locations (wells, soil samples, and water treatment plants). ATSDR's use of groundwater models to reconstruct trends during a historical gap in concentration measurements is a legitimate and not unprecedented application of groundwater models. In fact, there are other publications in which doing this is documented and considered to be a normal and necessary part of the model calibration process, as discussed in more detail below. Modeling is the best and most logical approach for providing this information.

The ATSDR modeling work was reviewed and commented on by Dr. Alex Spiliotopoulos and Dr. Remy J.C. Hennet. In turn, I was asked to review the reports prepared by Dr. Spiliotopoulos and Dr. Hennet. This report presents my response, comments, and concerns about the technical content of Dr. Spiliotopoulos' and Dr. Hennet's reports. A list of the materials I have considered in rendering my opinions will be provided within seven days.

My opinions expressed in this rebuttal report are based on my review of the reports of Dr. Spiliotopoulos, Dr. Hennet, Mr. Maslia (Oct. 2024), Dr. Aral (Oct. 2024) and Jones & Davis (Oct. 2024), the ATSDR published reports, published literature, documents produced in this litigation, my work on the Camp Lejeune Expert Peer Review Panels, and my experience and expertise in the fields of hydrogeology and groundwater modeling. I hold these opinions to a reasonable degree of scientific certainty. I reserve the right to supplement and/or amend my opinions in this matter as necessary if additional documents or information are made available for my review.

Background comments about groundwater modeling related to DOJ Expert Reports

This section responds to the opinions of Drs. Spiliotopoulos and Hennet regarding the methodology used by ATSDR to reconstruct groundwater contamination, including their assertions that this methodology is novel, speculative and unfounded, and their repeated claims that this methodology cannot be used where there is limited to no historical data. (*E.g.*, Spiliotopoulos Report, pages 25-30).

A numerical computer model of groundwater flow and/or transport is a simplified representation of a complex reality. A model uses averages, approximations, and assumptions to simulate groundwater behavior and to reproduce its properties and characteristics. Because of uncertainty in defining aquifer properties and boundary conditions, groundwater models must be calibrated. Field observations of aquifer responses (such as changes in water levels for flow models and changes in concentration for transport models) are compared to corresponding model-calculated values. The objective of this calibration procedure is to minimize differences between the observed data and calculated values. The minimization is accomplished by adjusting parameter values within their ranges of uncertainty until a best fit is achieved.

Anderson and Woessner (1992) present a dichotomy of prevailing opinions about mathematical models:
1. "Models are worthless because they require too many data and therefore are too expensive to assemble and run. Furthermore, they can never be proved to be correct and suffer from a lack of scientific certainty."
2. "Models are essential in performing complex analyses and in making informed predictions."
They go on to conclude that "Although groundwater models are time-consuming to design and therefore expensive in terms of labor time, it is also true that use of a groundwater model is the best way to make an informed analysis or prediction about the consequences of a proposed action. … For these reasons, the bias of this book is, of course, toward opinion #2."

Groundwater contamination became widely recognized as a serious and pervasive problem in the 1980s. It is common that the existence of a groundwater contamination problem in a particular area would not be recognized until that contamination has migrated far enough and long enough that it affected a water-supply well or a surface water source. Then a monitoring program might be initiated. But this might not happen for several years to a few decades after the contaminant had entered the aquifer. Therefore, it is common that early-time data on concentrations are simply not available, as is the case at Camp Lejeune. Groundwater modeling is a widely recognized and accepted approach to understanding and managing these contamination problems. Models must be (and have been) calibrated in the absence of early time concentration data, as ATSDR has done. Other representative published examples where this has been successfully accomplished include the Rocky Mountain Arsenal, CO (Konikow, 1977) and Lawrence Livermore National Laboratory, CA (Rogers, 1992). In both of these cases, the early time history was reconstructed as part of the model calibration process (it just wasn't called "hindcasting").

In comparing hindcasting to forecasting, there are some similarities and some differences. In both cases, the analyst is using the model to estimate conditions during a time period outside of the calibration period, and both types of "predictions" have uncertainty associated with them. One difference is that for predictions of future conditions (forecasting), you can come back later and assess the accuracy of those model predictions. With hindcasting, that is not directly possible. Another difference is that with forecasting (predicting), future conditions are somewhat unbounded, so that uncertainty will tend to increase with time beyond the calibration period. With hindcasting, there is often a way to estimate initial or early time conditions, thereby putting a constraint or bound on uncertainty going back in time. While predictive uncertainty exists and must be recognized, hindcasting is an acceptable and reasonable way to use a calibrated model to assess groundwater conditions during a historical period when there were no observations.

"Hindcasting" was accomplished as part of a study of the Rocky Mountain Arsenal (CO) contamination problem, in which I developed and calibrated a groundwater flow and transport model (Konikow, 1977). The RMA began operations in or about 1943. A groundwater contamination problem was recognized in 1954 & 1955. No observations of concentration (chloride in this early case) were made until late 1955 to 1956. The model was developed to simulate the entire history of operation and contamination at RMA, starting in 1943, but no concentration data were available for the first 13 years of operation. Konikow (1977) made and described reasonable assumptions about the initial conditions, source locations, and source loading—but of course there was uncertainty associated with those estimates (as described by Konikow and Thompson, [1984]). The RMA model was calibrated using measurements made at four distinct times including 1956, 1961, 1969 and 1972. Work was documented and published in a 1977 USGS Water-Supply Paper (https://pubs.usgs.gov/wsp/2044/report.pdf), which received wide distribution. The RMA site became one of the first sites to fall under the Installation Restoration Program. Another example of reconstructing the early history of contamination migration was published by Rogers (1992) in *Groundwater* journal about their model calibration at the Lawrence Livermore National Laboratory site in California. In both of these earlier studies, the historical reconstruction wasn't called "hindcasting," but was considered a scientifically valid component of the model development and application.

Numerical simulation models of groundwater flow and transport processes in porous media are probably the most valuable single tool available to help analysts understand subsurface systems, integrate available data, evaluate conceptual models, and predict responses of groundwater systems to various stresses (such as pumping from wells and leakage or loading of contaminants into the subsurface environment). Groundwater flow models typically estimate the head distribution (equivalent to water levels, water table elevation, or potentiometric surface) in an aquifer system and how the head may change over time in response to changes in well locations or pumping rates. Groundwater transport models (solute transport or contaminant transport for dissolved chemicals) calculate how the concentration of a particular dissolved chemical will vary from place to place and over time. Groundwater systems are three-dimensional in nature, and their properties vary both horizontally and with depth. Therefore, groundwater models must typically be three-dimensional in nature. There is a large record in the published peer-reviewed literature of cases describing the development and application of models for complex real groundwater problems.

Contaminant transport in the subsurface is strongly influenced by the groundwater flow field. Thus, contaminant-transport modeling for a specific site requires a reasonably reliable groundwater flow model. If the contaminant is nonreactive or mildly reactive, the groundwater velocity (based on hydraulic gradients and effective porosity) is the primary control on advective and dispersive contaminant migration.

Comments about the distribution coefficient (K_d) and the retardation coefficient (R_f)

This section provides background information in support of my responses later in this report to Opinion 3 of Dr. Spiliotopoulos and Opinion 11 of Dr. Hennet regarding the methodology ATSDR used to calculate the retardation factor.

If a contaminant undergoes chemical reactions during the transport process, its net movement relative to the flow of groundwater may be slowed down. Such effects can be (and often are) represented in a simplified manner as a retardation process. Two parameters that are used to simulate retardation are discussed frequently in the comments by Dr. Spiliotopoulos. The contaminant transport conceptual model is that the migration of a contaminant may be slower than the average velocity of the groundwater in which it is dissolved because of adsorption to material in the aquifer. The net effect of this process is described by a so-called "retardation factor" (R_f), which is calculated as:

$$R_f = 1 + (\rho_b K_d)/\theta$$

where R_f = retardation factor; ρ_b = bulk density; K_d = distribution coefficient; and θ = porosity.

The model calculates R_f on the basis of the three parameter values on the right side of the above equation, all of which can vary in space and will include uncertainty in their estimated values. If ρ_b is estimated too high by 25% and K_d is too low by 25%, then the errors in those two estimates cancel each other out (i.e., they are compensating errors), and the net estimated value of R_f used in the model will be the same as if those two parameters were estimated precisely to their "true" values.

In general, the use of a distribution coefficient (K_d) as a component of a retardation factor in contaminant transport modeling in groundwater systems is a common modeling approach in simulating contaminant transport in aquifers, but one whose rigorous scientific basis is debatable. The K_d approach assumes that sorption of the PCE is instantaneous, reversible, and follows a linear equilibrium isotherm, and that "the solid matrix has an infinite sorption capacity" (Zhang & Bennett, 2002, p. 81). But in transport through complex heterogeneous porous media, the actual behavior of PCE would not match these idealized assumptions. Nevertheless, it is a simplifying assumption that can be useful in light of the uncertainties about the contaminant's distribution and reactive behavior. In effect, it represents an engineering approximation, which is why using a model calibration process to arrive at an approximate average value is an acceptable, reasonable, and common approach. Thus, Drs. Spiliotopoulos and Hennet's concern about precisely and accurately defining a value for K_d is misplaced because the theoretical underpinnings for this parameter are not rigorous. That is, conceptual uncertainty in its application must always be recognized, and this conceptual uncertainty carries forward to the use of a conceptually simple retardation factor in the transport equation. This theoretical uncertainty, however, does not preclude the use of these two parameters (K_d and R_f) for characterizing the average transport behavior of a contaminant such as PCE in flowing groundwater.

Zheng & Bennett (2002) describe some limitations in modeling sorption processes. They note that there are significant computational difficulties inherent in coupling advective-dispersive transport with chemical reactions (p. 79). They further note (p. 79-80) that "… field problems always involve uncertainty as to the nature of the controlling reactions, and as to the quantities and properties of the reacting substances. As a result, the biogeochemical processes represented in field-scale transport models at the present time are largely limited to reactions of the simplest kind, based on highly idealized representations of the effects of more complex reactions."

Kret et al. (2015) studied a Quaternary sandy aquifer to estimate sorption coefficients for PCE fate and transport modeling. They estimated K_d from both batch and column experiments and concluded that reasonable values for R_f for PCE are typically between 1.1 and 3.6.

Rogers (1992) developed a groundwater transport model for the Lawrence Livermore National Laboratory (LLNL) site in California, which includes "several hundred feet of complexly interbedded, unconsolidated alluvial sediments" with an upper boundary represented by an unconfined water table condition. Their calibration and history matching resulted in reasonable matches for R_f values between 1.0 and 3.0, with their conclusion that "a spatially averaged retardation factor of approximately 3 is recommended…"

<u>Model Documentation:</u>

To facilitate assessment of the scientific credibility and scientific defensibility of a groundwater model, the model study should be well documented. Reilly and Harbaugh (2004) state: "Because models are embodiments of scientific hypotheses, a clear and complete documentation of the model development is required for individuals to understand the hypotheses, to understand the methods used to represent the actual system with a mathematical counterpart, and to determine if the model is sufficiently accurate for the objectives of the investigation. … The appropriate level of documentation will vary depending on the study objectives and the complexity of the simulations."

Reilly and Harbaugh (2004) list ten topics that should be addressed in reports documenting model studies. These are:

1. Describe the purpose of the study and the role that simulation plays in addressing that purpose.
2. Describe the hydrologic system under investigation.
3. Describe the mathematical methods used and their appropriateness to the problem being solved.
4. Describe the hydrogeologic character of the boundary conditions used in the simulation of the system.
5. If the method of simulation involves discretizing the system (finite-difference and finite-element methods for example), describe and justify the discretized network used.
6. Describe the aquifer system properties that are modeled.
7. Describe all the stresses modeled such as pumpage, evapotranspiration from groundwater, recharge from infiltration, river stage changes, leakage from other aquifers, and source concentrations in transport models.
8. For transient models, describe the initial conditions that are used in the simulations.
9. If a model is calibrated, present the calibration criteria, procedure, and results.
10. Discuss the limitations of the model's representation of the actual system and the impact those limitations have on the results and conclusions presented in the report.

The documentation for the ATSDR model studies at Tarawa Terrace and HPHB study areas are detailed, comprehensive, and clear, and meet or exceed these guidelines, as evidenced by the series of model documentation reports that include 11 separate book chapters for Tarawa Terrace and 4 separate book chapters and 8 supplemental volumes for HPHB. Careful review of this comprehensive documentation indicates that ATSDR used scientifically acceptable tools and followed correct scientific methodology in performing its historical reconstruction, in contrast to the assertions of Dr. Spiliotopoulos and Dr. Hennet.

Review Comments on Dr. Spiliotopoulos' Opinions:

Opinion 1: Dr. Spiliotopoulos states "Due to the absence of sufficient historically observed data and site-specific parameters, the results of these calculations [in the ATSDR models] are highly uncertain and cannot be used for determining dose reconstructions at the level of detail that ATSDR presented in their analyses." I would counter that although early time data are lacking, there are still a lot of data and historical observations available, as documented in the several ATSDR reports on the investigations. Dr. Spiliotopoulos fails to specify how much data would be "sufficient". In any groundwater modeling study, there are never "enough" data and there is always uncertainty in the final model results. This is normal and expected. In this case, there were enough data to calibrate groundwater flow and transport models, and the data deficiencies were not so great as to prevent a historical reconstruction. In fact, a reasonable historical reconstruction was indeed accomplished, so it was possible. The historical reconstruction recognized the existence of uncertainty and assessed its impact on the results.

Dr. Spiliotopoulos refers to Section 4 of his report as his support for this opinion. Following are comments about his discussion in Section 4 of his report.

In the introduction to Section 4 (p. 27, para. 2), Dr. Spiliotopoulos overstates the lack of data for the Camp Lejeune groundwater system. He says that without site-specific data and a lack of observations, a model "can even be considered speculative and unfounded." That might be true if there were no site-specific data and no observations. But that is simply not true for these models. There are certainly site-specific data available on subsurface properties, as well as observations of heads, boundary conditions, and chemical concentrations for some time periods. These are all described in detail in the numerous reports published by ATSDR. There is no basis for applying the characterization of "speculative and unfounded" to the ATSDR models of TT and HPHB. Even for predictive periods, the system behavior simulated in the model still obeys the laws of physics and hydraulic principles, and contaminants will move in directions predictable by the hydraulic gradient, as calculated with the flow model.

In para. 3 (p. 27), he states that "'predictions' refer to model output, regardless of whether its results are used for hindcasting or forecasting …" I agree with this statement. However, in the next paragraph he discusses "When historical data are not available…" But whether the model predictions are used for forecasting or hindcasting, if it's truly a prediction, then there will be no measurements available (except later for a forecasting prediction). But at the time of model development, observation data for heads and concentrations will only be available during the calibration period. Implying that the lack of data during a predictive period is a problem is misleading. (If data were available during a historical period of interest, hindcasting would not be needed—it would just be used as part of the observed data set for the calibration period.)

In para. 2 (p. 29), Dr. Spiliotopoulos states that Dr. Clement (in Clement's 2011 publication) "indicated that ATSDR's analysis implied almost exact knowledge of past conditions." I disagree. I find that ATSDR is clear that uncertainty exists about the conditions during the historical reconstruction period, as well as during the calibration period, and the results include assessments of uncertainty. If Dr. Clement inferred that ATSDR believed they had an exact knowledge of past conditions, then that is Dr. Clement's mistake. In the same paragraph on p. 29, Dr. Spiliotopoulos quotes Dr. Clement's comments about the uncertainty analysis. Although the quote starts with Dr. Clement saying that "the results appear to be reasonable …", he ends the quote with an apparent criticism by saying: "The figure also shows that closer to the initial starting point the confidence band is almost 100%, implying that our knowledge of initial conditions, initial source loadings, and initial stresses is almost exact." Although it may be counterintuitive, as I discuss in my Introduction, I actually do have high confidence in the assumption that there were no (or negligible) contaminants in the groundwater from ABC Cleaners prior to Jan. 1953, and probably very little for at least several months after that. Thus, at some point the confidence band should get narrower going backwards in time towards the starting date of the simulation.

In his Summary of Opinion 1 (p. 30), Dr. Spiliotopoulos says "these models were largely not constructed using site-specific data …" I strongly disagree. The geometry and boundary conditions of the model and its hydrogeologic framework are derived from hydrogeologic and geophysical studies of the subsurface aquifer system at the Camp Lejeune and adjacent areas, as documented in USGS reports and in several of the ATSDR reports. This type of information provides a critical and necessary foundation for the models. The potentiometric and water table maps also provide important information for the construction and calibration of the models. Dr. Spiliotopoulos also states in this summary that the models were not "calibrated to observed data for the first 30 years of simulation." Of course, because those concentration data did not exist. That is the reason these models were built—to estimate those concentrations in a state-of-the-art way that is consistent with principles of groundwater flow and transport processes. The models did not generate arbitrary or random numbers. The results are based on the physics of groundwater flow and contaminant transport, and the results appear reasonable and realistic, and the existence of error bands or uncertainty ranges around the estimates is expected and openly acknowledged.

Opinion 2: Dr. Spiliotopoulos says that ATSDR used "parameters and assumptions that are incorrect or not representative of site conditions …" Parameter values for groundwater models are never known precisely and accurately. That is an unfortunate fact of life in groundwater modeling. The parameter estimation process (essentially, the model calibration exercise) is conducted to adjust parameter values within a range of reasonable values to yield a best fit between model simulation results and the limited observation data available. This naturally allows and/or creates compensating errors in the input data for the model. Dr. Spiliotopoulos says this results in conservative estimates of estimated monthly contaminant concentrations. It is not clear what is meant by "conservative" or why that is not a good trait. He also says the results are biased high. His main argument for that opinion seems to be that early (in time) results often lie above the mid-point of the uncertainty bands. The uncertainty bands reflect a zone within which results are expected 95% of the time; if results mostly fall within the uncertainty bounds, they should be considered acceptable. He cites sections 4.1.1 and 4.1.2 of his report for support of this Opinion.

On p. 31 (Section 4.1, 4th para.) Dr. Spiliotopoulos states "ATSDR's calibrated model sits at the top of the uncertainty range, … This demonstrates that the calibrated model was biased high." But it does not prove ATSDR's model is wrong. The results are within the uncertainty bounds and true values are expected to lie somewhere within the uncertainty bands. Furthermore, best estimates of concentrations do not have to lie at the center of the error band. A model may become insensitive to certain parameters used to create the error bounds at their upper or lower limits, and the response of the model to some parameter variations is not linear.

In para. 7 on p. 31, Dr. Spiliotopoulos quotes the NRC (2009) report where it says "Reporting precise values based on model predictions gives the misleading impression that the exposure of the former residents and workers at Tarawa Terrace during specific periods can be accurately defined." Would he prefer imprecise values? NRC gives no examples of where the ATSDR-reported values are too precise or are prone to misinterpretation in light of the pervasive discussions of model uncertainty provided by ATSDR in its reports. Furthermore, Dr. Spiliotopoulos fails to cite the first sentence of that same paragraph, where the NRC report states "The committee concluded that ATSDR applied scientifically rigorous approaches to address the complex groundwater-contamination scenario at Tarawa Terrace." [emphasis added.]

For Section 4.1.1 (p. 32), Dr. Spiliotopoulos uses the heading "Available data are limited to non-existent", but the first statement after that notes that there were 36 aquifer tests at TT to estimate aquifer properties. This is actually a lot of data, especially considering that aquifer tests are time-consuming and expensive to run. Data for TT are certainly *not* non-existent. I am sure many groundwater models have been developed for areas where there were less than 36 aquifer tests available.

In his summary of Opinion 2 (p. 33), Dr. Spiliotopoulos references his Fig. 5, which includes a reproduction of ATSDR's Fig. F16 about TT results, and goes on to say that ATSDR's work resulted in "biased high estimates." I reproduce that part of Dr. Spiliotopoulos' Fig. 5 (Fig. F16) here because it actually illustrates the opposite. It shows 5 measured PCE concentrations in samples from well TT-26 collected within weeks of each other in early 1985. Over this relatively short time span, the concentrations varied greatly (bracketed between a high of 1,580 ug/L on 01/16/1985 to a low of 3.8 ug/L on 02/12/1985)—a rate of change that cannot be replicated in a model using monthly time steps. Most importantly, the plot shows that the model results fell almost exactly at the midpoint of the range of observed values (about 800 ug/L)—countering the claim of the model being biased high.

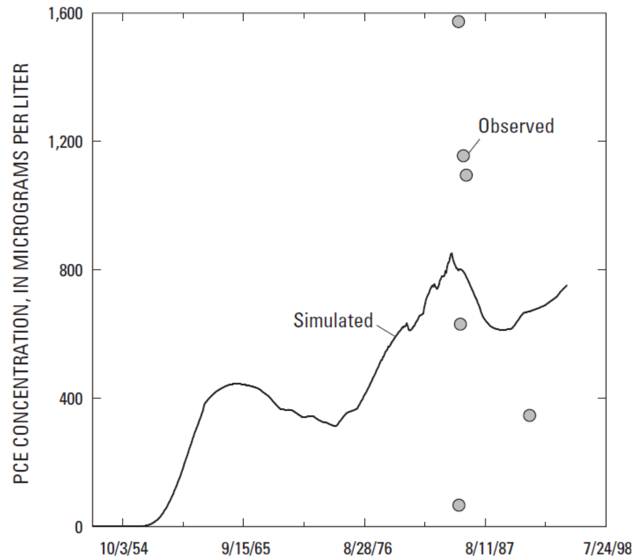


Figure F16. Simulated and observed tetrachloroethylene (PCE) concentrations at water-supply well TT-26, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina, January 1952–December 1994 (see Figure F6 for location).

Section 4.1.2, p.34, 1st para.: Dr. Spiliotopoulos quotes TT Chapter C (p. C38) saying that "… simulation results are unqualified for the years 1951-1977, …" This is a statement of recognition by ATSDR that there is a paucity of water-level measurements during that early time period. This is also part of ATSDR's consistent messaging that uncertainty exists, and is greater for some time periods than for other time periods. However, it does not disqualify or "unqualify" the model itself, as even during that same time period, other calibration controls and constraints exist in terms of boundary conditions and stresses. Specifically, the adjacent surface water systems represent hydrologic boundaries with known average elevations that change very little over periods of decades. Average monthly recharge can also be estimated based on precipitation and other climatic data that are available. Given such constraints, there is a limited range over which the simulated heads can vary, and that range is not unqualified or unconstrained.

In Section 4.1.2, p.34-36, Dr. Spiliotopoulos cites ATSDR (TT, Chapter F) as noting that 53% of comparisons of simulated to observed concentrations violated ATSDR's calibration target. But many of these samples were collected on the same day or within a short time of other samples (Figure 6 (Table F13), p. 35), so giving equal weight to each comparison is not statistically reasonable. These temporally closely spaced samples are not truly independent samples. Alternatively, I would say a fair comparison should be made on the basis of the quality of the agreement between simulated and observed concentrations at the 11 separate sampling (well) locations. This gives equal weight to every sampling location. Of these, 8 can be deemed "accurate" (including two that have some low and some high samples, so accurate on average), one is high but within the target range, one is slightly high, and one is consistently high (TT-23). On this basis, 73% of the sampling wells show reasonably and acceptably accurate simulation results. Also see my related discussion of calibration targets below (for Section 3.3).

On p. 36, para. 4, in his summary of Opinion 2, Dr. Spiliotopoulos states that the “model calibration did not rely on observed data prior to 1984.” Yes, no contaminant concentration data were available then, and that is why ATSDR needed a deterministic groundwater simulation model to estimate how the contaminants were distributed in the aquifer during that time period.

<u>Opinion 3</u>: This Opinion notes that the calibrated model for TT was built using different parameter values and assumptions than the HPHB model. Dr. Spiliotopoulos cites sections 4.1.2.2, 4.1.2.3, and 4.2.3.2 of his report for support. In general, I note that these two study areas do not overlap. Although they are adjacent, and one would expect similar characteristics, having differences is not surprising and certainly the two independent calibrations can yield different values for the various parameters in the models. The models were also developed and calibrated at different times (TT being the earlier model) and improved calibration (parameter estimation) software was applied in developing the latter (HPHB) model.

Dr. Spiliotopoulos (Section 4.1.2.2.1, p. 37) indicates that an error was made in calculating the bulk density (ρ_b) for the TT system. Using an average value for total porosity of about 35%, he calculated that ρ_b should be lower, stating that “In the Hadnot Point model, this error was not repeated.” That value was 1.65 g/cm^3. He states that “This has a significant impact on the calculation of the retardation factor, resulting in faster (sooner) arrival of PCE at the water-supply wells, …” However, as Dr. Spiliotopoulos himself admits, this significant impact on R_f does not actually occur because the calibration process compensates for an overestimate of ρ_b by estimating a value for K_d that appears to be too low. Recall that neither of these two parameters are used directly in the transport model. Rather, the retardation factor is used to calculate the migration velocity of the contaminant, and this retardation factor depends on the product of ρ_b and K_d. The calibration process yields a very reasonable value for R_f for PCE—a value (about 2.9) that is very consistent with values in other field studies reported in the literature (e.g., Rogers, 1992; Kret et al., 2015). In Section 4.1.2.3, Dr. Spiliotopoulos has a whole paragraph describing the erroneous consequences “if ATSDR had used a retardation factor of 6.44.” But ATSDR did *not* use a R_f = 6.44, so this argument is irrelevant. In summary, the two specific possible errors cited by Dr. Spiliotopoulos for ρ_b and K_d largely offset each other, and have a minimal or negligible impact on the final results, as documented by ATSDR (CLJA_WATERMODELING_01-0000075468; ATSDR_WATERMODELING_01-0000887324).

Dr. Spiliotopoulos (Section 4.1.2.4, p. 39 and elsewhere) and Dr. Hennet (Opinion 11) raise concerns that site-specific data were not used to estimate total organic carbon (TOC) or to calculate K_d. TOC is used to estimate f_{oc}, which in turn is used together with an estimate of K_{oc} to estimate K_d, which in turn is but one factor in the equation used to estimate R_f. That is a long string of dependencies. Appendix A of Dr. Spiliotopoulos’ report shows that reported values of TOC vary over a range of about four orders of magnitude. That is a huge variation and uncertainty, which is not accounted for. You cannot simply assume that the mean of that distribution of TOC values is the true and correct one to use to estimate K_d. Overall, there would be much less uncertainty, greater value, and more clarity in just estimating an average value for R_f as part of the calibration process, which is the methodology ATSDR employed. I believe that this is not optional and that R_f must be estimated during and in accordance with the calibration process. In light of this, it simply would not have mattered if K_d had been preliminarily estimated by ATSDR using highly variable site-specific measurements of f_{oc}/TOC. In the end, the value of R_f = 2.9 calibrated by the ASTDR modeling work is very close to other values reported in the literature for aquifers having similar geologic materials.

Dr. Hennet also criticizes ATSDR for failing to consider available site-specific data for f_{oc} (fraction of organic carbon) to estimate values of K_d (his Opinion 11). Rogers (1992, p. 51) in discussing the K_d parameter says "Numerous researchers have used theoretical methods correlating the organic carbon content (OCC) of the subsurface material and the K_d (Karickhoff, 1984). Others have used the partitioning between octanol and water to predict the K_d (Kenega, 1980). **These methods are not considered appropriate where the OCC is less than approximately 0.1%**." OCC is equivalent to TOC, and 0.1% is equivalent to a fraction or 0.001. Hennet's Expert report lists (Exhibit 3-2, and p. D-11 to D-12) 21 Camp Lejeune samples where f_{oc} is given. The median value is 0.0013, barely above the indicated limit, and 9 samples (43% of the samples) have values <0.001, indicating that the use of f_{oc} to estimate K_d is not appropriate. If ATSDR had used this approach, it would have introduced additional errors and sources of uncertainty.

In his summary of his Opinion 2&3 (p. 38-39), Dr. Spiliotopoulos states (in reference to ρ_b and K_d) that "parameter values in the Tarawa Terrace model were different than those used in the Hadnot Point model, even though both models simulated similar hydrogeologic conditions." This is not a problem, and it would be more surprising if they had applied identical values. The areas have similar conditions, not exactly the same conditions. Hydraulic conductivity measurements show notable differences between the two areas, reflecting local differences in aquifer material properties. These differences also cause differences in the factors contributing to the R_f. There is nothing wrong or unexpected about this. R_f was estimated in the calibration process, and the HPHB calibration used a different (and supposedly better) automated parameter estimation software package, which was not used in the TT calibration. So of course some differences will result. If they had applied the same parameter estimation software to both sites, it still would most likely result in different values for the average R_f in the two different areas. But the differences are small and inconsequential.

In a summary of his Opinion 3 (p. 39), Dr. Spiliotopoulos states that "these incorrect assumptions resulted in faster plume migration in the aquifer and estimated monthly concentrations that were conservative and biased-high." However, this would only be the case if the errors in the two parameters were considered separately and alone. But the model does not respond to these values separately. It responds to their net effect on the retardation factor, which was calibrated to a very reasonable value consistent with other peer-reviewed studies. The errors were compensatory and that compensation was built into the critical R_f value by the calibration process, as would be expected from a calibration process for a groundwater model.

<u>Opinion 4</u>: Dr. Spiliotopoulos says that use of "parameter values based on site-specific data … in Tarawa Terrace would result in substantially lower estimated monthly concentrations. Furthermore, the model uncertainty range would also be lower." Dr. Spiliotopoulos cites his Section 4.1.2.5 as support.

On p. 39, Dr. Spiliotopoulos argues that site-specific data for calculating K_d would result in a higher K_d value. Again, the model calibration process adjusted values of K_d, one component of the retardation factor, so that the value of R_f was as reasonable and accurate as possible for maintaining consistency with the available observed concentrations. Furthermore, in calculating K_d, Dr. Spiliotopoulos used a porosity value of 20%, which was the effective porosity used in the transport model. However, in calculating ρ_b, the other component of R_f, Dr. Spiliotopoulos used a porosity value of about 35%--a value representing the total porosity measured in two soil samples (p. 37). Using two different values for porosity in the same equation is inherently wrong, creating an inconsistency of 75%, and is done with no explanation.

In section 4.1.2.5, Dr. Spiliotopoulos develops a "revised" model using a late start date and a different K_d value. He presents his results in comparison to the ATSDR model results in his Figs. 7 and 8. He accentuates the early time differences by plotting results arithmetically rather than logarithmically. But that's a minor point. The proper start date is outside the scope of my opinions. But adjusting the K_d without also adjusting p_b is one-sided. In any case, Dr. Spiliotopoulos' value for R_f in the revised model is 3.48. The value of 2.93 used by ATSDR is only 16% lower than this new value used in Dr. Spiliotopoulos' revised model. This difference is relatively small. Furthermore, as seen in those two figures, the difference between the ATSDR results and Dr. Spiliotopoulos' revised model results are very small after approximately 1970. More importantly, both models are consistent in showing that PCE concentrations are above the MCL for most of the study period—and since Jan. 1, 1960 in both models, at both Well TT-26 and in influent to the TT WTP.

Also noteworthy in Dr. Spiliotopoulos' Fig. 7 is that for both models, there is a peak concentration shortly before 12/84. When K_d is higher and R_f is consequently higher, then one would expect that a peak moving through the groundwater system would be somewhat delayed, yet there is no indication in the results for Dr. Spiliotopoulos' revised model that this peak concentration was delayed at all. Instead, it appears to have arrived at TT-26 at the same time as in the ATSDR model. This demonstrates a lack of sensitivity to the value of K_d in this particular system. It simply did not make a significant difference.

Dr. Spiliotopoulos' only support for his opinion that the uncertainty range would be lower is a concluding statement in his Summary on p. 41, which states, "The uncertainty range for such historical reconstruction would also be lower, as it would be based on slower plume migration and lower concentrations for many years after the start of contaminant releases from the source." However, this is an inference that itself is not supported by analytics. Dr. Spiliotopoulos has not demonstrated that the uncertainty range would be lower. Dr. Spiliotopoulos' results also do not demonstrate significantly slower plume migration (peaks are coincident) or significantly lower concentrations (after 1970 they are almost identical—differing at TT-26 by an average of about 30 or 40 ug/L out of an average concentration of roughly about 500 ug/L—less than 10%).

<u>Opinion 5</u>: This opinion states that the ATSDR groundwater model for TT "resulted in biased-high estimates of monthly contaminant concentrations at one of the water-supply wells." The well in question is TT-23. Dr. Spiliotopoulos cites Section 4.1.2.6 of his report in support of this opinion.

Section 4.1.2.6 (p. 42) offers no clear evidence that the discrepancy at this one well (out of many) has a substantial impact on the overall results. Based on ATSDR Table E2, of the nine unique sampling dates for this well, six had an observed level of PCE or TCE above the MCL. Furthermore, with respect to the overall effect on concentrations estimated at the WTPs, it is important to note that TT-23 was operational for only about 9 months or less, starting in 1984, and had the shortest operational (pumping) period of any of the 16 pumping wells operating in the TT area (see Table H3 in Chapter H of the TT series of reports). When it was pumping, the contribution from this well provided only a small fraction of the total groundwater inflow to the WTP with concentrations far less than well TT-26 (with its modeled concentrations likely being underestimated). Thus, if indeed the estimates for this well were too high (by less than two times), the effect on calculated concentrations in the WTP would be minimal both in magnitude and in duration.

<u>Opinion 6:</u> Dr. Spiliotopoulos says that the ATSDR model did not reflect "observed data that indicated absence of contamination in the aquifer." Does he doubt that there was contamination in the aquifer? The presence of contamination in the aquifer is well documented; the absence of contamination in some locations means little overall—only that the contamination was not everywhere. That is normal. The statement and implication that there is no contamination in the aquifer is simply incorrect. The ATSDR reports clearly document observations where the contaminants were not detected (e.g., Table F13), and their analyses reflect that. Support for this opinion is stated to lie in Section 4.1.2.7.

In Section 4.1.2.7, Dr. Spiliotopoulos makes a major point about plotting non-detects, and he criticizes ATSDR for not plotting nondetects. He cites the reason as being that "non-detections listed as zeros are not visible in a logarithmic-scale scatterplot. This is because a logarithmic scale can only show numbers greater than zero." However, nondetects do not mean that the value is zero—only that it is less than the detection limit. In aiming to support his point, Dr. Spiliotopoulos relies on an analysis that is arbitrary, incorrect, and biased. He selects a value of 0.1 ug/L to represent all nondetects. For these samples, the detection limits were between 2 and 10 for most analyses. Helsel and Lee (2006) say: "The most common procedure within environmental chemistry to deal with nondetects continues to be substitution of some fraction of the detection limit. This method is better labeled as "fabrication", as it reports and uses a single value for concentration data where a single value is unknown. Within the field of water chemistry, one-half is the most commonly used fraction, so that 0.5 is used as if it had been measured whenever a <1 (detection limit of 1) occurs." If representing nondetects in a plot is to be done, a reasonable value and common way to represent a nondetect would be halfway between the detection limit and zero. For the Camp Lejeune data with detection limits of 2.0 and 10.0, the plotted position should be either 1.0 or 5.0 respectively (the latter being 50 times greater than the arbitrary value Dr. Spiliotopoulos used—so plotting 0.1 instead of 5.0 is a significantly misleading/biased-low way to present the data). This will make a big difference on his plot (such as his Fig. 18). Note: On this topic, Helsel and Lee (2006) also state: "All such plots [scatterplots using halfway points] are misleading, because unique censored values are unknown. Instead, left-censored data can be plotted as intervals between zero and the detection limit for each observation. In this way, no false statements about where an individual value is located, or that all such observations are at the same value, are made." There may also be other alternatives for plotting nondetects (newer and better, but more complicated). Regardless, Dr. Spiliotopoulos' selection of 0.1 to represent all nondetects is arbitrary, misleading, and wrong. ATSDR's approach of not plotting nondetects avoids the possible perception of "fabrication" and is more defensible than Dr. Spiliotopoulos' approach of assuming all nondetects can be fairly represented by an arbitrary value of 0.1, as shown in his Fig. 9 (p. 43). The discussions of Helsel and Lee (2006) justify the ATSDR's approach for not including nondetects on the data plots because of the risk of appearing to fabricate data or presenting misleading plots. ATSDR does show nondetects in all tables of measured concentrations.

In para. 1 (p. 45), Dr. Spiliotopoulos notes that the model results indicate a low value of 5.8 ug/L in well TT-54, but the observed value was a nondetect. He states that the calibration “is not supported by the non-detection in the sample collected in February 1985.” I would argue that it is indeed supported by that data. The detection limit for that analysis was 10 ug/L (TT Table F2). The halfway point between zero and the detection limit is 5.0, a value that is very close to ATSDR’s simulated value, and that close agreement is certainly supportive of the quality of the calibration.

Dr. Spiliotopoulos notes (p. 45) that “Well TT-54 had a reported non-detection in July 1991. However, the ATSDR model indicated an increasing concentration trend at well TT-54, suggesting that the PCE plume continued arriving at that well until that time. This is unlikely to be accurate.” However, if one examines the predevelopment and transient potentiometric surfaces (TT Chapters C and F), it is clear that TT-54 is downgradient from the ABC Cleaners, and that a plume evolving from that source while several water-supply wells are operational will likely contribute some contaminants to well TT-54.

Dr. Spiliotopoulos’ Summary of Opinion 6 (p. 45) picks two of the wells to generalize that “ATSDR’s model overestimated the plume migration extent and rate of migration, which were both conservative and biased-high.” This is an overgeneralization that ignores other wells and locations where estimates were very close or were underestimated. The nature of model calibration is that there will be compensating errors and that some simulated values will be too high and others too low. Certainly, the results for the flow model (e.g., Fig. C9) do not support a generalization that the flow model is inaccurate or biased-high.

Opinion 7: Dr. Spiliotopoulos states that “the presentation of results of the uncertainty analysis conducted by ATSDR for the Tarawa Terrace model was misleading by showing a narrow uncertainty range around the calibrated model.” Support is given in Section 4.1.3.1.

In 4.1.3.1, Dr. Spiliotopoulos’ characterization changes from “misleading” to “visually misleading.” The stated reason is that “they used a logarithmic scale, which visually compresses the uncertainty range around their calibrated model [results].” However, the use of a logarithmic scale is a valid and common approach in engineering and scientific studies, and is not characterized as being misleading by scientists and engineers. He observes that the plot ranges over six orders of magnitude on the axis for PCE concentration, but the width of the uncertainty bands do not. When values span such a large range, it is normal and standard to use a log plot. Using just an arithmetic scale would effectively hide all the changes in the lower part of the scale.

Dr. Spiliotopoulos states (p. 46, para. 4) that “the difference between the high and low values in Figure 11 [ATSDR’s Fig. I29] is not significant enough to justify the use of a logarithmic scale.” I disagree because the observed values span more than two orders of magnitude (excluding nondetects) and the simulated values span more than five orders of magnitude. Plotting these using a log scale is reasonable and informative, and is the only way to portray the early time results of the simulation in the same graphic. It is fine to also present these results plotted on an arithmetic scale (Fig. 12), but not sufficient to do so solely. Dr. Spiliotopoulos’ concern over the concentration plots is mostly cosmetic.

On p. 48 (para. 1), Dr. Spiliotopoulos criticizes the uncertainty analysis, saying "… the concentrations calculated by the model should be generally in the middle of the uncertainty range … However, the calibrated model-simulated concentrations are almost identical to the upper bound of the uncertainty range in the early years of operation (1957-1963)." However, if one examines his Fig. 12 (p. 48 of his report), it clearly shows that the results are indeed generally in the middle of the uncertainty range. In the few early years it is above the middle, but consistently below the upper bound, as desired. Such a result is within a probabilistic expectation. In those early years the concentrations are the smallest. For example, in 1960 the difference between the upper bound and the middle of the range is only about 10 ug/L, which is a small value on the full scale of PCE values considered. Being "generally near the middle" is not an objective or quantitative rule.

Opinion 8: Dr. Spiliotopoulos states that "ATSDR's uncertainty analysis was not bound by historical concentration data, and as a result, focused only on model precision and not accuracy in predicting COC concentrations. ATSDR's uncertainty analysis was presented as though it evaluated the model's accuracy. It did not." Support is stated as being in Section 4.1.3.2.

The criticism is based on the lack of historical data on concentrations prior to 1982 (Section 4.1.3.2, p. 49), and would mean that "the uncertainty analysis would result in precise but not necessarily accurate solutions …" However, once again, the lack of concentration data prior to 1982 is the reason that the model was developed. Data are available afterwards, and initial conditions for the contaminant distribution can be stated with reasonable reliability that the concentrations in the TT area were zero prior to the start of operations at ABC Cleaners. That is an important known concentration condition for the early 1950s. What the model does is estimate how the concentration changed spatially between the time of the start of ABC operations and the time when observations of PCE became available, and it does so in a manner that is consistent with the principles of groundwater flow field and solute transport, with the further recognition that the groundwater flow field has been simulated with acceptable accuracy.

The ATSDR assessed uncertainty using a sophisticated but standard and acceptable statistical approach—using a Monte Carlo simulation method. They carefully documented their approach, which generated 840 realizations. In a Monte Carlo simulation approach, no single realization is expected to be "accurate." Rather, the ensemble of realizations is intended (and expected) to bracket a range of feasible but realistic outcomes. The range of results (generally considering 95% of the outcomes) is a measure of the model's predictive accuracy. The Monte Carlo uncertainty analysis would not be expected to yield a different calibrated model.

In the last paragraph on p. 49, Dr. Spiliotopoulos states that "one of the most critical parameters for determining how fast contaminants will migrate in the aquifer is the retardation factor." I would argue that both the speed and direction of migration is more critically determined by the head distribution (hydraulic gradients, as determined by the groundwater flow model) and the effective porosity. The retardation factor will have no effect on the direction of transport of a contaminant for a given flow field. Furthermore, the results presented by Dr. Spiliotopoulos in his Fig. 7 show that the model results, at least at Well TT-26, are relatively insensitive to a range of uncertainty in the assumed value of K_d and R_f.

On p. 50 (para. 3), the Monte Carlo approach used by ATSDR is criticized by Dr. Spiliotopoulos "… because ATSDR implemented a 'probability distribution function' … to describe how values closer to the mean value of the range are more probable than those away from the mean." I do not see a problem here as this is an option within standard practice for random sampling of parameter values for a MC analysis when information or theory indicates that a parameter has a statistically normal or log-normal distribution. Zheng & Bennett (2002, p. 353) say "The Monte Carlo method is by far the most commonly used method for analysis of uncertainty associated with complex numerical methods." They further state (p. 356) "The heart of the Monte Carlo method is the generation of multiple realizations (or samples) of input parameters that are considered to be random variables. Each random variable is assumed to follow a certain probabilistic model characterized by its probability density function (PDF). The probability distributions commonly used in hydrogeologic studies include *normal*, *lognormal*, *exponential*, *uniform*, *triangular*, *Poisson*, and *beta* distributions." It is worth noting that when this book was published, co-author Bennett was an employee of SSP&A and first author Zheng was a former employee and affiliate of SSP&A.

The plots shown in Fig. 13 are discussed in para. 8 (p. 50, Section 4.1.3.2). Dr. Spiliotopoulos notes that the results of the calibrated model "sits at the upper bound of the retardation-factor uncertainty range." However, that is not true for the majority of the simulation period. It is close to the middle of the range during the period of 1962 through the end (around Dec. 1987). And prior to 1962, it still lies within the uncertainty bounds, which is acceptable and not indicative of bias. As stated earlier, error bounds need not be evenly distributed around the mean because a model can be sensitive to a parameter at either high or low values, but not both.

In the 3rd paragraph on p. 51, Dr. Spiliotopoulos presents the values for the retardation factor with four significant figures. Whether R_f is estimated by adjustments during model calibration or estimated from highly variable and uncertain site-specific data, presenting it with 4 significant figures is an unjustified and meaningless precision.

Opinion 9: This continues the previous discussion of the uncertainty analysis and cites the same section (4.1.3.2) as support. Dr. Spiliotopoulos says that the uncertainty analysis for TT "… did not encompass uncertainty bounds representative of site-specific conditions, resulting in biased-high uncertainty range."

It is not clear exactly what is meant by a "biased-high uncertainty range." If it means that the uncertainty range is incorrectly too high, that implies that the model is even more accurate than indicated.

On p. 52 and in Fig. 14, Dr. Spiliotopoulos discusses the results if R_f were 4.3 instead of 2.9. But this value of 4.3 is higher than those presented in published peer-reviewed articles of PCE transport in similar types of aquifer materials (Rogers, 1992, and Kret et al., 2015). Even with Dr. Spiliotopoulos' high value of R_f, Fig. 14 shows that after about 1970, the differences at Well TT-26 are small—less than 100 ug/L difference during the final 20 years of the simulation, with Dr. Spiliotopoulos' revised model showing lower concentrations because it includes a larger sorption rate. Again, it is relevant to note that the observed data shown in this figure range from about 3 ug/L to almost 1600 ug/L for samples collected over a relatively short time period in early 1985. The ATSDR model results fall very close to the midpoint at that time—at about 800 ug/L—not indicative of any bias. However, Dr. Spiliotopoulos' revised model with the higher R_f value calculated a PCE concentration of about 700 ug/L at the time when the data are available—lower than the mid-point, which does not provide evidence that the higher value of R_f is more accurate (actually, it's an indication that it is less accurate). Either way, the computed PCE concentration values are higher than the MCL for all times after 1960, which is a critical point.

The three highest observed values of PCE in well TT-23 were underestimated by the ATSDR model, which counters the claim that the ATSDR model is biased high.

On p. 55, Dr. Spiliotopoulos says that "ATSDR's selection of the retardation factor parameters forced the calibrated model to simulate fastest arrival of PCE at well TT-26 …" This use of the word "forced" appears to unfairly attribute an unscientific and biased motive to the way the model calibration was conducted. First of all, this was not the fastest possible arrival. If they had used a value of $R_f = 2$, the arrival would have been faster than the value they calibrated to. I think a fairer way to characterize the calibration relative to R_f is that they varied the values of R_f and of other parameters and selected parameter values that yielded the best overall fit to the available data. This happened to be a value of 2.9 for R_f, which was very consistent with other values reported in the literature for PCE transport in similar types of geologic material.

<u>Opinion 12:</u> This opinion focuses on the model post-audit performed by Jones and Davis. The opinion says that the post-audit showed that "ATSDR's dose reconstruction groundwater model for drinking water in Tarawa Terrace used parameters and assumptions that resulted in conservative and biased-high estimates of monthly contaminant concentrations." Support is said to be given in Section 4.1.5.

It is my understanding that Jones and Davis, as well as Maslia, will respond to this opinion in their rebuttal reports. A few general comments about the content of section 4.1.5 follow.

In Section 4.1.5.1 (p. 60, para. 2) Dr. Spiliotopoulos states that "Observed concentrations of zero correspond to non-detections." As mentioned previously, this statement is not accurate in the sense that nondetect values do not necessarily have a value of zero, but their value may be anywhere below the detection limit for that particular analysis. Also, in para. 3 and Fig. 18 (p. 60), Dr. Spiliotopoulos repeats the same error in assuming that a nondetect can be substituted by a value of 0.1 ug/L. This is arbitrary and biasing.

Dr. Spiliotopoulos calculates a mean error for partitioned segments of the data set—separately for points where the observed value is higher and separately for points where the simulated value is higher. This is not a common or standard way to compute a mean error. Based on my experience and expertise, the standard methodology is to compute the mean error for all data.

<u>Opinion 13:</u> This opinion also focuses on the model post-audit performed by Jones and Davis, and is closely related to Opinion 12. It suggests what Maslia and Aral should have done with the data of Jones and Davis. Support is again said to be given in Section 4.1.5. It is my understanding that Maslia will respond to this opinion in his rebuttal report, but I have a general comment regarding the absence of data.

On p. 63, Dr. Spiliotopoulos expresses concern that "no data are available to evaluate whether the overall extents of the simulated plume are real." Some data are certainly available. It would be nice if more data were available. If extensive data were available to map the plume in detail over time, there would be little need for a simulation model. The ATSDR models reliably simulate the groundwater flow field and head distributions so that the transport models can simulate advective and dispersive processes, as modified by chemical reactions and adsorption (as simplified using the retardation factor), to fill in the gaps in the observational database in a way consistent with widely accepted governing principles of groundwater hydraulics and transport phenomena. This is a reasonable and appropriate approach to addressing this issue.

Opinion 14: This opinion restates previous ones, but for Hadnot Point, and says that the ATSDR model "was constructed and calibrated using parameters and assumptions that are uncertain or incorrect." Support is said to be given in Sections 4.2.1, 4.2.2, 4.2.3, and 4.2.4.

In general, groundwater systems occur within subsurface geologic frameworks that are complex, heterogeneous, and hidden from view. There are and always will be uncertainty associated with even the best efforts to define the properties and relevant characteristics of these systems. This does not preclude the development of reliably sound numerical models to simulate groundwater flow and transport processes. But model developers must always be aware of, and assess, the existence of uncertainty and the sensitivity of the model results to this uncertainty. ATSDR has indeed accomplished this. For TT, they have produced a 187-page chapter (Chapter I) solely about this task (in addition to many discussions of it throughout the other chapters). For HPHB, there are two sections in Chapter A of their reports focused on these topics.

Dr. Spiliotopoulos states (p. 68, para. 4) that "Unlike the Tarawa Terrace model, ATSDR did not know the precise location of all contamination sources and the magnitude of contamination each source contributed." This is true—there is uncertainty in the source terms (as with all model parameters). But that can be handled and does not preclude the development of a reasonable flow and contaminant transport model. Assumptions had to be made, but they were not "arbitrary" and were clearly and comprehensively documented. He cites the NRC (2009) report, which said "There were multiple sources of pollutants, including an industrial area, … [etc.]" What is certain is that all of these are likely sources of groundwater contamination. Industrial operations in the 1950s, 60s, and 70s were typically not concerned with protecting groundwater quality.

In footnote 235 (p. 68-69), Dr. Spiliotopoulos says, "ATSDR used simulated contaminant concentrations in the influent to the WTP to calculate concentrations in the water delivered to a family housing or other facility, without considering any contaminant losses during treatment." However, unless the treatment process was designed to treat these contaminants, it would have been "arbitrary" and highly uncertain to simply assume that the treatment reduced contaminant concentrations or removed contaminant mass.

p. 69: Dr. Spiliotopoulos cites "evaporative" losses in a treatment plant. However, evaporation is rarely significant in a water treatment plant and direct evidence would be needed to support this hypothetical claim. Contaminant loss due to volatilization during the treatment and distribution process was discussed at the March 28, 2005 expert panel meeting where panelists—including Dr. Pommerenk of AH Environmental— opined that any loss would be minimal (See March 28, 2005 Expert Panel Meeting Transcript at 55:2-57:14, 56:2-57:14).

In para. 3, Dr. Spiliotopoulos says "Based on [his] professional judgment, there was insufficient data to conduct groundwater flow and contaminant transport model calibration and uncertainty analysis." But in fact, ATSDR did "conduct" it, and clearly documented their calibration and uncertainty analyses. In my professional judgment, they did a good job with the limited data available.

In para. 4 (p. 69), Dr. Spiliotopoulos repeats that "prior to 1982, no water quality data were available …" However, groundwater flow directions can be deduced with typically small uncertainties, and flow rates (velocities) and advective-dispersive transport can be simulated with some additional uncertainty, but these key processes are reasonably well defined. Also, it is highly certain that prior to the start of these industrial and landfill operations, the contaminant concentrations were zero—an important early-time data point.

In para. 7, Dr. Spiliotopoulos quotes NRC (2009) as saying "simpler modeling approaches should be used to assess exposures from the Hadnot Point water system." While this is easy to say and sounds appealing, they don't say how to do that or what simple modeling approach would work. How does one know if a model is too simple? What processes should be eliminated in the simpler model? In fact, the way to produce a simpler model is to first develop and calibrate a maximally realistic "complex", detailed, and comprehensive model that can be then used to assess which processes or factors have little effect on the results and so can be safely eliminated to produce a simpler model. The benefit cited by NRC is faster and more efficient modeling, but that potential benefit is not a major need here, and the use of models that might be too simple is offset by their reduced realism and risk of oversimplification.

On p. 70 (section 4.2.1), Dr. Spiliotopoulos says "available data are limited or non-existent" but in the first bullet point states that "more than 200 aquifer and slug test analyses" exist. This is a lot of data! There are many groundwater models that have been developed and calibrated on the basis of much fewer hydraulic testing at the specific site of interest.

On p. 70, Dr. Spiliotopoulos is also concerned that pumpage data for individual wells were estimated on the basis of "ancillary data." This is common standard practice in groundwater modeling, as pumpage measurements for wells are often not available or are of questionable quality.

In the last para. (p. 70) Dr. Spiliotopoulos notes that the HP WTP was built in 1942 and during its first 40 years of operation, there were no water quality data for the contaminants of concern. This is unfortunate, but not unexpected; it is rather common for groundwater contamination problems that a chemical that turns out to be problematic at a later date is not monitored prior to that awareness. This is why ATSDR had to use modeling to help reconstruct the historical record as well as possible, using documented quantitative methods. Of course, there will be uncertainty in the results, but they seem reasonable given the information that is available.

p. 71, Fig. 25 (ATSDR Fig. A18): Dr. Spiliotopoulos presents four plots of simulated and observed TCE concentrations at four wells in the HPHB study area. All four plots show that the simulated values were either close to the middle point between observations (HP-602 and HP-608) or below the observed values (HP-634 and HP-601/660). There is no indication here that the model overestimated concentrations (or was biased-high).

In summarizing Opinion 14 (p. 71), Dr. Spiliotopoulos says "Selection of model parameters was based, primarily, on professional judgment." This is always the case. Data are always limited, and professional judgment is required to assess how to deal with that paucity of data and how much weight to give the limited number of measurements. A groundwater modeler always wishes they had more data, but the reality is that there are never so much data available so as to avoid using professional judgment.

In Section 4.2.2 (p. 72) the claim is made that ATSDR "made arbitrary assumptions to reconstruct pumping history …" In my opinion, the assumptions were not arbitrary, but rather were well-informed, well-reasoned, and carefully documented. Assumptions had to be made about the pumping history, and they were made, but they were not arbitrary. For example, Dr. Spiliotopoulos notes that "Yearly volumes are available for some years prior to 1980. A trendline was used to estimate raw-water flows for years prior to 1980 when no data exist." This appears to be a sound statistical approach, and the use of a trend line is certainly not arbitrary.

In Section 4.2.2 (p. 72-73) Dr. Spiliotopoulos offers a further criticism that "it was assumed that a well would be operated in the historical period based on a pattern similar to the more recent 'training period,' with further adjustments to account for information on the varying capacity of wells, where available." Dr. Spiliotopoulos' statement actually contradicts his assertion that estimates were arbitrary. Here he describes a reasoned and reasonable approach to estimating a pattern of past water use (well pumpage)—an approach that is not "arbitrary."

In several additional paragraphs on p. 73 (as well as elsewhere), he repeats the claim that pumping rates were based on arbitrary assumptions. ATSDR uses sound statistical methods (such as regression and correlation) to estimate pumpage. This is neither arbitrary nor unreasonable. Similar wells managed by the same operating authority are likely to have been operated in a similar manner. If not, that would be arbitrary. It is unlikely that Dept. of Navy engineers operating the well fields did so in an arbitrary manner. In the early years they just weren't required to maintain as detailed records as would be expected today. Again, ATSDR made reasonable assumptions with the data that they had available.

Near the top of p. 77, Dr. Spiliotopoulos states that model calibration was "improperly influenced" by "erroneous concentrations reported for well HP-634 … while non-detections were ignored." It has not been established nor agreed that erroneous concentrations (actually, one single value) were reported for well HP-634. This is discussed in more detail below in reference to Section 4.2.3.3. Non-detections were not ignored. They are clearly listed and labeled in many tables presented in the ATSDR reports (such as Table A4 in Chapter A of the HPHB report series, and in many other places too).

In Section 4.2.3.1 (p. 77) Dr. Spiliotopoulos claims that "The groundwater flow model has significant limitations in the absence of data for calibration." Although the model has limitations, there is no evidence that the limitations are significant for the purposes that the model was developed. Furthermore, there is not an "absence of data for calibration." In the very next paragraph, Dr. Spiliotopoulos notes that more than 700 water-level measurements were used in calibrating the predevelopment model, which is also the initial conditions for the transient groundwater flow model. Also, there are a lot of data available on the boundary conditions and hydrogeologic framework for the model.

In the 6th paragraph (p. 77), Dr. Spiliotopoulos indicates that the simulation of contaminant transport in the aquifer is inherently uncertain. This is true for all groundwater models. But the uncertainty does not mean that the model is not useful.

In Section 4.2.3.2, p. 78, Dr. Spiliotopoulos notes that ATSDR recognizes that explicit data defining source locations and mass loadings are not available, but then he criticizes ATSDR by saying "these quantities were arbitrarily assigned to the model in order to fit the limited water-quality data available starting in 1982." However, by criticizing ATSDR's methodology, Dr. Spiliotopoulos in effect is criticizing the essence of the model calibration, history matching, and parameter estimation process practiced in groundwater modeling, in which parameter values are adjusted (either manually or automatically) in order to improve the fit (e.g., see Hill and Tiedeman, 2007). Furthermore, the source locations and mass loadings were not "arbitrarily assigned." The general locations of the sources are well-documented, and sources were placed in the vicinity of these documented locations. Consistent with principles of model calibration, the exact placement and strength of these sources were varied within limits until the observed concentrations were reasonably matched by the model. The variation in the exact location, timing, and strength of sources is rarely known, and adjustment of source properties is a commonly-accepted part of calibrating a flow and transport model.

p. 79: Dr. Spiliotopoulos discusses the lack of data to define the source loading terms for the model in the HPHB area. However, there is no doubt that these chemical contaminants (including TCE and PCE) were present in the groundwater at toxic concentrations (above the MCLs) in the HPHB area, and that they were pumped out of the aquifer by several operating water-supply wells.

p. 79: In the summary for Opinion 14, Dr. Spiliotopoulos criticizes the ATSDR for having "assumed constant mass loading of the same magnitude at all sources for more than 40 years", which he characterizes as "highly uncertain, if not impossible." Viewed from a different perspective, what ATSDR did was apply an average rate over the critical time period because there was no basis for differentiating how the loading might have varied over time. In my opinion, this was a reasonable approach. Furthermore, the constant source resulted in a reasonable model calibration, and so there was no reason to incorporate a variable source in the absence of data on transient source characteristics.

<u>Opinion 15:</u> In this opinion, Dr. Spiliotopoulos repeats the claim that ATSDR included an erroneous value in its analysis and model calibration (presumably for the 1,300 ug/L value measured in a sample from HP-634). Section 4.2.3.3 is cited for support.

In Section 4.2.3.3, Dr. Spiliotopoulos argues that concentration data for well HP-634 was incorrectly interpreted and that the reported value of 1,300 ug/L on Jan. 16, 1985 "should be considered erroneous" (although he considers other samples from that well that showed non-detects to be valid). I believe that his basis for this conclusion is speculative and unsupported by facts, as discussed below.

On p. 80, Dr. Spiliotopoulos says "it is unlikely that this well [HP-634] was ever contaminated with elevated TCE concentrations," and he and Dr. Remy Hennet argue that the analysis showing a concentration of 1,300 ug/L should be thrown out. Although Dr. Spiliotopoulos and Dr. Hennet claim the well was shut down permanently, documentation suggests that HP-634 was online in January 1985 (see CLJA_CLW00000004559, CLW4546, and CLW1818). However, even if the well was shut down permanently shortly before the date this sample was collected, I strongly disagree with Dr. Spiliotopoulos' argument that "contamination could not have reached that well when it was non-operational." It is plausible and possible that TCE could have reached the well sometime after the previous sample had been collected. As Dr. Spiliotopoulos surely knows, after a pumping well is shut off, water levels do not instantly recover and the head distribution does not instantly return to a nonpumping configuration and nonpumping hydraulic gradients. During predevelopment (nonpumping steady-state) conditions, flow near HP-634 is predominantly to the west and southwest (see HPHB reports Fig. A19 for 1951, reproduced below). While this well was operational, a cone of depression (a drawdown of water levels) formed around it, lowering the heads and reversing local hydraulic gradients, and enabling the movement of contaminants from nearby areas containing contaminants west of HP-634 to move eastwards towards HP-634 (as also shown for later times in Fig. A19 below). When a well is shut down, the heads take time to recover (recovery is not instantaneous). During the slow recovery period, water and contaminants will continue to move towards the well while the cone of depression is slowly filled in and recovers. This simple normal response of groundwater systems to the cessation of pumping easily explains the presence of contaminants in a sample collected after the pumping was stopped. Note that concentrations of DCE and VC were also unusually high in this same sample, so the TCE value is not an isolated “outlier” (see table C7 in report Chapter C). This progression is seen in the maps for all three layers for the November 1984 maps shown in Fig. A19 below, where the contaminant is shown to have moved very close to HP-634 from its previous location in the industrial area just to the west. If Dr. Spiliotopoulos argues that it is not possible for contaminants to reach HP-634 once its pump ceases operation, then it is contingent on him to provide some evidence that (a) the recovery is so fast that it is irrelevant (i.e., how long would it take for the hydraulic gradients to reverse again and return to a predevelopment condition?), and (b) that the contaminants were so far from HP-634 when it was shut off that it could not have migrated that distance during the recovery time. Without such calculations or evidence, one can conclude that it is indeed possible for contamination to reach that well shortly after it became non-operational. The primary evidence that it did become contaminated is the measurement of 1,300 ug/L in the January 1985 well sample, and I do not see conclusive evidence that that sample analysis should be discarded.

Dr. Hennet argues that this well was not contaminated by TCE because some vials in the shipment were broken (he does not say the samples for this analysis were in broken vials, so the relevancy of other vials being broken is not apparent). I doubt that the lab would or could perform an analysis or report a value on a sample taken from a broken vial. Dr. Hennet says a CCLJ report shows the value as 10 ug/L. However, the lab that did the analysis reported 1,300 ug/L. Hennet and Spiliotopoulos also say that the value of 1,300 is an outlier, so should be discarded. But there are many high-valued “outliers” in the record, and the record shows other instances where the value can change over similar large magnitudes in a very short time (e.g., TT-26 shown in Fig. F16, where the PCE concentration changed from 1,580 to 3.8 ug/L in successive samples collected just 4 weeks apart, mirroring the change in HP-634 from ND to 1,300 ug/L in a similar 4 week timeframe). The reasoning by Dr. Spiliotopoulos and Dr. Hennet to discard this reported value seems entirely speculative. They offer no actual evidence that the analysis or its reporting was erroneous.

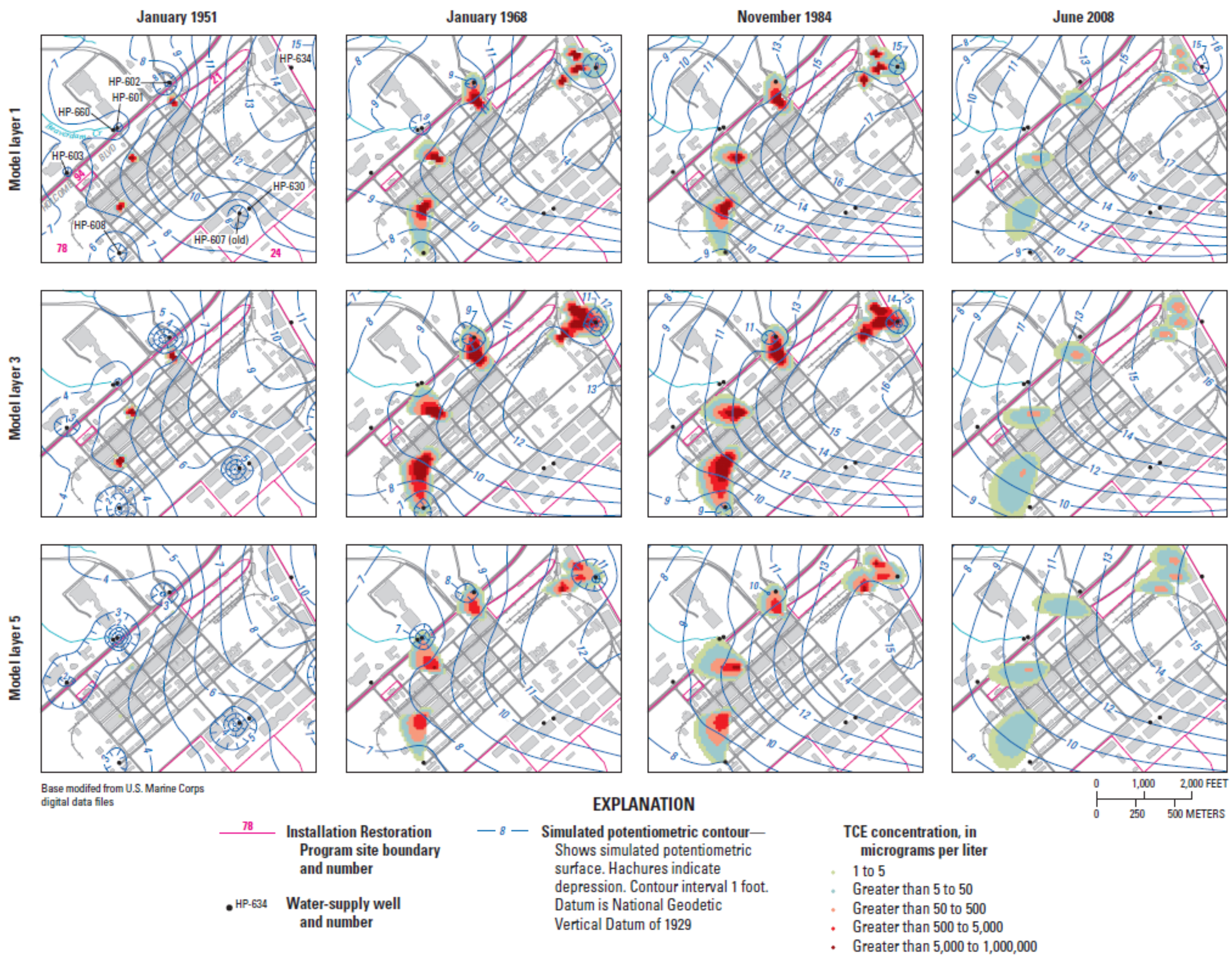
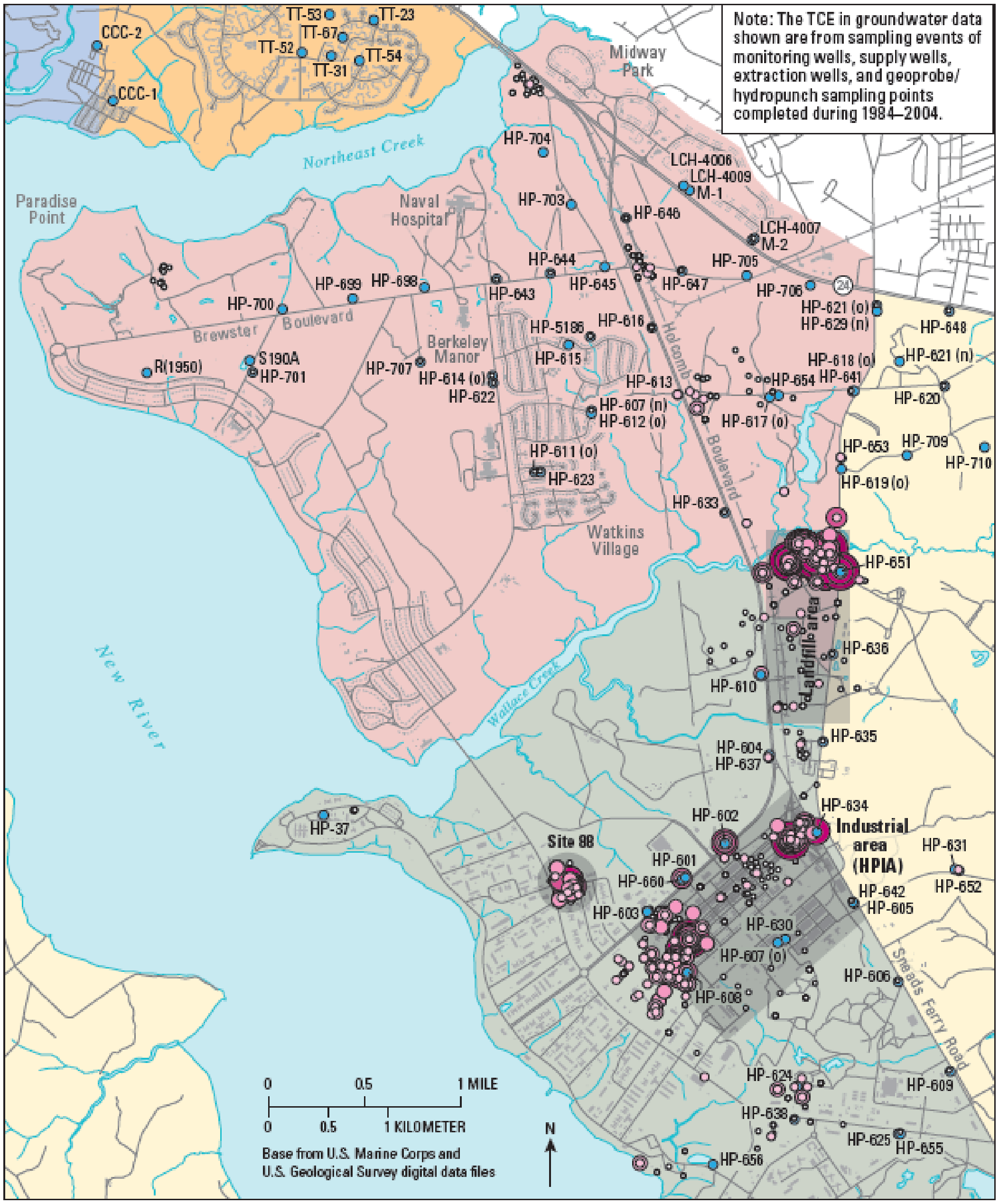


Figure A19. Reconstructed (simulated) water levels and distribution of trichloroethylene (TCE) within the Hadnot Point Industrial Area fate and transport model subdomain, model layers 1, 3, and 5, Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina, January 1951, January 1968, November 1984, and June 2008. (See Figure A13 for location and building numbers; see Appendix A4 for more detailed maps and results.)

On p. 81, Dr. Spiliotopoulos presents his Fig. 31 plotting of TCE concentrations in HP-634. However, he purposely does not include the data point with the value of 1,300 in his plot; including it would yield a very different picture, and show a much better match between simulated and observed TCE at the well location. TCE is found to be present in many locations immediately adjacent to HP-634, as seen in Fig. C33 (reproduced below). HP-634 is within the industrial area HPIA in that map (close to its northeastern boundary).



EXPLANATION

Historical water-supply areas of Camp Lejeune Military Reservation

- Montford Point
- Tarawa Terrace
- Holcomb Boulevard
- Hadnot Point

Other areas of Camp Lejeune Military Reservation

HP-624 **Water-supply well and identifier**

TCE concentration—In micrograms per liter

- Non-detect or below detection limits
- 0.19 to 10
- >10 to 100
- >100 to 1,000
- >1,000 to 10,000
- >10,000 to 200,000

Figure C33. Groundwater sample locations for trichloroethylene (TCE) and ranges of TCE concentration in monitor and supply wells within the Hadnot Point–Holcomb Boulevard study area, U.S. Marine Corps Base Camp Lejeune, North Carolina.

Opinion 16: Dr. Spiliotopoulos argues here that the model for VOC degradation products was based on limited data, and "ATSDR's historical reconstruction prior to December 1984 cannot be verified." He cites section 4.2.4 as support.

In section 4.2.4 (p. 82-83), Dr. Spiliotopoulos states that "As illustrated in Figure 33 [ATSDR Fig. A25], the historical reconstruction prior to 1985 cannot be verified, due to lack of observed data for the period." This is true, and it is the reason why a simulation model was needed and was developed. For the four contaminants shown in Fig. 33, the agreement between simulated values and observed data is excellent in all four plots. This close agreement when observations are available builds confidence in the reliability of the model and its predictions, including for the hindcasting results for times prior to 1985.

In the summary for Opinion 16 (p. 83), Dr. Spiliotopoulos repeats that "… such data were not available prior to December 1984. Therefore, the estimated monthly contaminant concentrations cannot be verified." Again, the whole point was to use a technically sound model, which would be calibrated to available data in and after 1985, to estimate the values during the 15 or so years prior to that calibration period to inform the epidemiological studies. For PCE and TCE, the fit with the LCM model was actually slightly better than with the MT3DMS model, which was not designed to simulate degradation products. The quality of that fit is illustrated in Figure A25.

Opinion 17: Dr. Spiliotopoulos says that "the sensitivity analysis for the various contaminant sources in Hadnot Point indicated that the timing of source-release start date is uncertain and, therefore, it is impossible to determine the historical period that contamination was present in groundwater." The conclusion of this sentence does not follow from the precedent. Of course there is uncertainty in the timing of the release. That is well known. But the uncertainty does not make analyses impossible. Also, the uncertainty is not unconstrained. The model helps constrain the reconstructed history as it incorporates the physics of groundwater flow and solute (contaminant) transport. It is *not* impossible "to determine the historical period that contamination was present in groundwater." It can be (and was) estimated, but with the recognition of uncertainty in the model and in the predictions. There are a fair amount of data on the groundwater flow field, which provide the calibration basis for the flow model, and the calibrated flow model has sufficient accuracy and reliability to estimate groundwater velocities and directions. The model basically shows that to simulate the observed increases in concentration at observation points, the timing of the source release becomes more narrowly constrained and its uncertainty is reduced (but not eliminated). The key is that the flow model simulates groundwater flowpaths and velocities with reasonable and acceptable accuracy.

On p. 84, referring to underground storage tanks, Dr. Spiliotopoulos says "The empirical data for UST releases may or may not be applicable to the USTs installed at Camp Lejeune and, therefore, assignment of timing and magnitude for these sources is arbitrary and uncertain." Although uncertainty is clearly recognized, the assignment is not arbitrary. The basis is the EPA data on more than 12,000 leak incidents. Without direct observation to the contrary, why would one think that these USTs would behave much differently than the average failure time for such a large representative sample of documented cases? The approach used is not arbitrary, nor "highly" uncertain, nor an unreasonable assumption.

On p. 85, Dr. Spiliotopoulos goes on to discuss the range of years used in the sensitivity analysis, which spanned ±9 years. The point is not that the starting release date could have been anytime in that 18-year span, but rather to examine how sensitive the results are to such uncertainty. The results shown in Fig. 34 (ATSDR Fig. A37) indicate that at the later times—i.e., during the 18 years of the epidemiological studies—uncertainty in the starting release dates has little effect on estimated TCE concentrations. For the period between about 1950 and 1970, results from each of the various starting dates tend to converge on the same solution after only 3 or 4 years of simulation time.

In the summary for opinion 17 (p. 86), Dr. Spiliotopoulos says "it is not possible to confidently determine the actual period of groundwater contamination …" I would counter that it is possible to do so with some reasonable level of confidence, and ATSDR has done so. Of course there is uncertainty.

<u>Opinion 18</u>: Dr. Spiliotopoulos states that "the sensitivity analysis of the dose reconstruction model for HP was based on parameter variability unsupported by data." And that "the results of the sensitivity analysis were incorrectly presented as an uncertainty analysis range." Support is said to be in Section 4.2.5.1.2.

First, I note that there is some overlap and linkage between sensitivity analysis and uncertainty analysis. Anderson & Woessner (in their 1992 book on "Applied Groundwater Modeling") in discussing sensitivity analysis state: "The purpose of a sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses, and boundary conditions."

On p. 87 (Section 4.2.5.1.2) Dr. Spiliotopoulos argues that the sensitivity analysis used extreme values for parameters. But these "extreme" values were not used for the hindcasting (historical reconstruction), which was done using the calibrated model and calibrated parameter values. The wide range in parameter values was only used to assess model sensitivity and uncertainty, and thereby gain some further understanding of how and why the model is behaving as it does. This is not unusual. It has minimal or negligible effect on the calibrated model.

On p. 89, Dr. Spiliotopoulos argues that the range of parameter values in the sensitivity analysis was too wide. The inference then seems to be that the range of results (shaded areas) shown in Fig. 35 (ATSDR's Fig. A34, shown on p. 90) is too wide and should be narrower (closer to the results for the calibrated model). This doesn't seem like a major problem, as it would imply that the model results may be better defined than indicated otherwise. In looking at sensitivity, ATSDR did not imply that these "extreme" values were realistic or expected. They only illustrated a possible maximum bracketing of results.

In the Summary comments for Opinion 18, Dr. Spiliotopoulos concludes that "ATSDR presented the results of this analysis as indicative of the expected range of reconstructed monthly contaminant concentrations." I don't see where they said or implied this.

<u>Opinion 19</u>: Dr. Spiliotopoulos expresses a concern that the Hadnot Point analysis "only partially addressed model uncertainty." Support is included in Section 4.2.5.2.

In Section 4.2.5.2 (p. 91): In the first paragraph Dr. Spiliotopoulos seems to imply that ATSDR's use of Latin Hypercube Sampling was somehow an oversimplified approach. This is a valid and appropriate method to use in these circumstances. For example, in conducting the Performance Assessment for the radioactive waste repository at the WIPP site in New Mexico, DOE and Sandia National Labs used the LHS approach with their groundwater flow and transport models for the WIPP site, as part of their application for approval to begin operations. This work was carefully reviewed by a National Academy Committee (NRC, 1996) and WIPP was granted approval to begin operations by the U.S. Environmental Protection Agency in the mid-1990s. There is nothing wrong (and a lot right) with the use of this method. EPA approval was granted even though there were no observations at all of concentrations in the aquifer of concern, yet predictions were made for 10,000 years into the future.

Section 4.2.5.2 (p. 91): In indicating that the uncertainty analysis was incomplete, Dr. Spiliotopoulos says (para. 2, p. 91) "ATSDR considered a small number of only 10 uncertainty scenarios." While it is debatable as to whether ten is a "small" number of scenarios to evaluate, it is a reasonable number to consider, and the 10 scenarios encompass a lot of the uncertainty in parameters and boundary conditions. ATSDR accomplished the goal of completing and documenting an uncertainty analysis, although it would have been possible to add additional scenarios to consider. It is highly unlikely, however, that adding more scenarios would lead to a modification of the calibrated model or to a different historical reconstruction.

In the first paragraph on p. 92, Dr. Spiliotopoulos quotes Doherty: "ideally, the value of the prediction should lie somewhere near the center of the uncertainty band." He then states that the ATSDR calibrated model "fails to conform with this rule …" However, this is not anyone's "rule." It is an idealization. Where the calibrated model lies off the center of the uncertainty range of estimates, it may simply be because additional parameters and scenarios need to be incorporated into the Monte Carlo simulations. In statistical testing, it is generally acceptable for a point or sample to fall within a range of two standard deviations of the mean.

In his summary for Opinion 19 (p. 92), Dr. Spiliotopoulos states that "the analysis only partially addressed the model uncertainty." But if more scenarios were considered or if more than 95% of the results were shown, the increased number of scenarios would widen the range and place the calibration results more consistently towards the middle of the range. Most of the time, the calibration is within the range of uncertainty brackets; when not, it is only very slightly above them. Overall, this does not seem to be a major issue. If additional factors were considered, the range would likely be wider and encompass all of the calibrated results. I also see no reason why this would have led to a different set of calibrated parameters.

<u>**Section 4.2.5.3, Concluding Remarks (p. 92)**</u>: Dr. Spiliotopoulos reiterates his concern that there is lack of historical data to constrain the calibration. He quotes an article that says the "model should replicate observed system behavior." This must be taken in a general way because a model is by definition a simplified approximation of a complex real system, and no model can literally replicate a real system and its behavior. He argues that "The ATSDR model results did not meet this requirement." I disagree, and believe that there was a satisfactory representation of observed behavior for both head distributions and concentration distributions. Could it have been better? Sure, if more data had been available. Is it good enough to produce a reasonable hindcast historical reconstruction? I believe the answer is yes. Dr. Spiliotopoulos says "that there is 'no observed system behavior.'" This is simply wrong. There are some water-level data available, and very good agreement between observed and simulated heads (water

levels). This agreement provides confidence in the computed directions and velocities of contaminant migration. There are some observed concentrations. It would be nice if more concentration observations had been made in the past, but they weren't. Where such data are available, the model often provides a very good match to those data. With the goal and implementation of computing monthly averages, there is no way that the model could have replicated the large concentration changes sometimes observed over short time periods and between successive samples. He also states that "ATSDR failed to quantify the uncertainty range reliably." But they did quantify it and document it. They did so reliably. Perhaps it could have been more comprehensive and considered more factors, but that doesn't mean that they didn't "quantify it reliably." Although comprehensive uncertainty analysis is desirable, doing so is not a necessary condition for calibrating a groundwater model.

Section 4.2.5.3, Concluding Remarks (p. 93): Dr. Spiliotopoulos says "If parameter sensitivity and uncertainty can only be evaluated in a qualitative way, …" then the results and conclusions are not "scientifically defensible." The sensitivity and uncertainty analyses were definitely quantitative, and the quote from ATSDR (bottom p. 92) did not say these analyses were ONLY "qualitative". I believe that the model development by ATSDR for both TT and HPHB are scientifically defensible.

Review Comments on Chapter 3:

p. 10, Section 3.1.8 (Concluding Remarks): Dr. Spiliotopoulos says "Model calibration is not possible when there are no historical data to match." However, there are historical data available for Camp Lejeune. The ATSDR models were calibrated using comparisons to historical data—both groundwater level observations and some data on solute concentrations in water samples. There are many direct measurements of hydraulic conductivity—a key parameter in simulating groundwater flow and velocity. So the concluding statement above is simply not applicable to the ATSDR model development and calibration.

p. 12, Section 3.2: In this paragraph, Dr. Spiliotopoulos concludes by stating "However, the timing and quantification of contaminant releases from that source [ABC Cleaners] are uncertain, due to a lack of historical data." Of course, the timing and quantification of contaminant releases from ABC Cleaners has some associated uncertainty. However, there is knowledge of when they operated, precise information on its location, and there is little doubt that it was a source of contamination. The modeling exercises help reduce the uncertainty about the timing and strength of the contaminant source. It is rare (if ever) that the precise release dates and strengths of a historical contamination source are known. This is a type of uncertainty that is commonly dealt with in model development, and this type of uncertainty does not preclude the development, calibration, and usefulness of a groundwater model.

A related issue of contaminant travel times from ABC Cleaners to well TT-26: (**Hennet's report, p. 5-15 – 5-16 and his Attachment D**): Dr. Hennet estimates a range of values for travel times of PCE between ABC Cleaners and TT-26 that are stated to be "in the 15 to 25 years range", based on three assumed "representative" flow paths, indicating the arrival didn't occur until the 1970s. He presents supporting material and calculations in his Attachment D. Dr. Hennet assumes the horizontal travel distance in the shallow aquifer is either (1) 200 ft in the shallow aquifer and 800 ft in the pumped aquifer, (2) 500 ft in the shallow aquifer and 500 ft in the pumped aquifer, or (3) 800 ft in the shallow aquifer and 200 ft in the pumped aquifer. He further assumes that the hydraulic gradient in the layer 2 confining unit is the same in all cases (i.e., at three different distances from the pumping well). This is not a reasonable assumption (for example, see TT Figs. C19 & C21). In the pumped aquifer, a cone of depression will form with lowest heads adjacent to the well and higher heads further from the well. In the shallow aquifer, the heads will not change much due to pumping in the deeper aquifer. This drawdown effect is strongest near the well, and results in a greater hydraulic gradient (and faster velocity) across the confining layer closer to the well.

Pumping also results in a steeper horizontal gradient (and faster velocity) closer to the well in model layer 3, and a shallower gradient further from the well. Dr. Hennet's calculations assume the same horizontal velocity in the pumped aquifer regardless of the distance from the pumped well, which is not a valid assumption.

Examining the heads for model layers 1 and 3 as shown in TT Figs. C18 and C19, and looking at a point about halfway between ABC Cleaners and TT-26 and at a point very close to TT-26, the head difference between the two layers (across the confining bed) is about 10' – 9' = 1 ft at the halfway location and about 5' – 2' = 3 ft at a location close to TT-26. Therefore, the hydraulic gradient potentially driving downward flow is about 3 times greater close to the well than it is halfway between the well and the contaminant source. So this large spatial change in vertical hydraulic gradient must be accounted for, and the assumption that it is the same at all locations cannot be supported. Dr. Hennet does not account for the steeper vertical gradient in layer 2 for the path closer to the pumped well, nor does he account for the faster velocity in layer 3 when the travel distance is only 200 ft.

It is more likely that the travel distance in the shallower aquifer for much of the contaminated shallow groundwater would be more than 800 ft and the corresponding travel distance in the pumped aquifer would be less than 200 ft because (1) the vertically downward transport is more likely to occur where the vertical gradient is the strongest in the confining layer, which is closest to the pumping well, (2) the downward velocity would be fastest where the gradient is steeper close to TT-26, and (3) according to Dr. Hennet's calculations, the downward flux is only about 5% of the horizontal flux in the shallow aquifer, so that even if some contaminant leaked downward at further upgradient distances from TT-26, much would remain in the shallow aquifer to migrate to locations closer to, or even adjacent to, TT-26, where downward leakage would be the fastest. Thus, Dr. Hennet's three "representative" flow paths did not include a more critical flow path in which travel in the shallower aquifer is close to 1,000 ft. For this critical flow path, the travel time would be much less than 15 years—on the order of 3.5 to 5 years. For these several reasons, Dr. Hennet's estimates of travel times from ABC to TT-26 are erroneous, misleading, biased-high, and based on unreliable assumptions.

Well TT-26 pumpage (Hennet's report p. 5-36): Dr. Hennet continues in criticizing the pumpage assumptions about well TT-26. He says, "ATSDR assumed that supply well TT-26 was constantly pumping prior to 1980. This is unlikely as supply wells cannot remain in service for decades without shut down periods for repairs and maintenance." Dr. Hennet implies it is unreasonable to assume this, yet offers absolutely no evidence to support his contention. This can be contrasted with ATSDR's study, which (p. 18) states that they have documented pumping records for TT-26 (and other wells) for some time periods and those estimates "are based on documented information detailing periods of maintenance for specific wells." For earlier periods in which there are no explicit pumping records, TT Chapter C (p. C22-C23) describes their estimation approach in detail (and Dr. Hennet does not offer a better way that this could have been done). Furthermore, in general, well maintenance frequently only requires a day to a few days to complete. If TT-26 had been shut down for only a few days during a few months of every year for servicing, the monthly simulation model would still have to assume it operated for a full month each time, though at a proportionately reduced monthly pumping rate to reflect the actual total monthly withdrawal. It is hard to accept Dr. Hennet's speculative and hypothetical criticism or expect that it would make any difference.

p. 21-22 (Section 3.3) & p. 29: Dr. Spiliotopoulos cites Clement's 2011 issue paper (published in Ground Water journal); but these comments don't cite the Author's Reply (by Clement) to the published Comment by Maslia et al. in response to the original article. In his Reply to the Comment, Clement states "The goal of my article was not to review the Camp Lejeune (CLJ) modeling studies. Rather it was to use the CLJ problem as an example to highlight issues related to model complexities and to spark an open debate on when, where, and why we should limit model complexity." Therefore, Clement admits the article did not constitute a detailed technical review of the Camp Lejeune model study, so his 2011 Issue Paper that appeared to criticize it should not be taken as an expert analysis of the model or of its reliability or of the site. The Comment by Maslia et al. provided detailed rebuttals to Clement's concerns.

p. 21 (Section 3.3): Also, on p. 21 Dr. Spiliotopoulos states that "Dr. Clement's article echoed the NRC's concerns about the uncertainty in ATSDR's water model related to Tarawa Terrace and recommended a simpler approach for the water model related to Hadnot Point and Holcomb Boulevard to meet policy-oriented goals." Dr. Spiliotopoulos implies that the NRC report is a second independent review of the work. With regards to the groundwater modeling, it is not. Dr. Clement, a civil engineer, was the only groundwater expert on that committee (there were no geologists or hydrogeologists on that NRC Committee), so his concerns don't simply echo those of the NRC committee. Instead, it was likely that he was the source of those comments in the NRC Committee. While the use of "simpler models" might be okay for assessing policy-oriented goals, the simpler models would be subject to even greater uncertainty and lack of physical realism. Furthermore, the goals of historical reconstruction require a detailed and fairly complex modeling approach because the system being modeled is complex, and the use of simple models to meet such technical goals would be neither acceptable nor sufficiently accurate.

Regarding the 2009 NRC report and committee, Dr. Spiliotopoulos states that its primary charge was "to assess the strength of evidence in establishing a link or association between exposure to TCE, PCE, and other drinking-water contaminants and each adverse health effect suspected to be associated with such exposure." Consequently, almost all of the NRC Committee members were experts in medical and health fields. Only one was an expert in groundwater. The Committee had neither the focus, goal, intent, nor multiple experts to assess in depth the ATSDR's groundwater models. They were expected to focus on health effects.

Section 3.3 and scientific validity of ATSDR's models: In this section, Dr. Spiliotopoulos refers to statements by Dr. Dan Waddill. Dr. Waddill testified (Aug. 26, 2024, p. 234-235) regarding the ATSDR water modeling that "I do not think their results … were scientifically valid because, you know, science needs to be based on real-world observations and analysis. … and there were just not enough real-world measurements for this to count as a scientifically valid approach." He continues and concludes that the work was not scientifically valid because no concentration data were available in the 1950s-70s, and such observations can no longer be made (obviously). He argues that because of this, the hypothesis cannot be tested, so therefore it is not scientifically valid. I disagree.

I first note that Copi (1961) in discussing science and hypotheses states that "Few propositions in science are *directly* verifiable as true." He later states, "They can, however, be tested *indirectly*." Therefore, I would counter Dr. Waddill's statements by noting that in developing and applying the ATSDR groundwater models, that scientifically valid methods were used, and the models were based on sound hydraulic and physical principles that themselves have been tested and shown to be accurate and reliable approaches to describing and predicting groundwater flow and contaminant transport. The models were also based on many available hydraulic tests measuring hydraulic properties of the subsurface that do not change over time, and hence were data applicable to the site during the 1950s through 1970s. The models are indirectly tested during the calibration process in that available observations are compared to simulated values. This is an indirect type of model testing (or hypothesis testing) in which observations are compared to simulated values. The underlying theories and models have been tested in numerous field studies and are widely recognized as being scientifically valid.

The question should be whether this model for this site was sufficiently well calibrated and representative to perform a hindcasting prediction. I believe it was. I think there are many questions in our universe that are addressed using principles and models of physics that cannot (for all practical purposes) be directly tested in the foreseeable future. That does not render that work to be unscientific or lacking scientific validity. Predictive uses of models, whether forward in time or backwards in time, are widely accepted uses of scientifically valid models, while allowing for the existence and recognition of uncertainty in those predictions. The fact that there is uncertainty does not mean that they are not scientifically valid or scientifically defensible. The fact that one type or time period of observations are not available does not mean that the model is not scientifically valid.

Section 3.3 and Calibration Targets: At several places in this section, the issue of "calibration targets" is mentioned along with criticism that some simulated values did not fall within the calibration target. Relevant to this discussion are my comments in the 2009 Expert Panel Report (p. 101), with which I still agree and which I therefore repeat verbatim here:

> "a. **Are there established standards for establishing specific calibration targets? If so, what are they?** Overall, there are no standards and probably should not be any. Such targets are inevitably arbitrary and to some extent meaningless. They tend to distract from the quality of the calibration process and shift focus to the arbitrary goal. It is a "red herring." Not achieving a predetermined calibration target should not disqualify a model, nor does that prove a model is not valuable or useful. Conversely, meeting such a predetermined calibration target does not prove that the model is a good one or that it meets the needs of the particular study or that its calculations and predictions are accurate and/or reliable.
>
> "b. **Should ATSDR establish different calibration targets than for the Tarawa Terrace model?** In my opinion, the use of specific calibration targets should be abandoned. They have no real value in the context of hydrogeology, and can only serve to provide a false or meaningless image of the quality of the developed model. ATSDR only has a limited time to complete the study, and you will do the best job possible within that limited time and budget. Applying a calibration target will not lead to a better model, but it will cause some time to be spent on comparing the results to the target, and perhaps forcing the results to

fall within the target. It would be better to include on-going independent expert peer review during the model development process, as this will have a much higher payoff than calibration targets in terms of improving the quality of the final product."

Conclusions:

Groundwater models must be (and have been) calibrated in the absence of early time concentration data, as ATSDR has done. Other representative published examples where this has been successfully accomplished include the Rocky Mountain Arsenal, CO (Konikow, 1977) and Lawrence Livermore National Laboratory, CA (Rogers, 1992). In both of these cases, the early time history was reconstructed as part of the model calibration process (it just wasn't called "hindcasting"). This is a widely accepted procedure among groundwater modelers.

Although Dr. Spiliotopoulos repeatedly questions the accuracy of the ATSDR model and its calibration, I don't see any evidence that it is unacceptably inaccurate. In my opinion, ATSDR followed generally accepted methods that yielded reasonably accurate results for the mean monthly concentration of contaminants. ATSDR's TT Table F13 shows comparisons between observed and simulated concentration values, and most (but not all) are within the calibration target range. The presence of differences is not unexpected and does not indicate the model is unreasonably inaccurate or unscientific. Concentrations for many chemical constituents in groundwater typically show a high variation at local spatial scales and small time scales—much greater variability than presented by hydraulic heads. This is normal, and no groundwater transport model would be expected to reproduce or explain such small-scale variability in concentration.

Dr. Hennet presents a summary opinion on p. 5-36 of his report stating "ATSDR's assumptions are deficient, not verifiable, and at times demonstratively incorrect." I believe, to the contrary, that ATSDR's assumptions are reasonable and clearly documented with their supporting basis clearly described in detail and with recognition of uncertainty. I would argue that his counter examples, such as for bulk density and K_d, make little to no difference. Dr. Hennet's own estimates of travel times are clearly deficient and incorrect. Of course, the early time reconstructed concentrations cannot be directly verified. Those data don't exist. That is why the state-of-the-art simulation models were needed. He further states that "ATSDR estimates are not quantitatively reliable as different plausible assumptions would lead to different results." Nonuniqueness of calibrated groundwater models is a well-recognized issue. Different assumptions can lead to different results and different assumptions can also lead to identical results. This is true of every groundwater model ever developed. It does not negate the value or reliability of the model. This is why sensitivity and uncertainty analyses are helpful. Furthermore, it is why we put strong reliance on the expert judgment of those who have studied the particular aquifer system the longest and most in-depth, such as the ATSDR's authors of the modeling reports. Finally, Dr. Hennet says "ATSDR COC concentration estimates are for raw water which is not equivalent to COC concentrations in the distributed water." As I previously stated above, the opinion of experts on the 2005 Expert Review panel was that possible COC losses during water treatment at the Camp Lejeune WTPs would be small to minimal.

In my opinion, ATSDR has done an admirable job in completing a challenging task of using hindcasting with a calibrated model to reconstruct credible concentration distributions in time and space prior to the availability of data from chemical analyses of groundwater samples in the mid-1980s. In the face of missing historical data, the ATSDR models provide useful input to epidemiological studies. ATSDR clearly and comprehensively documented the model development—providing transparency to their work. There is uncertainty in the calibrated models (as there always is in such models) and in the hindcasted results, and that is clearly recognized and evaluated. The uncertainty is not so large or unexpected as to preclude the use of the model results in the epidemiological studies or for providing monthly mean concentrations for use by health professionals to estimate past exposure of residents on an "as likely as not" or "more likely than not" basis. The methods used were rigorous and scientifically sound.

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January 13, 2025

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EXHIBIT 16

Tarawa Terrace Flow and Transport Model Post-Audit

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ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
PCE	tetrachloroethylene
GMS	Groundwater Modeling System
MAE	mean absolute error
ME	mean error
NGWA	National Groundwater Association

EXECUTIVE SUMMARY

This post-audit report evaluates the performance of groundwater flow and transport models developed for the Tarawa Terrace region of Camp Lejeune by the Agency for Toxic Substances and Disease Registry (ATSDR). The models were originally designed to simulate the migration of tetrachloroethylene (PCE) contamination from the ABC Cleaners site, located adjacent to the northern boundary of Tarawa Terrace. The audit extends the original model's simulation period from 1995 to 2008 and assesses the accuracy of its predictions by comparing simulated PCE concentrations to actual concentrations measured at monitoring wells during this extended period.

The first step of the audit involved updating the original models, which were created using MODFLOW 96 and MT3DMS software. Both models covered a period between 1951 and 1994. These were successfully updated to MODFLOW 2000 and MT3DMS v5.3, ensuring compatibility with current software versions. Importantly, no significant discrepancies were detected between the original and updated models, confirming that the update process did not alter the results.

The simulation period was then extended to cover the years from 1995 through 2008. During this update, new rainfall and recharge data were incorporated in the MODFLOW model based on nearby weather stations, as the original station's data was incomplete. Additionally, the pumping rates for a set of remediation wells were included, as these wells played a role in altering groundwater flow during this period. The PCE source, which originated from ABC Cleaners and was terminated in the original model at the end of 1983, was left unchanged.

The extended MT3DMS model was found to perform well in simulating PCE concentrations at monitoring wells across the study area. The errors are remarkably well balanced, indicating a good overall fit between simulated and observed concentrations. There were localized discrepancies in error magnitude, particularly in areas where monitoring wells showed significant temporal and spatial variability. Some wells exhibited large fluctuations in measured concentrations over time, which likely resulted from natural subsurface variability, sampling errors, or differences in analytical methods. In other cases, wells showed significant differences in the magnitude of measured concentrations despite being adjacent to one another.

Despite these localized anomalies, the extended MT3DMS model captured the broader patterns of PCE plume migration with reasonable accuracy, particularly during the later years of the simulation. The largest errors were concentrated in a few monitoring wells that were already noted for irregularities in the observed data, but the model's predictions were generally consistent with observed concentrations at most well locations.

In summary, this post-audit found that the original Tarawa Terrace groundwater flow and transport models were developed using sound methodology and continue to provide reliable insights into the migration of PCE contamination. Despite the inherent challenges in simulating complex subsurface conditions and dealing with incomplete data, the model effectively simulates long-term trends in contaminant migration. Based on this post-audit, we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model.

1 INTRODUCTION

Our names are Norman L. Jones and R. Jeffrey Davis, and we have been asked to provide a post-audit of groundwater flow and transport models originally developed by the Agency for Toxic Substances and Disease Registry (ATSDR). This post-audit included extending both models from 1995 through 2008. Based on this review, effort, and analysis, as more fully described herein, we have reached the conclusions and opinions set forth below. A complete list of all materials relied upon to form the opinions in the report will be produced within seven days of the report's submittal. Our conclusions are subject to any new materials, data, or other information provided to us prior to depositions or trial at which time our opinions and conclusions may be updated.

In July 2007, the ATSDR, U.S. Department of Health and Human Services, published a report on a groundwater flow and transport model of the Tarawa Terrace region of the Camp Lejeune military base (Maslia et al. 2007; Faye and Valenzuela 2008; Faye 2008). The model was developed to simulate groundwater flow in the aquifers beneath Tarawa Terrace and to simulate the migration of tetrachloroethylene (PCE)[1] in the aquifers resulting from the release of PCE by ABC Cleaners, which is directly adjacent to the northern boundary of the Tarawa Terrace property. The original model was developed using the MODFLOW 96 software (USGS 1996) to simulate groundwater flow and the MT3DMS software (Zheng and Wang 1999) to simulate contaminant transport. MODFLOW and MT3DMS are companion programs where the groundwater flow field computed by MODFLOW is used by MT3DMS to simulate the fate and transport of PCE.

The original Tarawa Terrace flow model was designed to simulate flow conditions over a period from 1951 to 1994. The computation grid used by the model consisted of 270 rows and 200 columns, resulting in a uniform grid cell size of 50 ft x 50 ft. In the vertical direction, the model contained seven layers corresponding to a series of hydrogeologic units, including the Tarawa Terrace aquifer and the underlying Castle Hayne aquifer system. Model features include recharge resulting from vertical percolation of water from rainfall, general head boundary conditions on the north simulating exchange (primarily inflow) of water with the aquifer north of Tarawa Terrace, no-flow boundary conditions on the west representing a no-flow boundary along a topographic divide, and specified head boundary conditions on the south and east representing Northeast Creek. The model also included the withdrawal of groundwater via pumping wells and a drain representing potential discharge of groundwater to the channel of Frenchmans Creek on the west side of the model.

For the transport model, PCE was introduced through a single cell corresponding to the ABC Cleaners spill location at a mass loading rate of 1,200 g/day for a period from January 1953 to December 1983, and the resulting plume migration was simulated through the end of the flow

[1] PCE is also known by other names, including tetrachloroethene. In this report we refer to it as tetrachloroethylene.

and transport simulation period in December of 1994. Transport processes simulated include advection, dispersion, sorption, and biodegradation.

The original flow and transport models were calibrated using a multi-stage process. In the first stage, the flow model was calibrated to steady state flow conditions representing a pre-development state prior to the introduction of groundwater extraction wells. It was then converted to a transient model with pumping wells and time-varying recharge over the period of 1951 to 1994. The transient model was calibrated to transient water levels measured at monitoring wells in the region. In the final stage, the MT3DMS transport model was included, and the parameters of both the flow and transport model were adjusted until both the heads simulated by MODFLOW and the concentrations simulated by MT3DMS matched the field-observed heads, flows, and PCE concentrations within a reasonable range.

The objective of the post-audit is to extend the range of the groundwater flow and transport models from 1995 to 2008 and compare the output of the transport model with concentrations sampled at monitoring wells in Tarawa Terrace during the 1995–2008 period to assess the performance of the model as an interpretive and predictive tool. This comparison involved both a quantitative analysis of simulated versus observed concentrations and a qualitative analysis of the shape and migration of the simulated PCE plume over that period.

In the following sections, we described the steps we took to a) import the original model and update it to work with recent versions of MODLOW and MT3DMS, b) extend the flow model to 1995–2008 conditions, c) extend the transport model to 1995–2008 conditions, and d) compare the simulated PCE concentrations to field-observed PCE concentrations over the extended simulation period.

2 IMPORTING AND RUNNING THE ORIGINAL MODEL

To begin the post-audit, we were provided with a copy of the MODFLOW96 and MT3DMS input files used in the original model. We elected to use the Groundwater Modeling System (GMS) software, version 10.8 (Aquaveo LLC 2024) to perform the model updates. The GMS software is developed and distributed by Aquaveo LLC in Provo, Utah. GMS is a graphical user interface for the MODFLOW and MT3DMS codes and works as a pre- and post-processor (Owens et al. 1996). GMS can be used to build new models from scratch, or to import and modify existing models. The model data are then saved by GMS to input files that can be read by MODFLOW/MT3DMS. The model results output by MODFLOW/MT3DMS are then read by GMS where they can be displayed graphically and analyzed numerically.

We began by attempting to import the MODFLOW 96 files. MODFLOW has been continuously updated and improved since it was initially launched in 1984 (McDonald and Harbaugh 1984), resulting in numerous versions. MODFLOW 96 was released in 1996 and was widely used but was updated to MODFLOW 2000 (Harbaugh et al. 2000) and MODFLOW 2005 (Harbaugh 2005) in 2000 and 2005, respectively. More recent versions include MODFLOW-USG (Panday et al. 2013) and MODFLOW 6 (Langevin et al. 2017). While newer versions provide some new capabilities, both MODFLOW 2000 and MODFLOW 2005 are widely used and provide access to all of the model features used in the original Tarawa Terrace model. However, MODFLOW 96 has been mostly discontinued and is not supported by the GMS software. GMS does provide the capability to import MODFLOW 96 files and convert them to newer versions. When we attempted to import the original MODFLOW 96 files to GMS, we discovered that the files would not import properly, and GMS displayed an error message. After some exploration, we determined that we had to make a minor edit to the original WEL (wel.dat). Lines 4 through 13 were changed from a "-1" value to a value of "0." Once the model was imported, we saved a copy of the model in MODFLOW 2000 format. To import the MT3DMS files, we had to manually update the mass loading of 1,200 g/day in GMS from January 1953 through December 1983. This was due to an outdated version of the Source Sink Mixing (SSM) package used in the original simulation. The MT3DMS files were saved in an updated format compatible with the current version of MT3DMS (v5.3) used by GMS.

After importing and converting the MODFLOW and MT3DMS files and saving them to the newer formats, we re-ran the flow and transport simulations and imported the solutions to GMS. At this point, we performed a qualitative analysis to ensure that the process of converting the files and updating to the newer versions did not change the model outputs. First, the simulated head contours from the updated flow model were compared to the head contours described in the ATSDR modeling report (Faye and Valenzuela 2008) as shown in Figure 1. The results of the updated model seem to match the results of the original model. Next, we compared PCE concentrations simulated by the updated MT3DMS model and to the concentrations simulated by the original MT3DMS model (Figure 2). Once again, the results seem to match well, indicating that no errors were introduced to the model in the conversion process.

3 EXTENDING THE FLOW MODEL

After confirming that the flow and transport simulations were properly imported and updated, we proceeded to modify both the flow and transport simulations for the post-audit. The changes made to the MODFLOW model are described in this section. The only changes made to the MODFLOW model were to extend the simulation period, update recharge values over the new period, and modify the pumping rates at remediation wells. No other changes were made to simulation settings or boundary conditions and sources/sinks.

3.1 SIMULATION PERIOD

The original simulation was from January 1951 through December 1994. We extended the simulation period through December 2008 so that the simulation included the period from 1995 to 2008. For the new simulation, no changes were made to the inputs for the original 1951–1994 period and thus the model solution for that period remained unchanged in the new model. For 1995–2008, we used the same stress period interval used in the original model, with monthly stress periods and one time step per stress period.

3.2 RAINFALL-RECHARGE

For the original flow model, the primary source of water to the aquifer was input from precipitation that infiltrated to the water table, which is simulated in MODFLOW as recharge where the units are length/time (feet/day). In the original model, a single annual recharge rate was used for each year of the simulation as illustrated in Table C7 of Faye and Valenzuela (2008). The recharge rate was found by applying a recharge coefficient of 0.235 to the annual precipitation to find an effective recharge rate representing the fraction of rainfall that percolates to the water table. This recharge rate is then entered into the Recharge Package in MODFLOW, and the package applies water to the top active cell during each stress period.

The precipitation values used in the original simulation were obtained from the Maysville-Hofman Forest station, which is north of Tarawa Terrace. For the post-audit, we attempted to obtain precipitation data from the same station. We found three different precipitation data sets that were purported to be from the Hofman Forest station, but each of these data sets was determined to be unusable. None of the data sets had a complete set of precipitation data for the 1995 to 2008 period. Furthermore, for the partial data during the period of interest, one of the data sets contained some extreme anomalies in monthly precipitation that did not appear in neighboring rain gauge stations. As a result, we elected to use rain gauge data from other stations in the vicinity of Tarawa Terrace. Using the National Oceanic and Atmospheric Administration National Weather Service website (National Weather Service 2024), we located three rain gauges near Tarawa Terrace that had a complete set of rainfall measurements during the period 1995 to 2008. The locations of these gauges relative to Tarawa Terrace are shown in

Figure 3. The mean rainfall for each of these gauges over the 1951 to 1994 period is similar to the mean rainfall for the Hofman Forest station over the same period, and the annual variations were in a consistent range. Thus, we took a simple average of each of the three stations over the 1995 to 2008 period to estimate the average annual rainfall at Tarawa Terrace and multiplied these averages by 0.235 to get the effective recharge rate and converted it to units of feet/day for use in the extended MODFLOW simulation. The rainfall values, averages, and effective recharge rates are summarized in Table 1.

3.3 PUMPING AT WELLS

Another change to the MODFLOW model over the extended simulation period was related to pumping associated with a set of remediation wells. These wells withdraw water from the aquifer, thus impacting both the flow field and the subsequent movement of contaminants simulated by the MT3DMS simulation. We were provided with a list of remediation wells and their pumping history for a period beginning in 1999 and continuing through the end of 2008. The well names, coordinates, model layers, and pumping histories over the period of interest are shown in Table 2. In each case, the pumping rates were turned on for each well at the rates shown on the corresponding dates and held constant at that rate until the next rate change or until the wells were turned off. All the other pumping wells in the model had zero pumping rates during the extended simulation period. The locations of the remediation wells are shown in Figure 4.

4 EXTENDING THE TRANSPORT MODEL

For the transport model, no changes were required to the MT3DMS inputs for the extended simulation period, except for enabling the Transport Observation package. The same dynamic transport step options used in the original model were applied to the new stress periods from 1995 to 2008. The PCE source at the location of the ABC Cleaners facility was turned off at the end of 1983, matching the original model.

4.1 OBSERVED CONCENTRATIONS

The main objective of extending the flow and transport simulation was to assess the performance of the model in simulating the migration of the PCE plume over the extended period and to compare the simulated PCE concentrations to PCE concentrations observed at monitoring wells during the 1995–2008 period. A list of the monitoring wells is shown in Table 3, the PCE concentrations observed at the wells in Table 4, and the locations of the wells in Figure 5. As presented in Table 4, the samples were all taken at 12 distinct dates beginning in 1997 and ending in 2008. The model layers associated with each well were determined by comparing the well screen depths with the grid cell top and bottom elevations for the grid cells containing the monitoring well locations and confirmed by documents provided by counsel (Weston ABC One-Hour Cleaners Dataset).

The monitoring well locations and the observed concentrations were imported as observation points in an “observation” coverage (spatial features layer) in the Map Module of the GMS software. This information was then linked by GMS to the MT3DMS Transport Observation package, which was turned on and used in the simulation. This allows MT3DMS to calculate the simulated PCE concentrations at the cells containing the observation wells and output the results in a format that we could easily access and use in our analysis.

4.2 TEMPORTAL AND SPATIAL ANOMALIES

While the observed concentrations at each monitoring well listed in Table 4 are generally consistent over time, there are some exceptions that should be noted. For Well C13 in Model Layer 3, the observed concentration of 5,400 μg/L in 2002 is an order of magnitude higher than any subsequent concentrations observed at the same well and is substantially higher than all other concentrations but one. The highest concentration of 6,900 μg/L was measured at Well RWS-4A in Layer 1. The observed concentrations at this well showed extreme fluctuations over time. The observed concentration of 280 μg/L in January 2002 was followed only 3 months later by an observed concentration of 6,900 μg/L—the highest value measured. Then for the sequence of observations from 2003 to 2007, the concentrations oscillated from 1,100 → 0 → 1,000 → 92 → 1,600. This high degree of fluctuation could be due to sampling errors, differences in analytical techniques, and/or extreme heterogeneity in aquifer properties near the well.

In addition to variations over time, there are spatial variations in the observed concentrations. Well FWS-13 has zero or low (<5 μg/L) observed concentrations over the entire range of sampling dates. However, as shown in Figure 5, it is immediately adjacent to FWS-12, RWS-3A, and RWS-4A, all of which show high concentrations over the entire range of sampling dates. Likewise, in Model Layer 3, monitoring well C12 has low observed concentrations despite being adjacent to RWC-2, which has high concentrations. Furthermore, Wells FWC-11 and C5 have zero or low (<5 μg/L) observed concentrations over all sampling dates and are relatively close to C3, which has high concentrations over most dates. C14 has high concentrations over the four dates sampled despite being directly adjacent to C13, C15-S, C15-D, and C16, all of which have low concentrations on those dates.

This temporal and spatial variability in concentrations at selected wells illustrates the extreme variability often seen when dealing with concentration data from monitoring wells. It highlights why focusing on absolute concentrations at specific dates and locations when analyzing the performance of a flow and transport model is less important than assessing the overall distribution of simulated concentrations and comparing the shape of the simulated plume with the general spatial distribution of observed concentrations. Each of these sites with high variability is generally correlated with higher model error, as shown below in the Results section.

5 RESULTS

The main objective of this post-audit is to assess the performance of the flow and transport model over the extended period of 1995 to 2008 using PCE concentrations observed in monitoring wells over that period. Before presenting the results, it is helpful to remember that when simulating the migration of a PCE contaminant plume using MODFLOW and MT3DMS, achieving a close match between simulated and observed concentrations can be challenging for several reasons:

1. **Complex Subsurface Conditions**: The subsurface environment is inherently complex, with variations in soil heterogeneity, permeability, porosity, and hydraulic conductivity. These properties vary spatially in ways that are not fully captured in the model, affecting how the contaminant plume moves through the groundwater system.
2. **Temporal Variability**: The concentration of contaminants can change over time due to factors like seasonal variations in groundwater flow, biodegradation, and chemical reactions. Simulating these dynamic processes accurately over the entire simulation period is challenging.
3. **Limitations in Model Resolution**: MODFLOW and MT3DMS rely on discretizing the subsurface into numerical grids consisting of cells that represent a subset of the aquifer. The resolution of these grids can limit the model's ability to capture fine-scale variations in plume behavior, particularly in areas with sharp concentration gradients, small-scale heterogeneities, or preferential pathways.
4. **Measurement Variability**: The observed concentrations at observation wells may contain some degree of measurement error or uncertainty. Field data collection is subject to variability, which adds another layer of complexity when trying to match it closely with model outputs. As outlined above in Section 4.2, extreme variations were observed in some of the measured concentrations used in this post-audit.

Each of these challenges was highlighted in the Faye (2008) report on pp. F44–45. It was reported that at several sites, measured concentrations varied by several orders of magnitude over a few feet of depth.

Given these challenges, it is important to qualitatively assess the overall behavior of the simulated plume in addition to quantitatively analyzing the differences in simulated and observed concentrations at specific times and locations. A qualitative evaluation helps ensure that the model captures the key processes governing plume migration, such as its general direction, spread, and interaction with sources, sinks, and aquifer boundaries. This broader perspective can offer valuable insights into the overall value of the model as an interpretive or predictive tool.

After running both the extended MODFLOW and MT3DMS simulations, we analyzed the resulting PCE concentrations at a set of monitoring well locations and compared them to the observed concentrations. In the MT3DMS simulation, the spill at ABC Cleaners was simulated using a mass loading rate of 1,200 g/day at a single cell from January 1953 to December 1983 as described in Faye (2008). We did not alter this mass loading rate for the extended simulation. The resulting concentrations computed by the MT3DMS model are in units of grams/cubic foot. We converted these concentrations to units of micrograms/liter by multiplying the MT3DMS concentrations by a conversion factor of 35,314.7. We chose to present the simulated concentrations in micrograms/liter to match the units used in the original Faye (2008) report. This was applied to both the simulated concentrations at monitoring well locations and to the gridded data used to display the migration of the PCE plume.

5.1 MONITORING WELLS

A complete list of the observed and simulated concentrations at the monitoring well locations is shown in Table 5. The "Error" column represents the difference between the simulated and observed concentrations, and the "Abs(Error)" column is the absolute value of the error. These observations were sampled at a unique set of time periods as shown in Table 4. Taking all values into consideration, the mean error (ME) = 21 μg/L, indicating that the positive and negative errors are well balanced. The mean absolute error (MAE) = 334 μg/L.

These concentration values are displayed on a scatter plot of simulated concentrations versus observed concentrations in Figure 6. Because this is a log-log plot, it does not show values where either the simulated or observed concentrations are zero. The results are similar to the results for the original model shown in Figure F12 on p. F33 of the Faye (2008) report; although in this case, there are far more samples to compare. The dashed line in Figure 6 indicates a perfect match between the simulated and observed values. The points on the plot are mostly centered on the line, but as was the case with the original model, the simulated values appear to be biased on the high side, with the simulated values greater than the observed values. However, when the sites with zero observed or simulated concentrations (not shown on Figure 6) are factored in, the errors are balanced, as indicated by the low ME (21 μg/L) reported above.

We calculated a scatter plot of simulated versus observed concentrations for each monitoring well location where both the simulated and observed concentrations are non-zero, and the plots are shown in Figure 7. While there is high variability at some sites, most of the sites show good agreement.

Next, we generated time series plots of simulated versus observed concentrations at monitoring well locations. The results are shown in Figure 8. For Sites C1, S8, and S11, both simulated and observed concentrations were zero for all measurement dates. In general, the simulated and observed curves become closer as the simulation progresses. It should be noted that the vertical scale on each plot is variable, and the magnitude of the differences between simulated and observed concentrations can vary greatly from one plot to the next.

5.2 MIGRATION OF PCE PLUME

To get a qualitative understanding of the of the spatial distribution of the simulated PCE plume versus time and how it correlates with the temporal and spatial distribution of the observed PCE concentrations, we next generated a series of maps showing the simulated PCE plume in Model Layers 1, 3, and 5 at selected sampling dates (Figures 9–13). For each date, we overlaid the monitoring wells that were sampled on that date in each layer. The intervals and colors for the simulated PCE plume contours were selected to match those used in Figures F18–F25 in the Faye (2008) report. The monitoring well symbols are colored based on the relative magnitude of the absolute error at that date.

The results for each of the sampling dates are generally consistent. The spatial distribution of green and yellow symbols at monitoring well locations shows good overall fit of the simulated plume relative to observed concentrations, especially at the later sampling dates. The larger errors tend to be concentrated in the center of the plume where the simulated concentrations are greater. This is somewhat expected because comparing larger numbers will organically result in larger differences. Furthermore, the high errors generally coincide with the monitoring wells exhibiting high temporal and spatial variation, as described in Section 4.2. The wells identified in that section with extreme variability include FWS-13, RWS-4A, RWC-2, FWC-11, C5, and C14, all of which exhibit high errors. Other wells, such as S3 and S5, have high errors in the earlier dates but are in better agreement at later dates when the high simulated concentrations in the center of the plume dissipate over time.

To further compare the spatial distribution of the PCE plume with the PCE concentrations observed at monitoring wells, we took the errors and absolute errors from Table 5 and calculated the ME and MAE at each monitoring well location. The results are tabulated in Table 6. These MAE values were then used to create the maps shown in Figures 14–16. There is a separate map for each of the Model Layers 1, 3, and 5. In each figure, the MAE magnitudes for each monitoring well are displayed at the monitoring well locations and are superimposed on contour plots of the simulated PCE plume. The MAE error norm represents errors from multiple sampling dates, and the footprint of the plume migrated over time as illustrated previously in Figures 9–13. However, the intent here is to illustrate the spatial distribution of the error relative to the overall plume footprint, and the plume footprint is at the largest state at this point in the simulation, so it represents a useful basis of comparison.

The PCE plume for December 2008 for Model Layer 1 and the MAE at monitoring wells located in Layer 1 are shown in Figure 14. The errors at the wells are color-coded for three ranges, as shown in the figure legend. The spatial distribution of the errors indicates that there is a good overall agreement between the shape of the plume and the observed PCE concentrations at the monitoring wells. The wells with the highest errors are Wells FWS-13 and RWS-4A, which were noted in Section 4.2 as having high temporal and spatial anomalies. The simulated PCE plume for Layer 3 for the same date and the errors for monitoring wells in Layer 3 are shown in Figure 15. Once again, most of the wells on the fringes of the plume are in good agreement.

The highest errors are at Wells FWC-11, C5, C13, C14, and RWC-2, which were identified in Section 4.2 as having high anomalies. The simulated PCE plume and errors for Layer 5 are shown in Figure 16. This layer contained only two monitoring wells, and the errors are low.

In summary, the 7 wells identified as having anomalies in the observed data have high errors while the remaining 30 wells exhibit low or moderate errors, indicating good overall agreement between the simulated PCE plume and the observed concentrations over the range of the extended simulation.

6 CONCLUSIONS

Our conclusions from the post-audit analysis are as follows:

1. **Model Import and Update**: The original MODFLOW and MT3DMS models were successfully imported and updated to modern versions (MODFLOW 2000 and MT3DMS v5.3), ensuring compatibility with current software. The updated models matched the original model outputs, validating the update process.

2. **Extended Simulation Period**: The flow and transport models were extended from the original period (1951–1994) to cover the period from 1995 to 2008. Modifications included updating the recharge data based on new precipitation data and incorporating pumping rates for the remediation wells. The PCE source at ABC Cleaners was left unchanged, consistent with the original simulation ending in 1983.

3. **Observed vs. Simulated Concentrations**: The post-audit revealed that the updated MT3DMS model adequately simulated PCE concentrations at monitoring wells over the extended period. While there was a high variability at some monitoring well locations, the errors are remarkably well balanced, indicating a good overall fit between simulated and observed concentrations.

4. **PCE Plume Migration**: The extended model captured the overall migration of the PCE plume between 1995 and 2008. Simulated plumes were consistent with observed concentrations at most monitoring wells, especially during the latter stages of the simulation. The largest discrepancies occurred at a relatively small subset of wells that exhibited high temporal and spatial variability in observed concentrations. This variability may be due to sampling errors, aquifer heterogeneity, or variations in analytical methods.

5. **Model Performance**: The model performance was evaluated using both qualitative and quantitative methods. Despite challenges inherent in simulating subsurface flow and transport, such as soil heterogeneity, data uncertainty, and model resolution limits, the model reasonably captured the key behaviors of the PCE plume. The high variability in certain well measurements introduced some error but did not significantly undermine the model's overall accuracy.

In summary, the extended model demonstrates that the original model was developed using sound methods, and the model remains a reliable tool for understanding the general trends of contaminant migration in the Tarawa Terrace region. Based on this post-audit, we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model.

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[2] Reference will be updated.

8 QUALIFICATIONS

I, **R. Jeffrey Davis**, P.E., CGWP, have almost 30 years of experience with civil and environmental engineering, hydrogeology, groundwater fate and transport modeling, and software and model development. I have both undergraduate and graduate degrees from Brigham Young University in civil engineering. I currently serve on the board of directors for the National Ground Water Association (NGWA), as well as on NGWA's per- and polyfluoroalkyl substances and Managed Aquifer Recharge advisory groups. I was one of the leads for NGWA's Groundwater Modeling Advisory Panel. I have developed and used numerous groundwater models for the agricultural industry and the mining industry, including projects involving environmental impact statements, environmental assessments, water management, groundwater–surface water interaction and contamination, dewatering, and water treatment. I also have extensive experience with the oil and gas industry, including water supply, hydraulic fracturing, and groundwater protection for the upstream market, and worked on a variety of oil release projects. I have extensive knowledge of groundwater flow-and-transport principles and have led numerous workshops and classes in the United States and around the world. I have taught several classes and workshops in association with NGWA and other professional organizations and universities for the past 3 decades. I also share my research and project work regularly with the professional societies with which I am affiliated. I frequently use groundwater models to explain fate and transport of contaminants or groundwater supplies and availability. Recent such examples include groundwater impacts from agricultural activities in Minnesota; aqueous film-forming foam contamination impacts to groundwater in Martin County, Florida; a pipeline of produced water spill in North Dakota; and groundwater availability and surface water impacts in Ventura County, California. I am regularly asked to provide opinions or participate on panels to discuss groundwater, water supply, or contaminated groundwater issues.

I, **Norman L. Jones**, Ph.D., have 33 years of experience in civil and environmental engineering. I graduated with a B.S. degree in civil engineering from Brigham Young University and with M.S. and Ph.D. degrees in civil engineering from the University of Texas at Austin. I have been a faculty member in the Civil and Construction Engineering Department at Brigham Young University since January 1991 where I currently hold the rank of Professor. I have taught university courses in a variety of subjects, including computer programming, soil mechanics, seepage and slope stability analysis, and groundwater modeling. The primary focus of my research has been groundwater flow and transport modeling, software development, remote sensing, groundwater sustainability analysis, and hydroinformatics. I was the original developer of the GMS software, which is a graphical user interface for MODFLOW and MT3DMS and is used by thousands of organizations all over the world. GMS is now developed and maintained by Aquaveo, LLC in Provo, Utah, a company that I helped found in 2007. I have taught numerous short courses on groundwater flow and transport modeling over my career. I am a member of the Hydroinformatics Research Laboratory at Brigham Young University. I have been the principal or co-investigator on more than $20M of externally funded research. I have authored 179 technical publications, including 88 peer-reviewed journal articles, and 1 book. I am a recipient of the Walter L. Huber Civil Engineering Research Prize from the American Society of Civil Engineers and the John Hem Award for Science and Engineering from NGWA. I have been involved in a number of consulting projects, including work as a technical expert in litigation cases. I am an active member of the American Water Resources Association, the NGWA, the American Geophysical Union, and the American Society of Civil Engineers.

9 COMPENSATION

My, **R. Jeffrey Davis**, experience is summarized in my resume, which is included as Exhibit 1. I am being compensated at a rate of $498 an hour for my time in preparation of this report and $498 an hour for my deposition and trial testimony, if necessary. My compensation is not contingent upon the opinions I developed or the outcome of this litigation case.

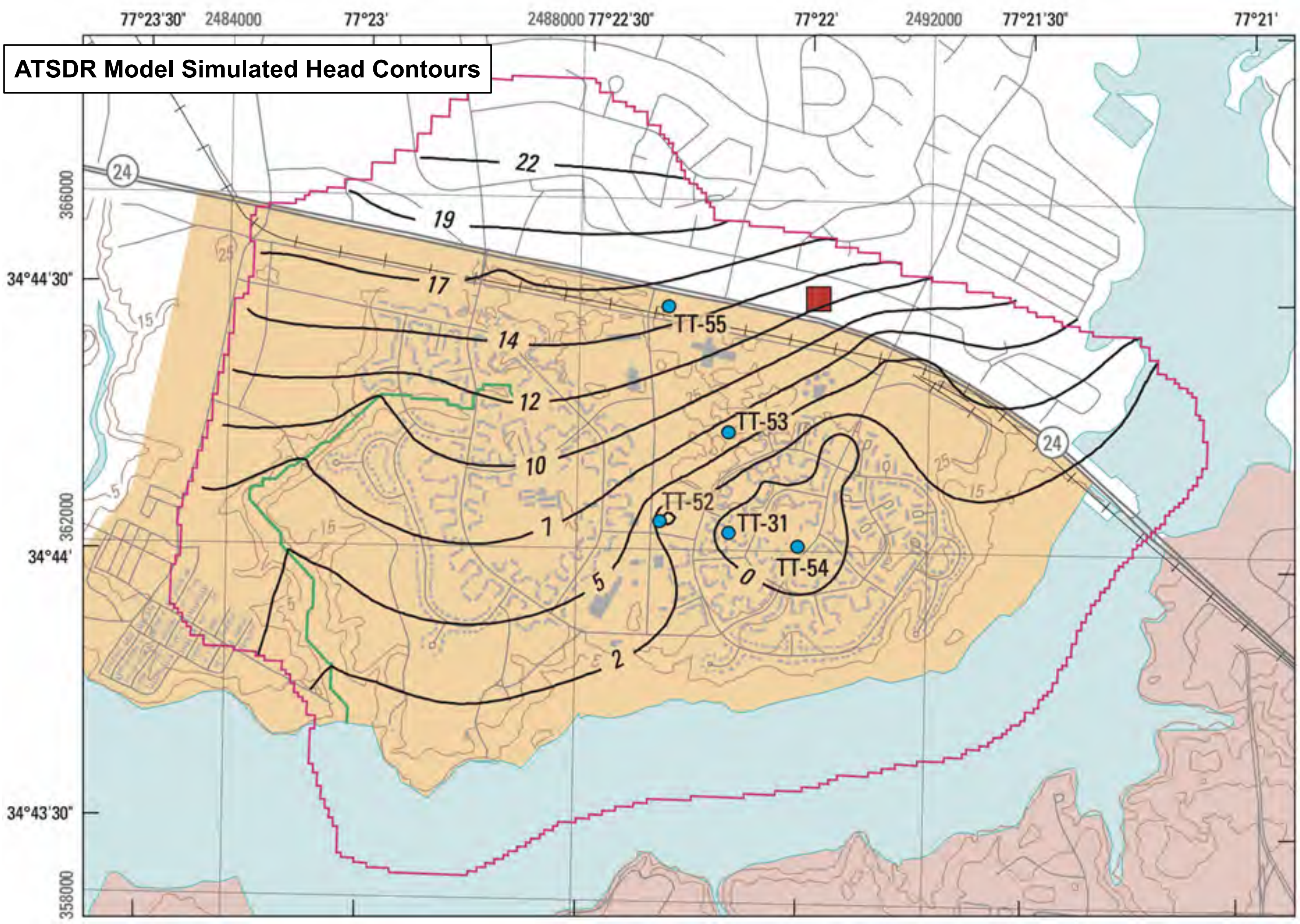
My, **Norman L. Jones**, experience is summarized in my resume, which is included as Exhibit 2. I am being compensated at a rate of $500 an hour for my time in preparation of this report and $1,000 an hour for my deposition and trial testimony, if necessary. My compensation is not contingent upon the opinions I developed or the outcome of this litigation case.

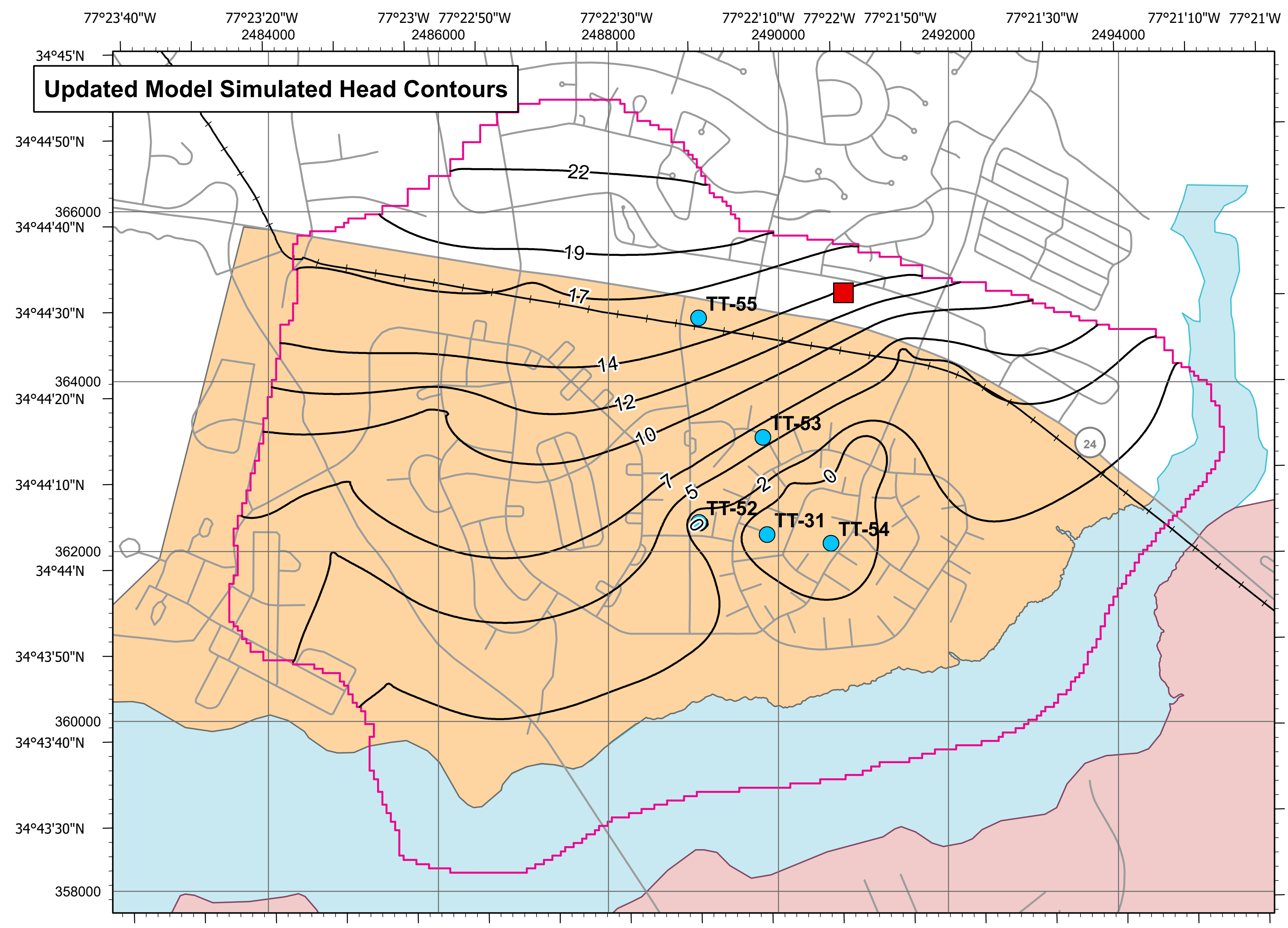
10 PREVIOUS TESTIMONY

I, **R. Jeffrey Davis**, have not given any deposition or trial testimony in the last 4 years.

I, **Norman L. Jones**, gave deposition testimony on October 20, 2021, in MICHAEL YATES and NORMAN L. JONES vs TRAEGER PELLET GRILLS LLC, in the United States District Court for the District of Utah Central Division, Case No. 2:19-cv-00723-BSJ. With the exception of this case, I have not given any deposition or trial testimony in the last 4 years.

Figures





Historical Water Supply Area
- Holcomb Boulevard
- Tarawa Terrace
- Model Boundary

- Simulated Potentiometric Contour (ft)
- Pumping Water Supply Well
- ABC One-Hour Cleaner
- Road

0 1,000 2,000
Feet

N

Notes:
- Head contours for model layer 1, stress period 408 - December 1984 are shown for both the ATSDR Model and the Updated Model.
- ATSDR Model-Simulated Head Contours were simulated in MODFLOW 96 and copied directly over from Figure C.18 (Maslia et al. 2007).
- Updated Model-Simulated Head Contours were simulated in MODFLOW 2000 and exported from GMS software.
- A visual comparison suggests that the updated model is accurately representing the results from the ATSDR model.
- Historic water supply areas were estimated from Figure C.18.

ATSDR = Agency for Toxic Substances and Disease Registry
GMS = Groundwater Modeling System

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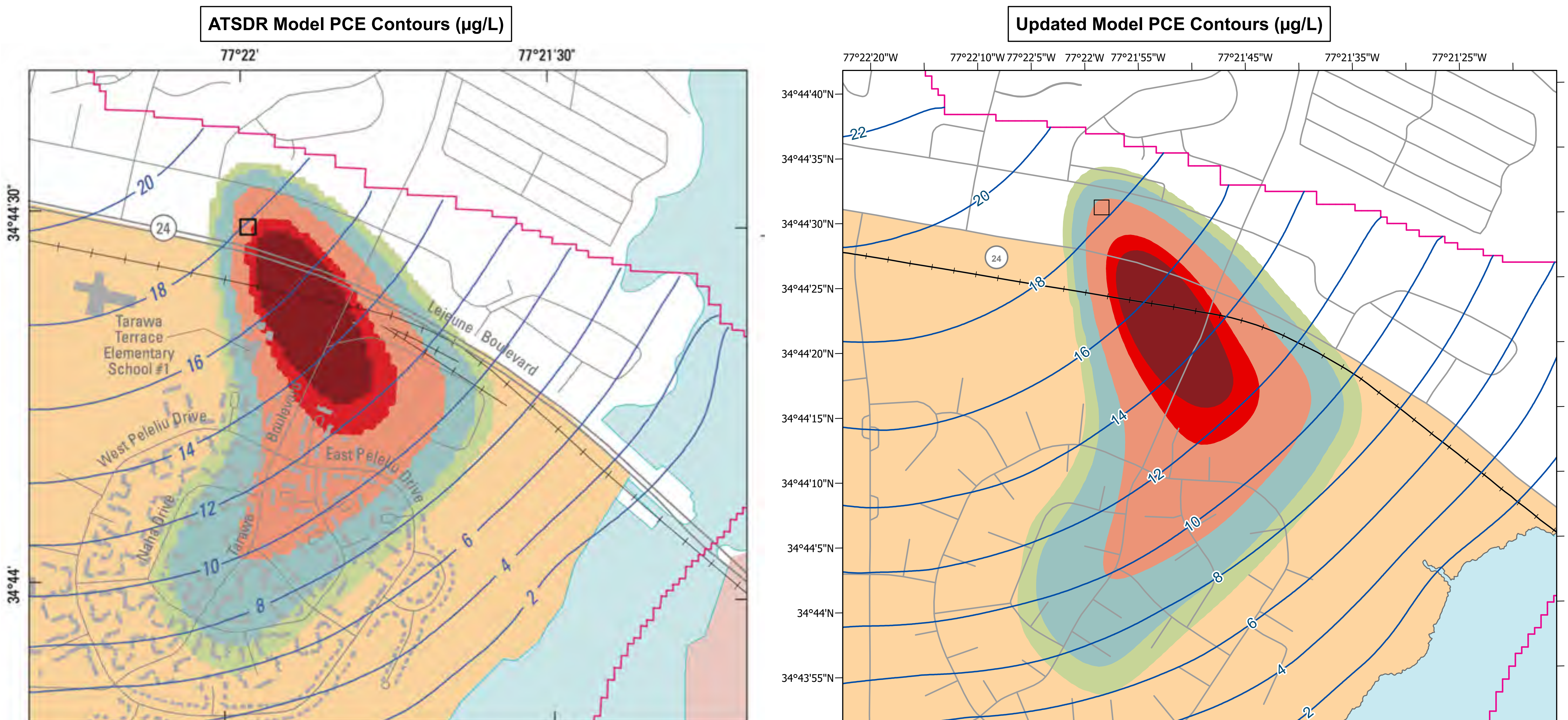
Figure 1.
Comparison of Original Model-Simulated Head Contours to Updated Model-Simulated Head Contours
Tarawa Terrace Flow and Transport Model Post-Audit



Historical Water Supply Area

- Holcomb Boulevard
- Tarawa Terrace
- Model Boundary
- Simulated Potentiometric Contour (ft)
- ABC One-Hour Cleaner

PCE Concentration (µg/L)

- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,000
- Greater than 1,000 to 5,000
- Road

0 1,000 2,000
Feet

N

Notes:
PCE concentrations for model layer 1 are shown for both the ATSDR Model and the Updated Model.
- ATSDR Model PCE Contours were simulated in the original MT3DMS model and copied directly over from Figure F23 (Maslia et al. 2007).
- Updated Model PCE Contours were simulated in MT3DMS and exported from GMS software.
- A visual comparison suggests that the updated model is accurately representing the results from the ATSDR model.

ATSDR - Agency for Toxic Substances and Disease Registry
GMS - Groundwater Modeling System
PCE - tetrachloroethylene

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Figure 2.
Comparison of Original Model-Simulated PCE Concentrations to Updated Model-Simulated PCE Concentrations
Tarawa Terrace Flow and Transport Model Post-Audit

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Figure 3.
National Weather Service Rain Gauge Locations Selected for Extended Simulation
Tarawa Terrace Flow and Transport Model Post-Audit

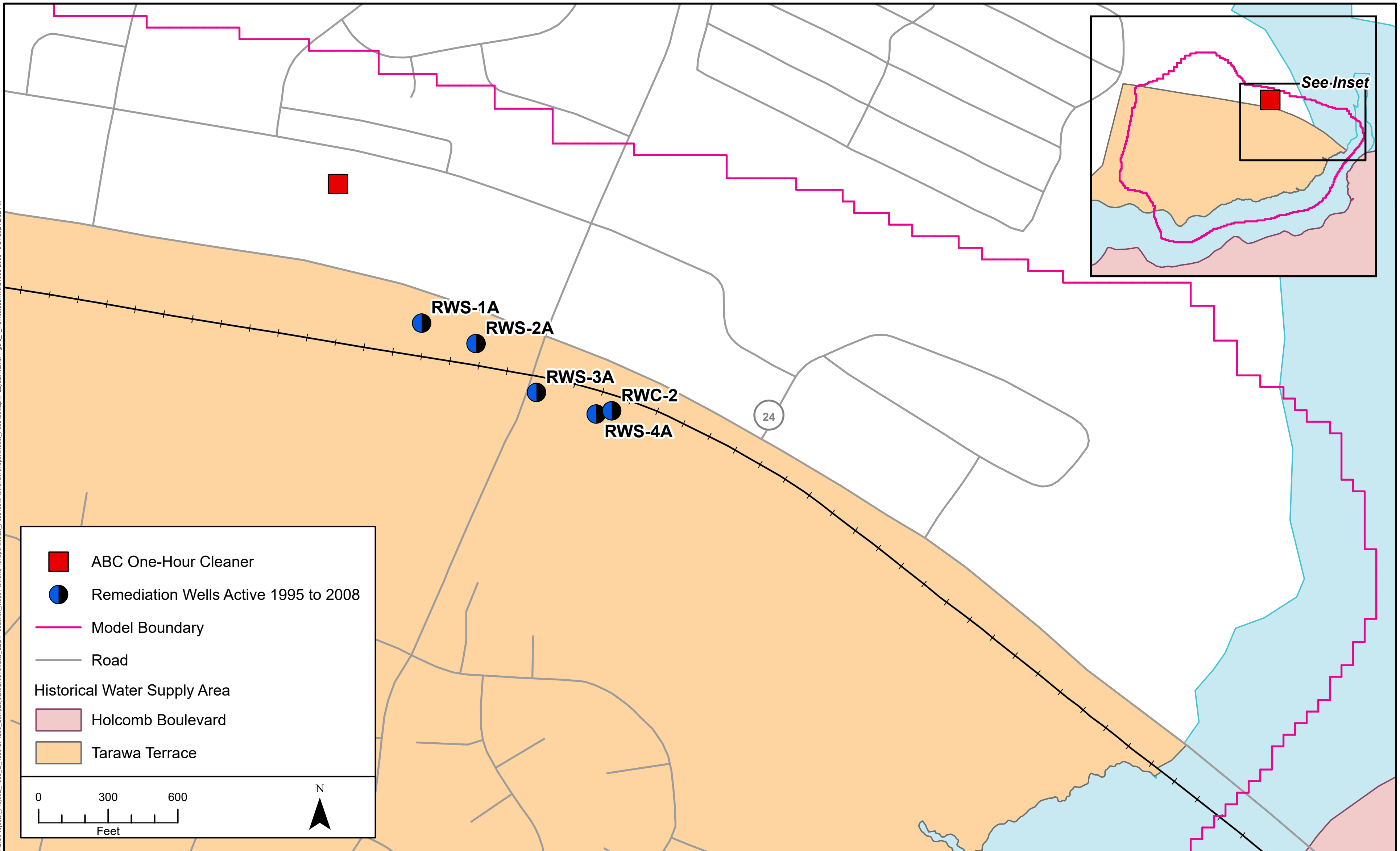

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Figure 4.
Location of Remediation Wells Active During the 1995 to 2008 Period
Tarawa Terrace Flow and Transport Model Post-Audit

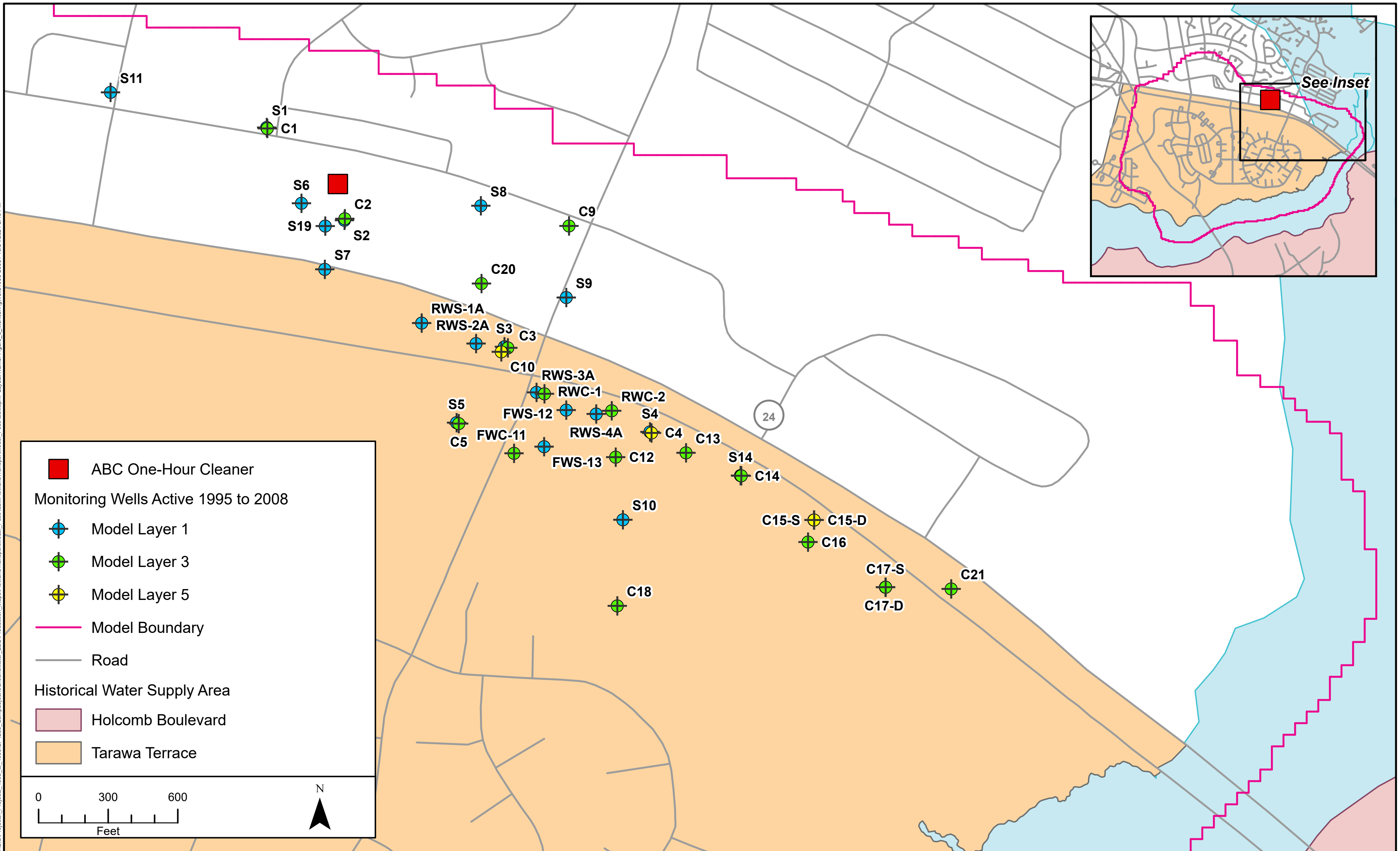

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Figure 5.
Location of Monitoring Wells Active During the 1995 to 2008 Period
Tarawa Terrace Flow and Transport Model Post-Audit

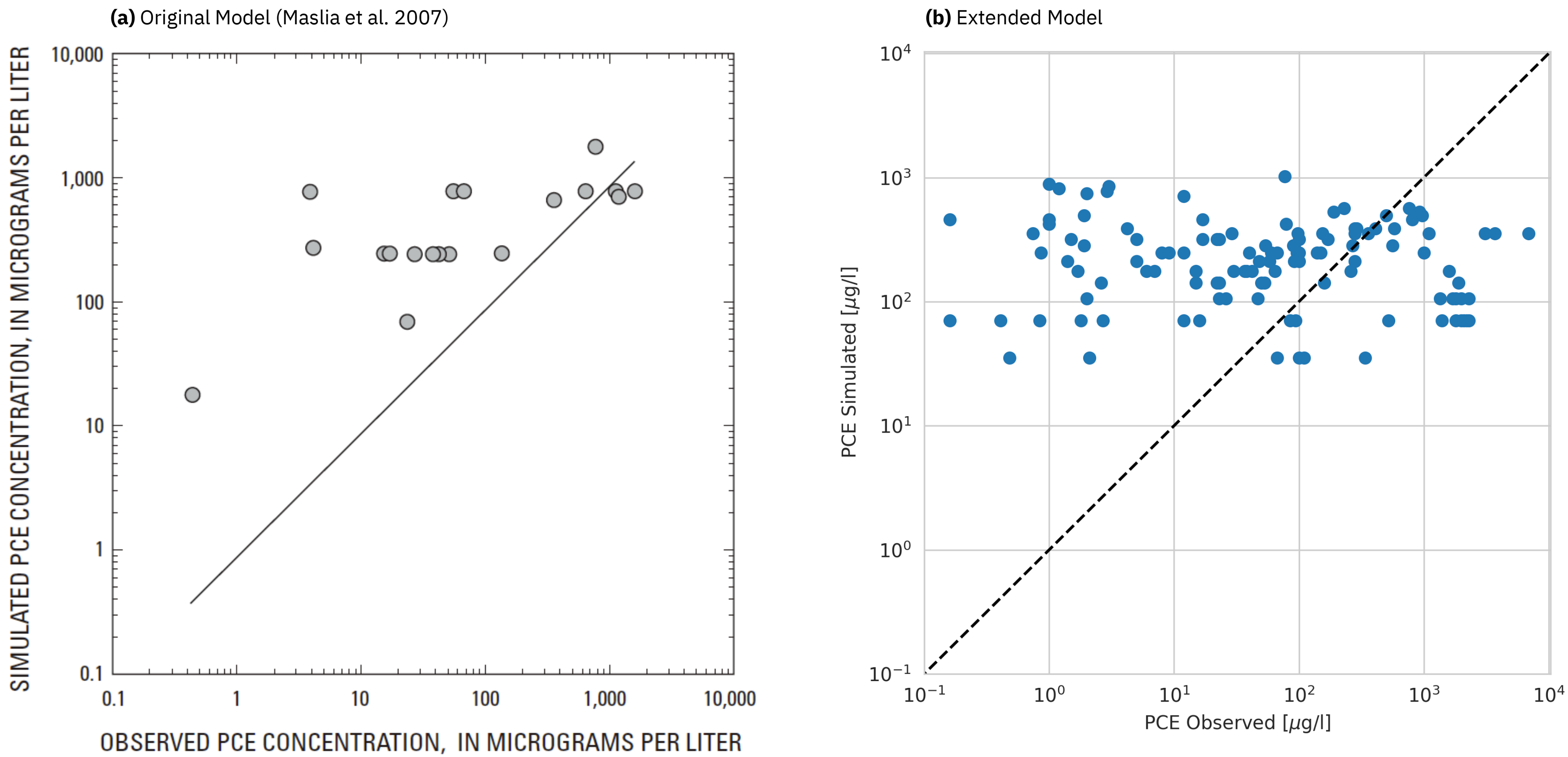

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Figure 6.
Simulated vs. Observed PCE Concentrations from (a) Original Model and (b) Extended Model
Tarawa Terrace Flow and Transport Model Post-Audit

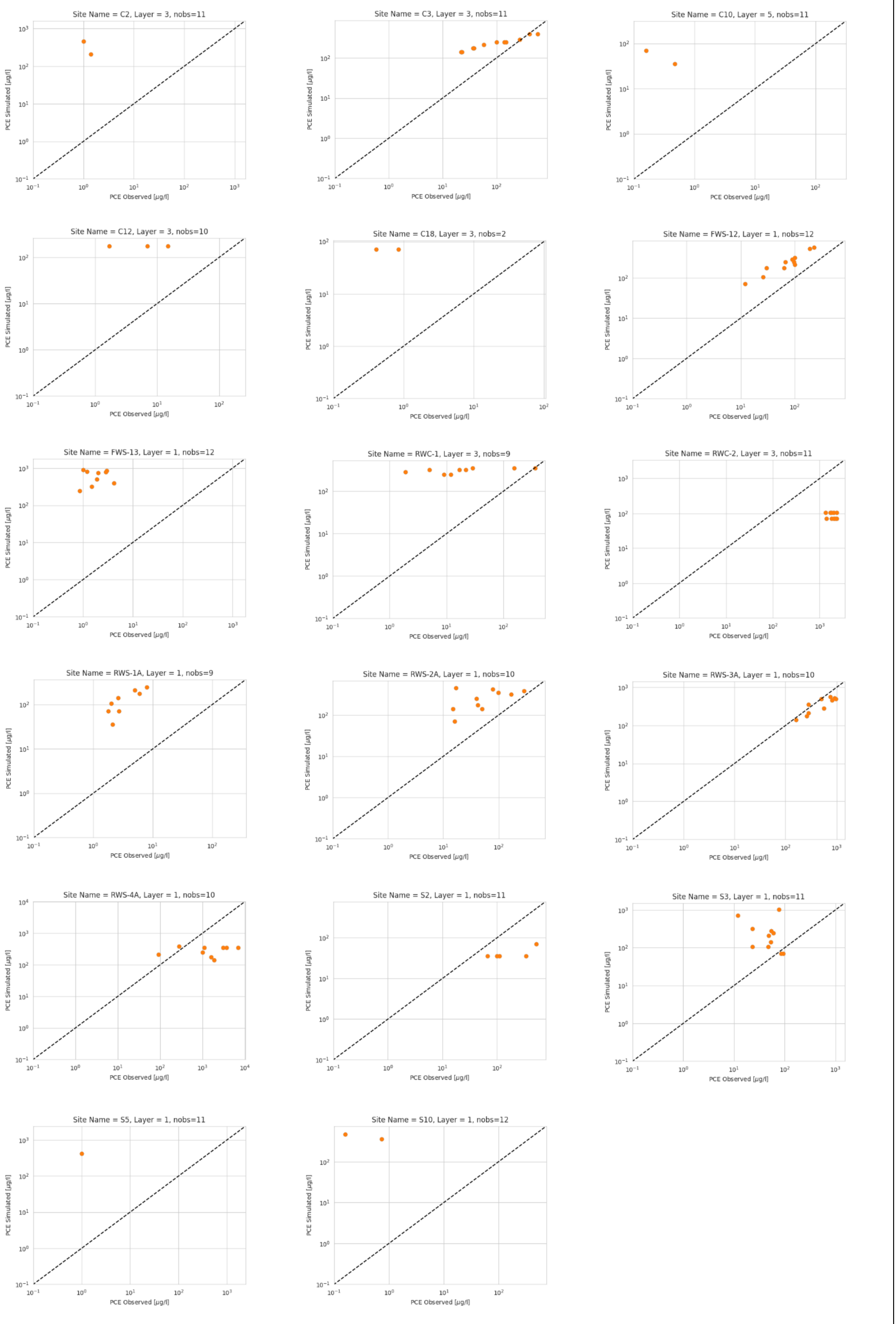

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Figure 7.
Simulated vs. Observed PCE Concentrations for Monitoring Well Locations
Tarawa Terrace Flow and Transport Model Post-Audit

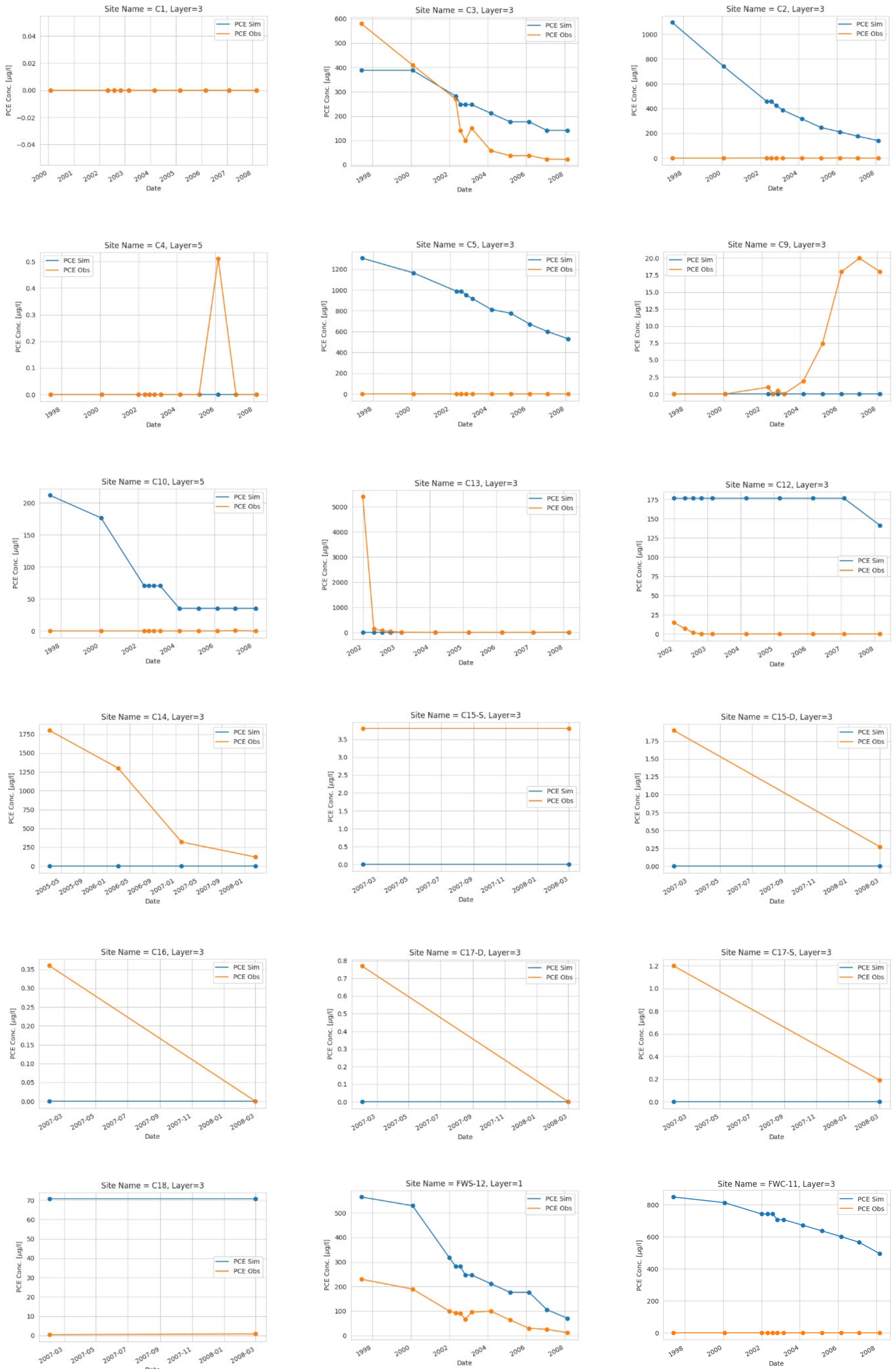

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Figure 8a.
Time Series Plots of Simulated and Observed PCE Concentrations at Monitoring Well Locations
Tarawa Terrace Flow and Transport Model Post-Audit

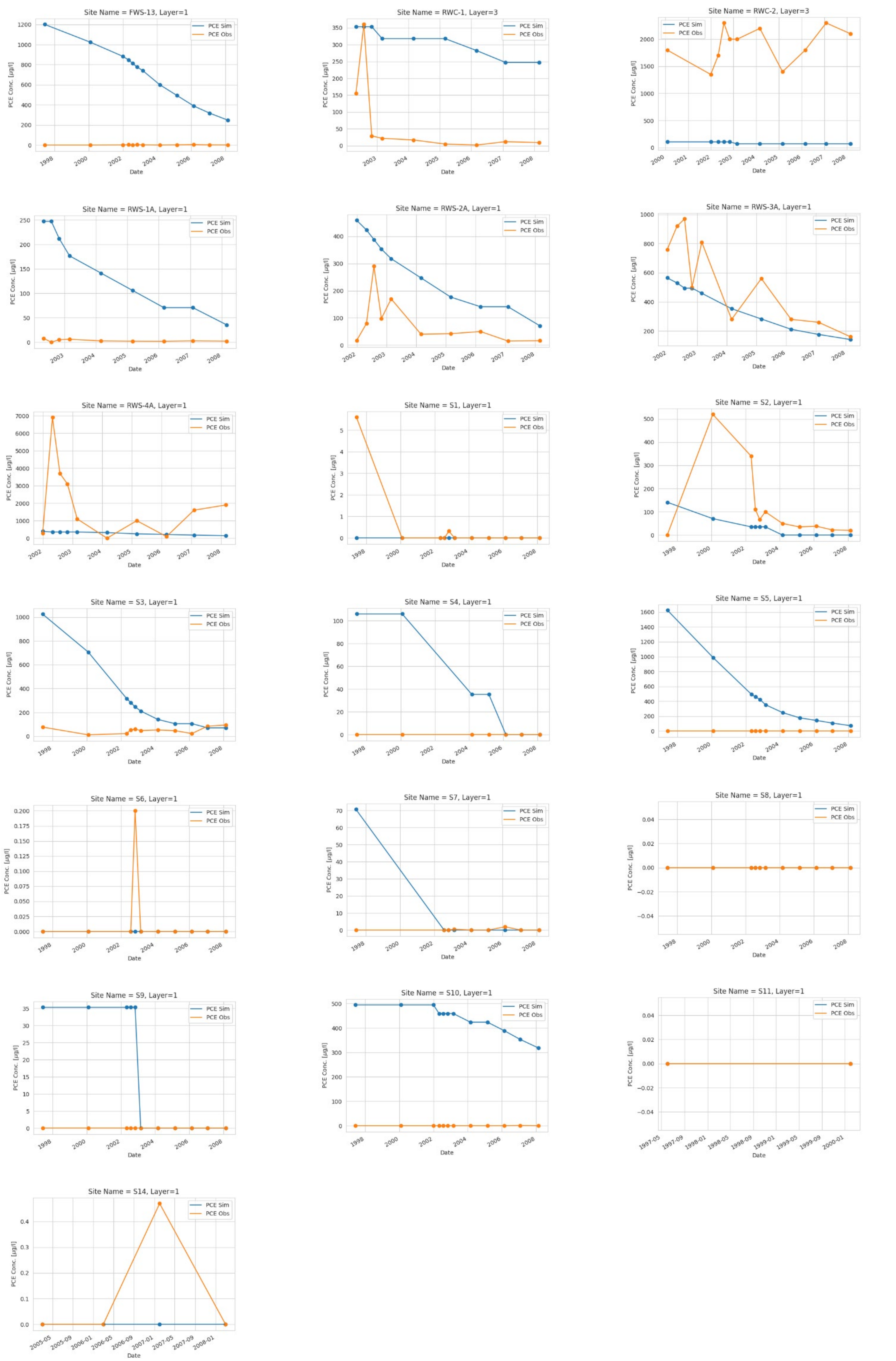

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Figure 8b.
Time Series Plots of Simulated and Observed PCE Concentrations at Monitoring Well Locations
Tarawa Terrace Flow and Transport Model Post-Audit

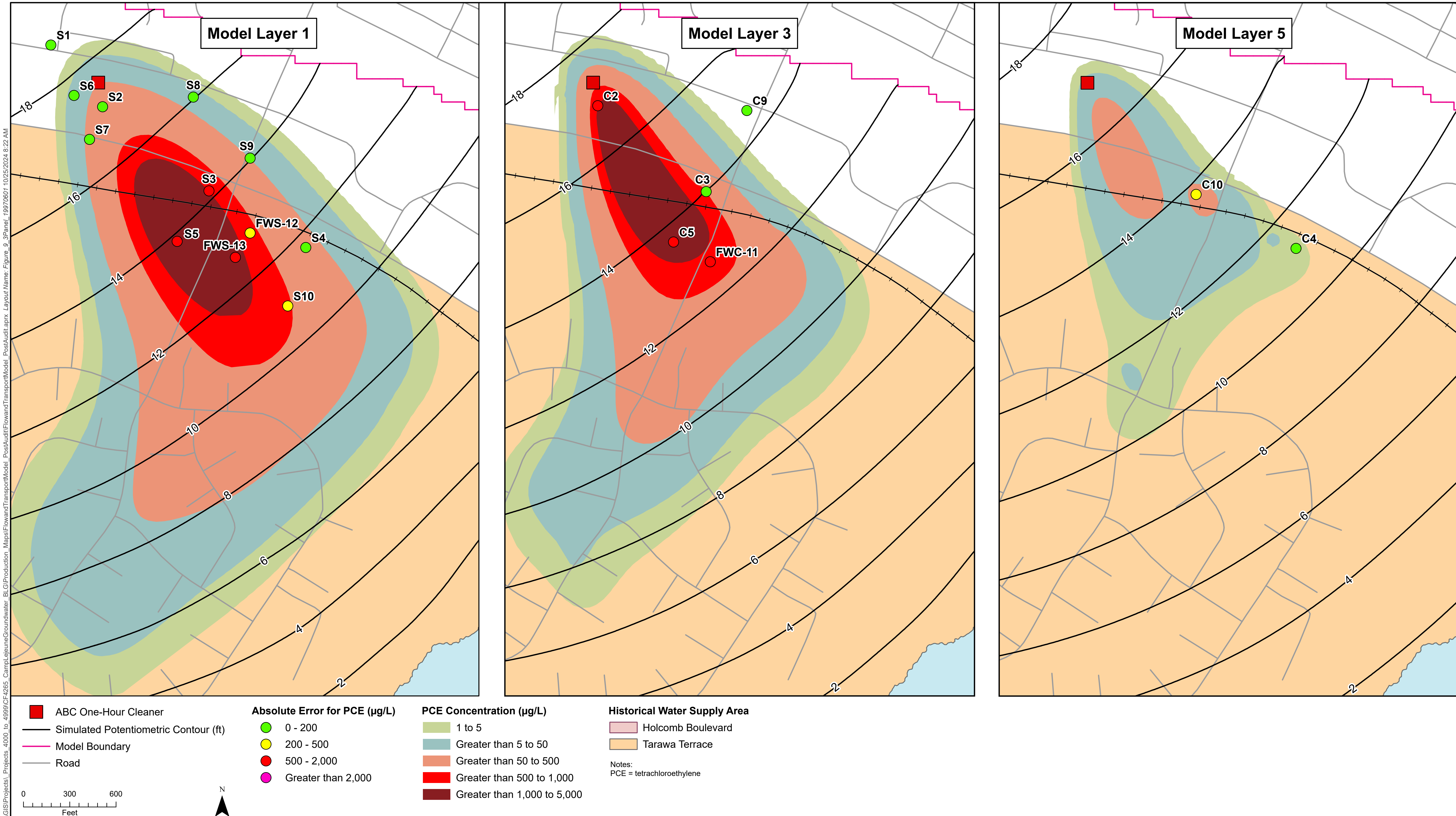

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Figure 9.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, June 1997
Tarawa Terrace Flow and Transport Model Post-Audit

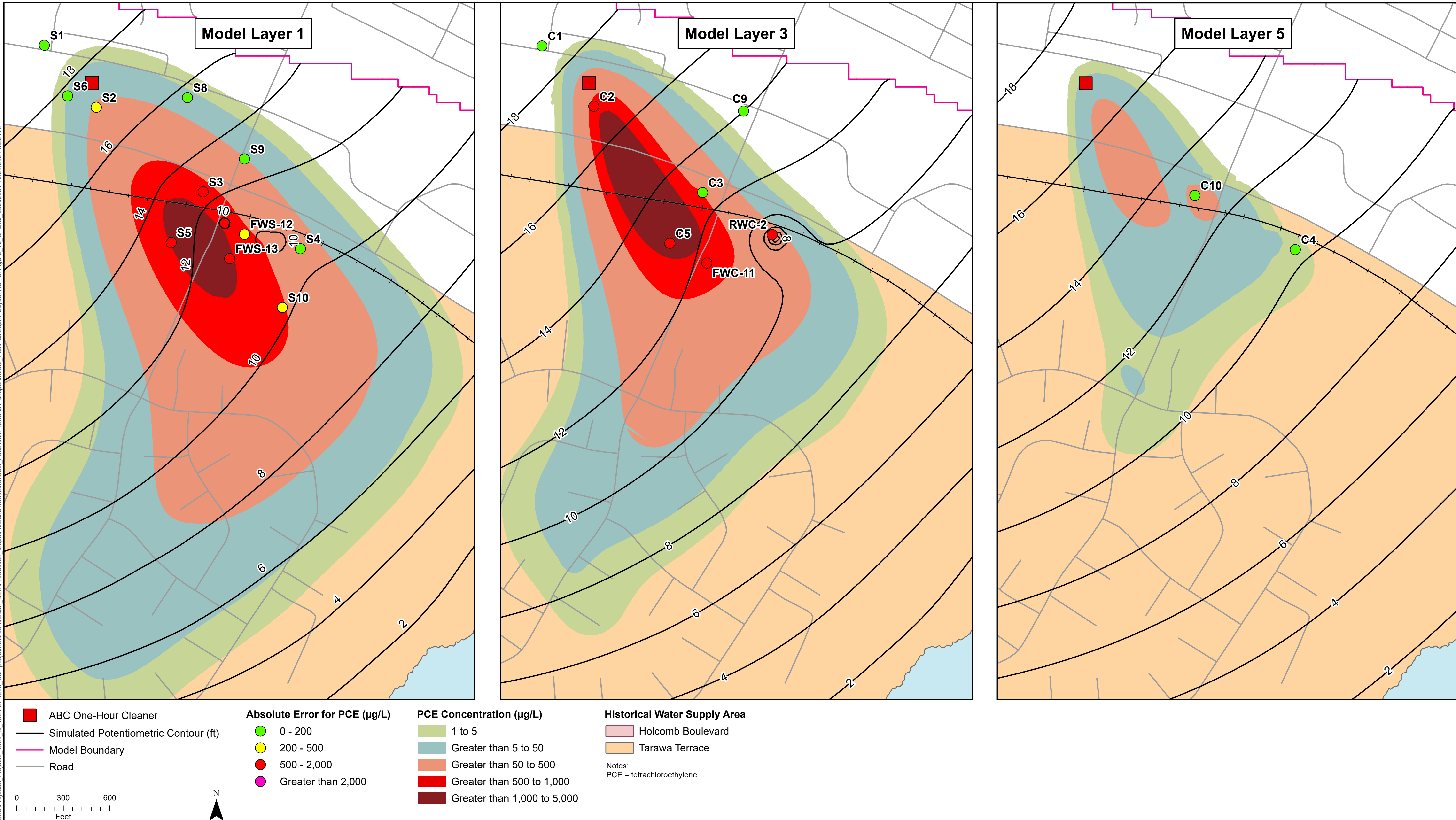

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Figure 10.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, February 2000
Tarawa Terrace Flow and Transport Model Post-Audit

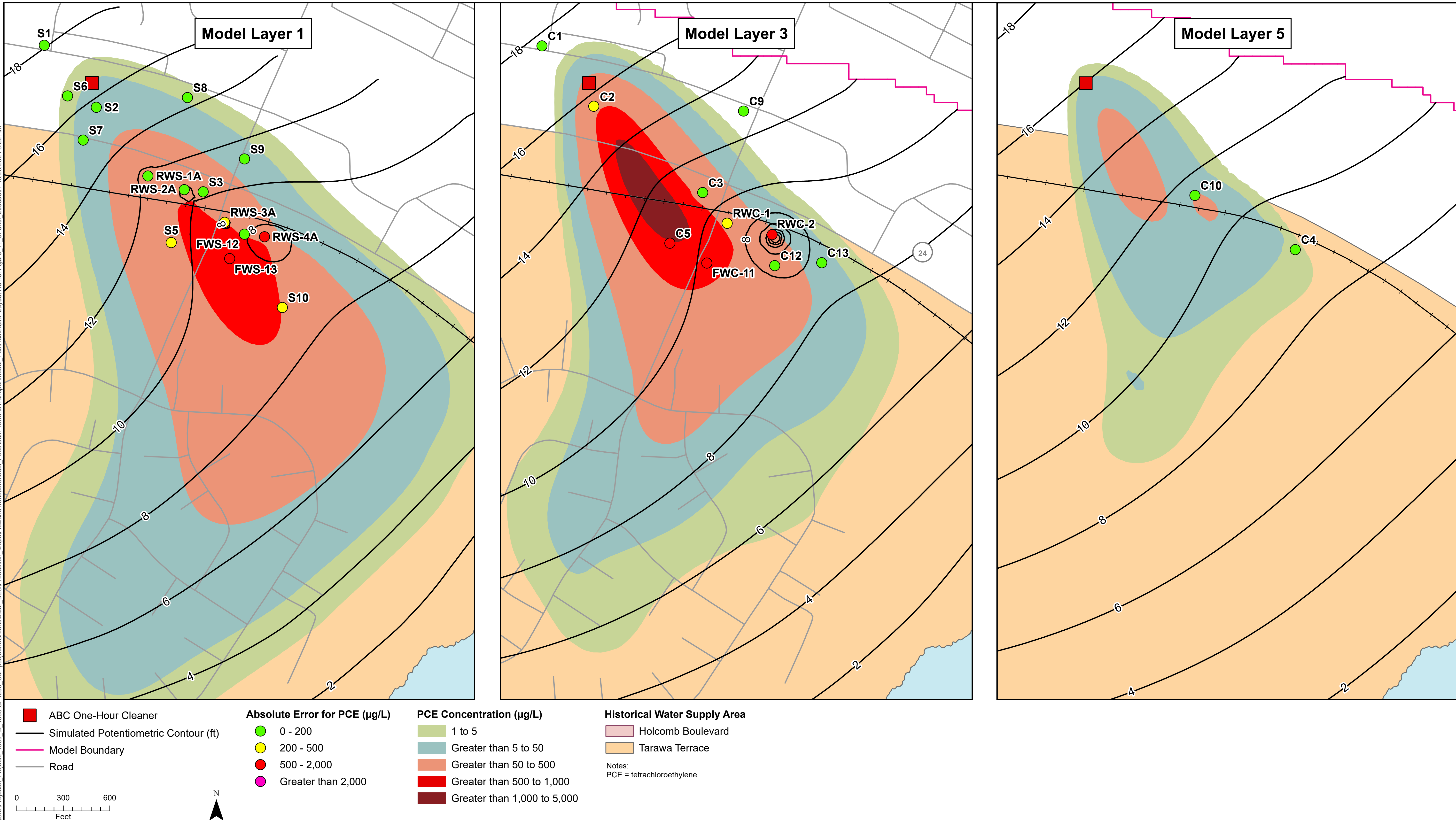

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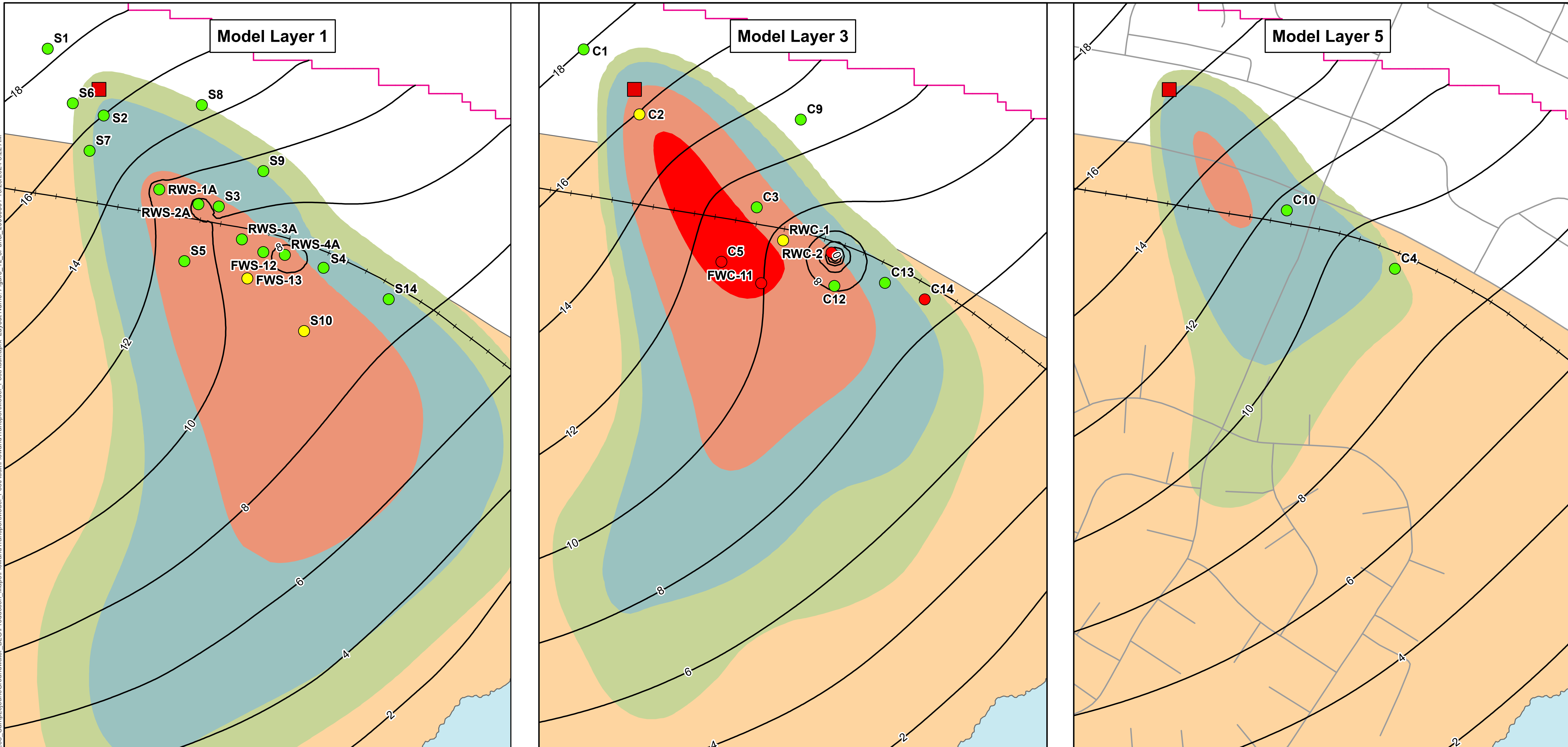
Figure 11.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2003
Tarawa Terrace Flow and Transport Model Post-Audit



ABC One-Hour Cleaner
Simulated Potentiometric Contour (ft)
Model Boundary
Road

0 300 600
Feet

N

Absolute Error for PCE (µg/L)
- 0 - 200
- 200 - 500
- 500 - 2,000
- Greater than 2,000

PCE Concentration (µg/L)
- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,000
- Greater than 1,000 to 5,000

Historical Water Supply Area
- Holcomb Boulevard
- Tarawa Terrace

Notes:
PCE = tetrachloroethylene

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Figure 12.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2006
Tarawa Terrace Flow and Transport Model Post-Audit

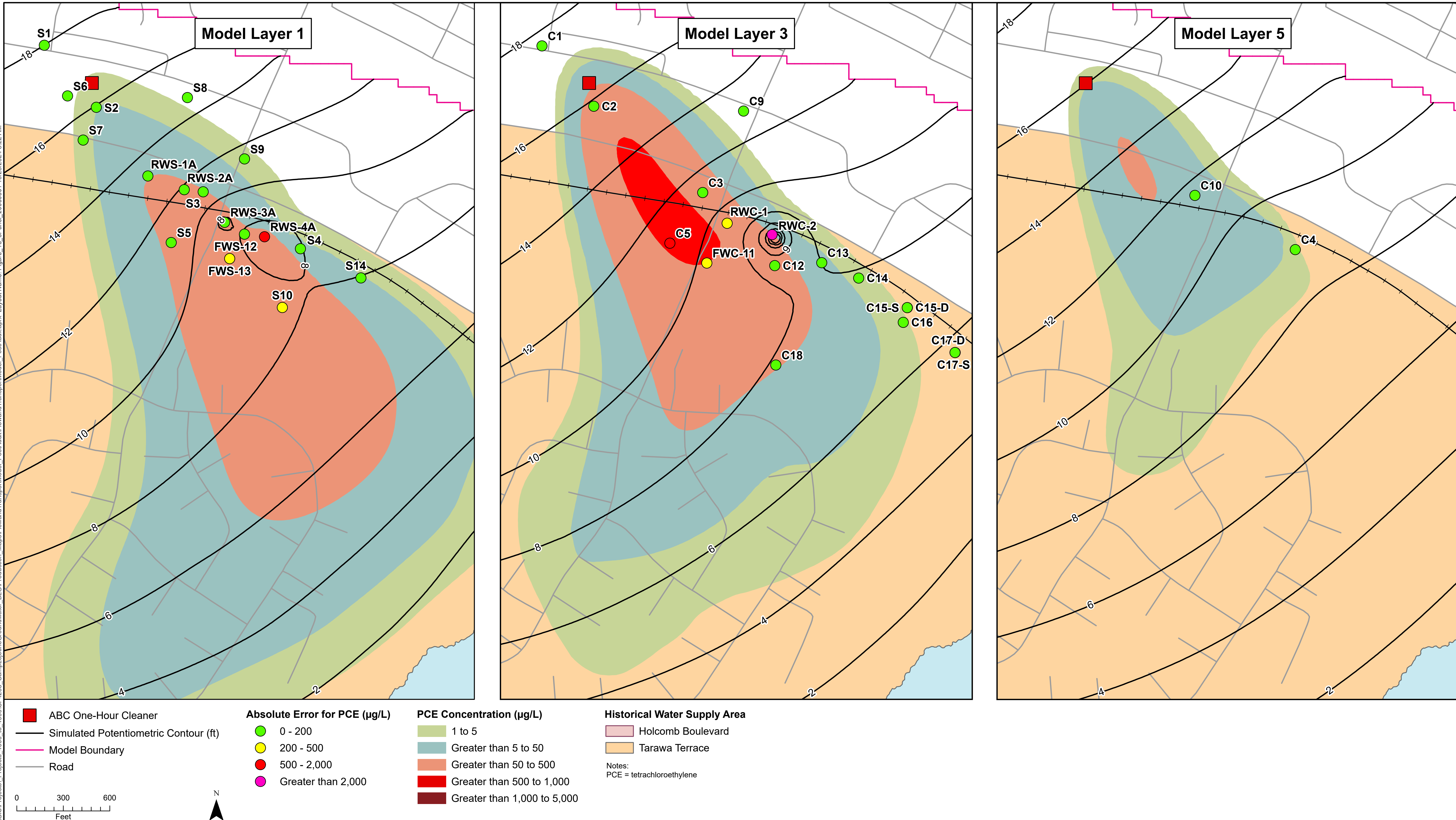

Figure 13.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2008
Tarawa Terrace Flow and Transport Model Post-Audit

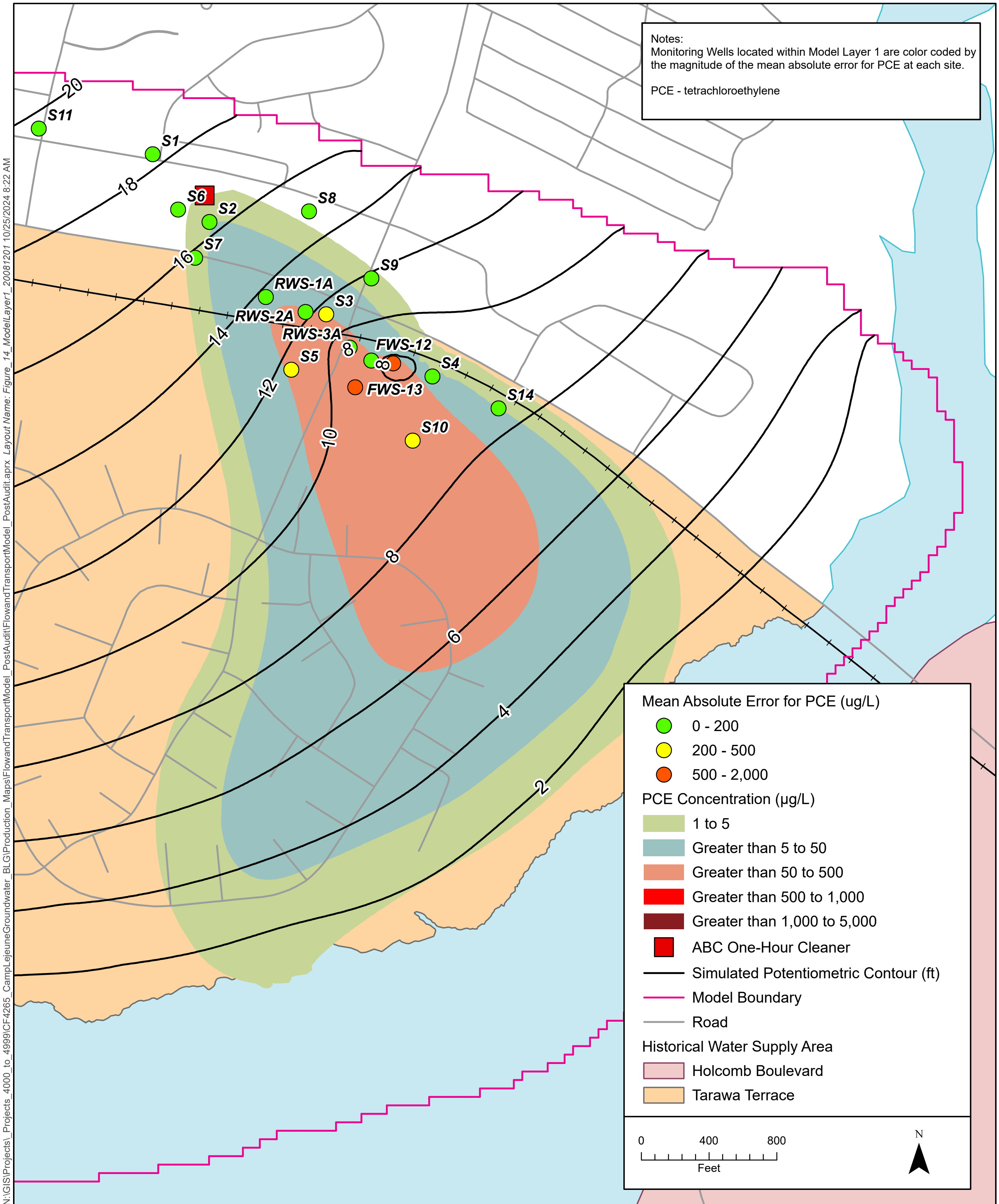

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Figure 14.
Simulated PCE Plume for December 2008 for Model Layer 1
Tarawa Terrace Flow and Transport Model Post-Audit

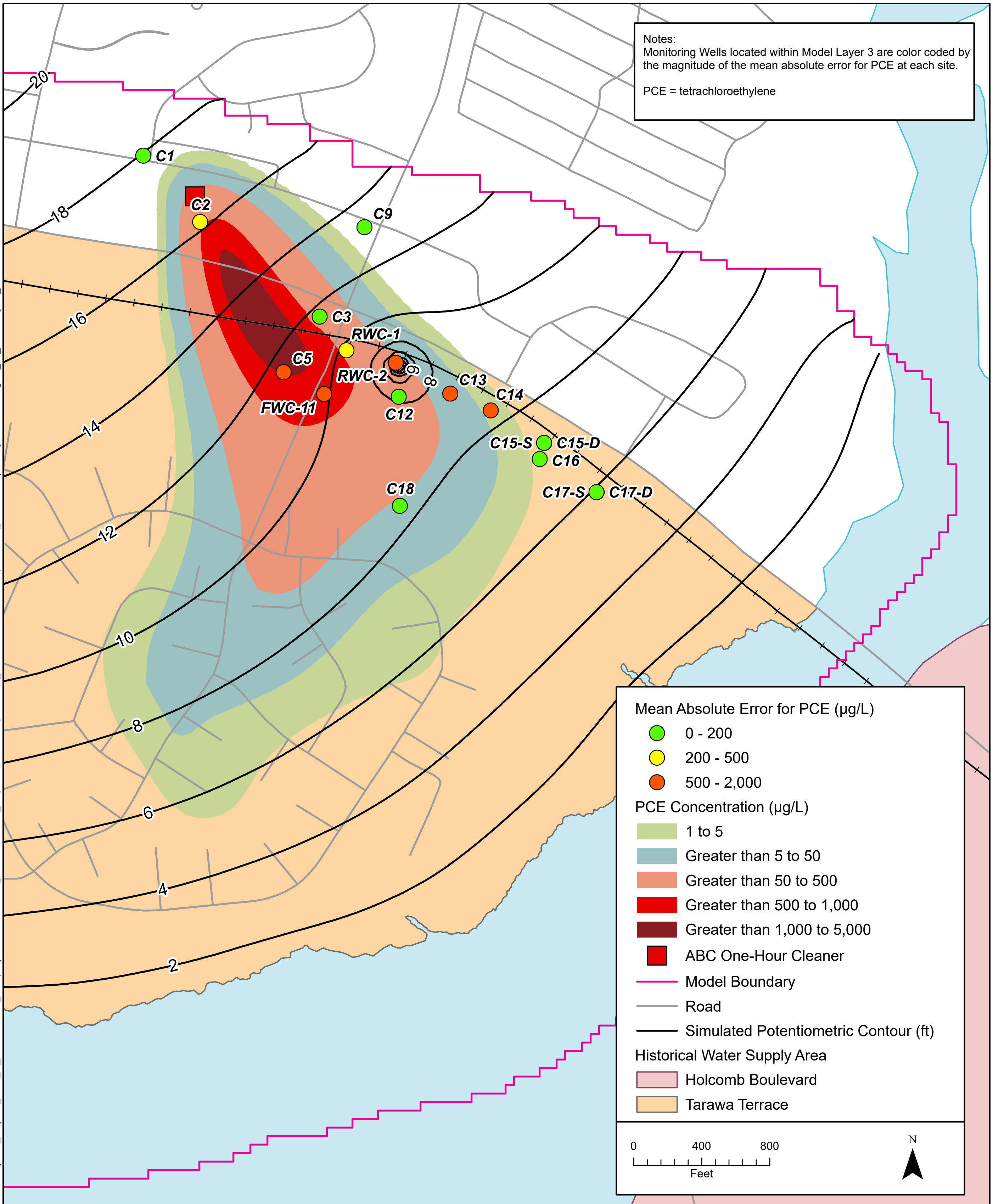

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Figure 15.
Simulated PCE Plume for December 2008 for Model Layer 3
Tarawa Terrace Flow and Transport Model Post-Audit

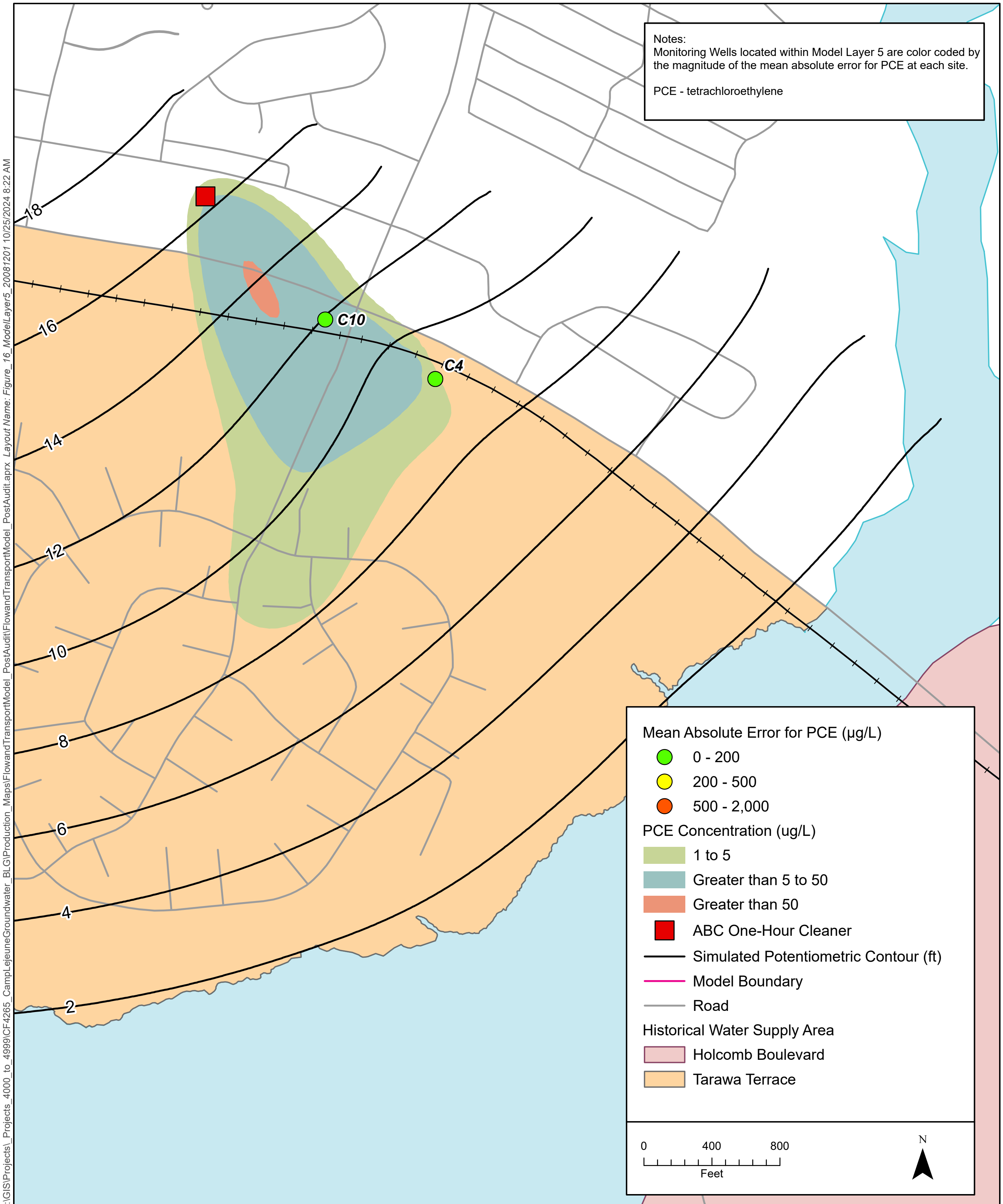

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Figure 16.
Simulated PCE Plume for December 2008 for Model Layer 5
Tarawa Terrace Flow and Transport Model Post-Audit

Tables

Table 1. Annual Rainfall and Effective Recharge Rates

	Rainfall (in./yr)				Effective Recharge	
Year	Wilmington Airport	Wilmington 7N	New River MCAF	Average Rainfall	(in./yr)	(ft/day)
1995	65.1	64.4	48.6	59.3	13.94	0.00318
1996	64.4	52.7	75	64	15.04	0.00343
1997	49.6	51	53.6	51.4	12.07	0.00276
1998	64.2	77.2	70.1	70.5	16.55	0.00378
1999	72.1	82.1	63.2	72.5	17.02	0.00389
2000	53.8	59.2	50.4	54.5	12.79	0.00292
2001	38	57.4	43.5	46.3	10.87	0.00248
2002	49.3	56.9	49.4	51.9	12.18	0.00278
2003	63.6	72.8	50.5	62.3	14.64	0.00334
2004	50.7	71.7	51.7	58.1	13.63	0.00311
2005	69.3	68.4	59.2	65.6	15.41	0.00352
2006	63.8	62.7	62.5	63	14.8	0.00338
2007	33.4	37.3	60.4	43.7	10.26	0.00234
2008	60.8	48.4	56.4	55.2	12.96	0.00296
2009	59.7	59.4	53.6	57.6	13.53	0.00309

Notes:

Data publicly available at: https://www.weather.gov/wrh/Climate?wfo=ilm

Annual rainfall data were available for three locations proximal to the Tarawa Terrace: Wilmington Airport, Wilmington 7N, and New River MCAF.

Table 2. Pumping Rates for Remediation Wells Operating 1995 to 2008

Well	Northing	Easting	Model Layer	Pumping Rate (gpm)							
				11/1/1999	11/6/2001	3/7/2004	12/16/2004	3/31/2005	3/6/2006	2/20/2007	3/11/2008
RWS-1A	364445.7	2491125	1	5.5	18	20.8	12.1	20	20	0	0
RWS-2A	364351.5	2491359	1	3.8	18	3.5	2.34	28	24	0	0
RWS-3A	364146.8	2491620	1	29.2	24	18	1.07	15	30	30	30
RWS-4A	364053.7	2491878	1	13.3	24	24	22.5	28	25	30	25
RWC-2	364067.5	2491842	3	28.2	40	40	32.1	40	42	40	40

Notes:

Northing and easting values are given in NAD 1983 HARN North Carolina State Plane FIPS 3200 (US Feet)

gpm = gallons per minute

Table 3. Monitoring Wells Included in Extended Simulation

Monitoring Well	Northing	Easting	Model Layer	Well Completion Date	Borehole Depth (ft)	Finished Well Depth (ft)	Well Type
C1	365285.0	2490460.1	3	4/4/1992	104	100	Monitoring Well
C2	364895.7	2490794.3	3	4/8/1992	87	84.5	Monitoring Well
C3	364338.9	2491496.9	3	4/9/1992	90.5	89.4	Monitoring Well
C4	363971.9	2492116.1	5	4/3/1992	200	130	Monitoring Well
C5	364012.1	2491285.3	3	4/7/1992	92.5	90.5	Monitoring Well
C9	364864.6	2491760.5	3	9/10/1993	76.5	76	Monitoring Well
C10	364321.6	2491468.6	5	9/28/1993	80	0	Monitoring Well
C12	363867.4	2491961.7	3	11/6/2001	84	70	Monitoring Well
C13	363886.1	2492264.8	3	11/6/2001	83	76	Monitoring Well
C14	363787.1	2492503.0	3	5/12/2005	87	84.9	Monitoring Well
C15-D	363596.3	2492817.1	3	2/9/2007	110	110	Monitoring Well
C15-S	363596.3	2492816.1	3	2/9/2007	110	89	Monitoring Well
C16	363501.3	2492790.7	3	2/13/2007	95	94	Monitoring Well
C17-D	363306.6	2493125.4	3	2/13/2007	117	95	Monitoring Well
C17-S	363306.6	2493124.4	3	2/13/2007	117	85	Monitoring Well
C18	363226.0	2491968.6	3	2/15/2007	87	84	Monitoring Well
FWC-11	363884.0	2491523.5	3	--	89	88.6	--
FWS-12	364070.4	2491748.5	1	--	40	39.6	Monitoring Well
FWS-13	363912.7	2491653.1	1	--	38.5	38.2	Monitoring Well
RWC-1	364140.6	2491654.6	3	1/3-4/1998	91.5	--	Recovery Well
RWC-2	364067.5	2491944.6	3	1/5-6/1998	90	--	Recovery Well
RWS-1A	364445.7	2491125.4	1	--	55.5	55.5	Recovery Well
RWS-2A	364357.4	2491359.9	1	--	56	48.5	Recovery Well
RWS-3A	364146.8	2491620.4	1	--	60	55	Recovery Well
RWS-4A	364053.7	2491877.8	1	--	58.2	53	Recovery Well
S1	365289.2	2490457.3	1	3/22/1992	28	25.5	Monitor Well
S2	364889.0	2490792.7	1	3/26/1992	39.7	39.7	Monitor Well
S3	364343.6	2491482.1	1	4/2/1992	39.5	39.5	Monitor Well
S4	363976.4	2492109.4	1	4/3/1992	34	34	Monitor Well
S5	364016.2	2491275.9	1	4/1/1992	28	28	Monitor Well
S6	364962.4	2490607.3	1	3/26/1992	40.5	40.5	Monitor Well
S7	364677.4	2490707.9	1	4/5/1992	30.3	30.3	Monitor Well
S8	364951.7	2491380.5	1	4/4/1992	28	28	Monitor Well
S9	364555.9	2491748.8	1	3/21/1992	40	28.3	Monitor Well
S10	363597.3	2491992.8	1	3/20/1992	40	35	Monitor Well
S11	365440.7	2489784.3	1	9/11/1993	31	--	Monitor Well
S14	363788.1	2492499.8	1	5/10/2005	87	29	Monitor Well

Notes:

Northing and easting values are given in NAD 1983 HARN North Carolina State Plane FIPS 3200 (US Feet).

-- = information not available

[a] Estimated value

Table 4. Observed PCE Concentrations at Monitoring Wells, 1995 to 2008

Monitoring Well	Model Layer	PCE Concentration (µg/L)											
		6/1/1997	2/1/2000	1/1/2002	5/1/2002	8/1/2002	11/1/2002	3/1/2003	3/1/2004	3/1/2005	3/1/2006	2/1/2007	3/1/2008
C1	3	--	<DL	--	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
C2	3	<DL	<DL	--	1	<DL	<DL	<DL	<DL	<DL	1.4	<DL	<DL
C3	3	580	410	--	270	140	100	150	58	37	38	23	22
C4	5	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	0.51	<DL	<DL
C5	3	<DL	<DL	--	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
C9	3	<DL	<DL	--	1	<DL	0.48	<DL	1.9	7.4	18	20	18
C10	5	<DL	<DL	--	<DL	<DL	0.16	<DL	<DL	<DL	<DL	0.48	<DL
C12	3	--	--	15	7	1.7	<DL	<DL	<DL	<DL	<DL	<DL	<DL
C13	3	--	--	5,400	140	68	44	6	3	2.8	2.5	2.7	7.8
C14	3	--	--	--	--	--	--	--	--	1,800	1,300	320	120
C15-D	3	--	--	--	--	--	--	--	--	--	--	1.9	0.27
C15-S	3	--	--	--	--	--	--	--	--	--	--	3.8	3.8
C16	3	--	--	--	--	--	--	--	--	--	--	0.36	<DL
C17-D	3	--	--	--	--	--	--	--	--	--	--	0.77	<DL
C17-S	3	--	--	--	--	--	--	--	--	--	--	1.2	0.19
C18	3	--	--	--	--	--	--	--	--	--	--	0.41	0.84
FWC-11	3	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
FWS-12	1	230	190	100	92	90	67	96	100	64	30	26	12
FWS-13	1	<DL	<DL	1	3	1.2	2.9	2	<DL	1.9	4.2	1.5	0.86
RWC-1	3	--	--	--	155	360	29	22	17	5	1.9	12	9.1
RWC-2	3	--	1,800	1,350	1,700	2,300	2,000	2,000	2,200	1,400	1,800	2,300	2,100
RWS-1A	1	--	--		8	<DL	5	6	2.6	2	1.8	2.7	2.1
RWS-2A	1	--	--	17	79	290	98	170	40	42	50	15	16
RWS-3A	1	--	--	760	920	970	500	810	280	560	280	260	160
RWS-4A	1	--	--	280	6,900	3,700	3,100	1,100	<DL	1,000	92	1,600	1,900
S1	1	5.6	<DL	--	<DL	<DL	0.32	<DL	<DL	<DL	<DL	<DL	<DL
S2	1	0	520	--	340	110	67	100	50	35	38	22	20
S3	1	77	12	--	23	54	60	48	53	47	23	85	94
S4	1	<DL	<DL	--	--	--	--	--	<DL	<DL	<DL	<DL	<DL
S5	1	<DL	<DL	--	<DL	<DL	1	<DL	<DL	<DL	<DL	<DL	<DL
S6	1	<DL	<DL	--	--	<DL	0.2	<DL	<DL	<DL	<DL	<DL	<DL
S7	1	<DL	--	--	--	<DL	<DL	0.5	<DL	<DL	1.9	<DL	<DL
S8	1	<DL	<DL	--	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
S9	1	<DL	<DL	--	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL

Table 4. Observed PCE Concentrations at Monitoring Wells, 1995 to 2008

Monitoring Well	Model Layer	PCE Concentration (µg/L)											
		6/1/1997	2/1/2000	1/1/2002	5/1/2002	8/1/2002	11/1/2002	3/1/2003	3/1/2004	3/1/2005	3/1/2006	2/1/2007	3/1/2008
S10	1	<DL	<DL	<DL	<DL	<DL	0.16	<DL	<DL	<DL	<DL	0.74	<DL
S11	1	<DL	<DL	--	--	--	--	--	--	--	--	--	--
S14	1	--	--	--	--	--	--	--	--	<DL	<DL	0.47	<DL

Notes:

-- = no sample collected

<DL = sample result reported below the detection limit

PCE = tetrachloroethene

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (μg/L)	PCE Simulated Concentration (μg/L)	Error	Abs(Error)
2/1/2000	C1	<DL	<DL	0	0
5/1/2002		<DL	<DL	0	0
8/1/2002		<DL	<DL	0	0
11/1/2002		<DL	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0
6/1/1997	C2	<DL	1095	1095	1095
2/1/2000		<DL	742	742	742
5/1/2002		1	459	458	458
8/1/2002		<DL	459	459	459
11/1/2002		<DL	424	424	424
3/1/2003		<DL	388	388	388
3/1/2004		<DL	318	318	318
3/1/2005		<DL	247	247	247
3/1/2006		1.4	212	210	210
2/1/2007		<DL	177	177	177
3/1/2008		<DL	141	141	141
6/1/1997	C3	580	388	-192	192
2/1/2000		410	388	-22	22
5/1/2002		270	283	13	13
8/1/2002		140	247	107	107
11/1/2002		100	247	147	147
3/1/2003		150	247	97	97
3/1/2004		58	212	154	154
3/1/2005		37	177	140	140
3/1/2006		38	177	139	139
2/1/2007		23	141	118	118
3/1/2008		22	141	119	119
6/1/1997	C4	<DL	<DL	0	0
2/1/2000		<DL	<DL	0	0
1/1/2002		<DL	<DL	0	0
5/1/2002		<DL	<DL	0	0
8/1/2002		<DL	<DL	0	0
11/1/2002		<DL	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		0.51	<DL	-1	1
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
6/1/1997	C5	<DL	1307	1307	1307
2/1/2000		<DL	1165	1165	1165
5/1/2002		<DL	989	989	989
8/1/2002		<DL	989	989	989
11/1/2002		<DL	953	953	953
3/1/2003		<DL	918	918	918
3/1/2004		<DL	812	812	812
3/1/2005		<DL	777	777	777
3/1/2006		<DL	671	671	671
2/1/2007		<DL	600	600	600
3/1/2008		<DL	530	530	530
6/1/1997	C9	<DL	<DL	0	0
2/1/2000		<DL	<DL	0	0
5/1/2002		1	<DL	-1	1
8/1/2002		<DL	<DL	0	0
11/1/2002		0.48	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		1.9	<DL	-2	2
3/1/2005		7.4	<DL	-7	7
3/1/2006		18	<DL	-18	18
2/1/2007		20	<DL	-20	20
3/1/2008		18	<DL	-18	18
6/1/1997	C10	<DL	212	212	212
2/1/2000		<DL	177	177	177
5/1/2002		<DL	71	71	71
8/1/2002		<DL	71	71	71
11/1/2002		0.16	71	70	70
3/1/2003		<DL	71	71	71
3/1/2004		<DL	35	35	35
3/1/2005		<DL	35	35	35
3/1/2006		<DL	35	35	35
2/1/2007		0.48	35	35	35
3/1/2008		<DL	35	35	35
1/1/2002	C12	15	177	162	162
5/1/2002		7	177	170	170
8/1/2002		1.7	177	175	175
11/1/2002		<DL	177	177	177
3/1/2003		<DL	177	177	177
3/1/2004		<DL	177	177	177
3/1/2005		<DL	177	177	177
3/1/2006		<DL	177	177	177
2/1/2007		<DL	177	177	177
3/1/2008		<DL	141	141	141

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
1/1/2002	C13	5400	<DL	-5400	5400
5/1/2002		140	<DL	-140	140
8/1/2002		68	<DL	-68	68
11/1/2002		44	<DL	-44	44
3/1/2003		6	<DL	-6	6
3/1/2004		3	<DL	-3	3
3/1/2005		2.8	<DL	-3	3
3/1/2006		2.5	<DL	-3	3
2/1/2007		2.7	<DL	-3	3
3/1/2008		7.8	<DL	-8	8
3/1/2005	C14	1800	<DL	-1800	1800
3/1/2006		1300	<DL	-1300	1300
2/1/2007		320	<DL	-320	320
3/1/2008		120	<DL	-120	120
2/1/2007	C15-D	1.9	<DL	-2	2
3/1/2008		0.27	<DL	0	0
2/1/2007	C15-S	3.8	<DL	-4	4
3/1/2008		3.8	<DL	-4	4
2/1/2007	C16	0.36	<DL	0	0
3/1/2008		<DL	<DL	0	0
2/1/2007	C17-D	0.77	<DL	-1	1
3/1/2008		<DL	<DL	0	0
2/1/2007	C17-S	1.2	<DL	-1	1
3/1/2008		0.19	<DL	0	0
2/1/2007	C18	0.41	71	70	70
3/1/2008		0.84	71	70	70
6/1/1997	FWC-11	<DL	848	848	848
2/1/2000		<DL	812	812	812
1/1/2002		<DL	742	742	742
5/1/2002		<DL	742	742	742
8/1/2002		<DL	742	742	742
11/1/2002		<DL	706	706	706
3/1/2003		<DL	706	706	706
3/1/2004		<DL	671	671	671
3/1/2005		<DL	636	636	636
3/1/2006		<DL	600	600	600
2/1/2007		<DL	565	565	565
3/1/2008		<DL	494	494	494

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
6/1/1997	FWS-12	230	565	335	335
2/1/2000		190	530	340	340
1/1/2002		100	318	218	218
5/1/2002		92	283	191	191
8/1/2002		90	283	193	193
11/1/2002		67	247	180	180
3/1/2003		96	247	151	151
3/1/2004		100	212	112	112
3/1/2005		64	177	113	113
3/1/2006		30	177	147	147
2/1/2007		26	106	80	80
3/1/2008		12	71	59	59
6/1/1997	FWS-13	<DL	1201	1201	1201
2/1/2000		<DL	1024	1024	1024
1/1/2002		1	883	882	882
5/1/2002		3	848	845	845
8/1/2002		1.2	812	811	811
11/1/2002		2.9	777	774	774
3/1/2003		2	742	740	740
3/1/2004		<DL	600	600	600
3/1/2005		1.9	494	493	493
3/1/2006		4.2	388	384	384
2/1/2007		1.5	318	316	316
3/1/2008		0.86	247	246	246
5/1/2002	RWC-1	155	353	198	198
8/1/2002		360	353	-7	7
11/1/2002		29	353	324	324
3/1/2003		22	318	296	296
3/1/2004		17	318	301	301
3/1/2005		5	318	313	313
3/1/2006		1.9	283	281	281
2/1/2007		12	247	235	235
3/1/2008		9.1	247	238	238
2/1/2000	RWC-2	1800	106	-1694	1694
1/1/2002		1350	106	-1244	1244
5/1/2002		1700	106	-1594	1594
8/1/2002		2300	106	-2194	2194
11/1/2002		2000	106	-1894	1894
3/1/2003		2000	71	-1929	1929
3/1/2004		2200	71	-2129	2129
3/1/2005		1400	71	-1329	1329
3/1/2006		1800	71	-1729	1729
2/1/2007		2300	71	-2229	2229
3/1/2008		2100	71	-2029	2029

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
5/1/2002	RWS-1A	8	247	239	239
8/1/2002		<DL	247	247	247
11/1/2002		5	212	207	207
3/1/2003		6	177	171	171
3/1/2004		2.6	141	139	139
3/1/2005		2	106	104	104
3/1/2006		1.8	71	69	69
2/1/2007		2.7	71	68	68
3/1/2008		2.1	35	33	33
5/1/2002	RWS-2A	79	424	345	345
1/1/2002		17	459	442	442
8/1/2002		290	388	98	98
11/1/2002		98	353	255	255
3/1/2003		170	318	148	148
3/1/2004		40	247	207	207
3/1/2005		42	177	135	135
3/1/2006		50	141	91	91
2/1/2007		15	141	126	126
3/1/2008		16	71	55	55
1/1/2002	RWS-3A	760	565	-195	195
5/1/2002		920	530	-390	390
8/1/2002		970	494	-476	476
11/1/2002		500	494	-6	6
3/1/2003		810	459	-351	351
3/1/2004		280	353	73	73
3/1/2005		560	283	-277	277
3/1/2006		280	212	-68	68
2/1/2007		260	177	-83	83
3/1/2008		160	141	-19	19
1/1/2002	RWS-4A	280	388	108	108
5/1/2002		6900	353	-6547	6547
8/1/2002		3700	353	-3347	3347
11/1/2002		3100	353	-2747	2747
3/1/2003		1100	353	-747	747
3/1/2004		<DL	318	318	318
3/1/2005		1000	247	-753	753
3/1/2006		92	212	120	120
2/1/2007		1600	177	-1423	1423
3/1/2008		1900	141	-1759	1759

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
6/1/1997	S1	5.6	<DL	-6	6
2/1/2000		<DL	<DL	0	0
5/1/2002		<DL	<DL	0	0
8/1/2002		<DL	<DL	0	0
11/1/2002		0.32	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0
6/1/1997	S2	<DL	141	141	141
2/1/2000		520	71	-449	449
5/1/2002		340	35	-305	305
8/1/2002		110	35	-75	75
11/1/2002		67	35	-32	32
3/1/2003		100	35	-65	65
3/1/2004		50	<DL	-50	50
3/1/2005		35	<DL	-35	35
3/1/2006		38	<DL	-38	38
2/1/2007		22	<DL	-22	22
3/1/2008		20	<DL	-20	20
6/1/1997	S3	77	1024	947	947
2/1/2000		12	706	694	694
5/1/2002		23	318	295	295
8/1/2002		54	283	229	229
11/1/2002		60	247	187	187
3/1/2003		48	212	164	164
3/1/2004		53	141	88	88
3/1/2005		47	106	59	59
3/1/2006		23	106	83	83
2/1/2007		85	71	-14	14
3/1/2008		94	71	-23	23
6/1/1997	S4	<DL	106	106	106
2/1/2000		<DL	106	106	106
3/1/2004		<DL	35	35	35
3/1/2005		<DL	35	35	35
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
6/1/1997	S5	<DL	1624	1624	1624
2/1/2000		<DL	989	989	989
5/1/2002		<DL	494	494	494
8/1/2002		<DL	459	459	459
11/1/2002		1	424	423	423
3/1/2003		<DL	353	353	353
3/1/2004		<DL	247	247	247
3/1/2005		<DL	177	177	177
3/1/2006		<DL	141	141	141
2/1/2007		<DL	106	106	106
3/1/2008		<DL	71	71	71
6/1/1997	S6	<DL	<DL	0	0
2/1/2000		<DL	<DL	0	0
8/1/2002		<DL	<DL	0	0
11/1/2002		0.2	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0
6/1/1997	S7	<DL	71	71	71
8/1/2002		<DL	<DL	0	0
11/1/2002		<DL	<DL	0	0
3/1/2003		0.5	<DL	-1	1
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		1.9	<DL	-2	2
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0
6/1/1997	S8	<DL	<DL	0	0
2/1/2000		<DL	<DL	0	0
5/1/2002		<DL	<DL	0	0
8/1/2002		<DL	<DL	0	0
11/1/2002		<DL	<DL	0	0
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0

Table 5. Observed and Simulated PCE Concentrations at Monitoring Well Locations

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Abs(Error)
6/1/1997	S9	<DL	35	35	35
2/1/2000		<DL	35	35	35
5/1/2002		<DL	35	35	35
8/1/2002		<DL	35	35	35
11/1/2002		<DL	35	35	35
3/1/2003		<DL	<DL	0	0
3/1/2004		<DL	<DL	0	0
3/1/2005		<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		<DL	<DL	0	0
3/1/2008		<DL	<DL	0	0
6/1/1997	S10	<DL	494	494	494
2/1/2000		<DL	494	494	494
1/1/2002		<DL	494	494	494
5/1/2002		<DL	459	459	459
8/1/2002		<DL	459	459	459
11/1/2002		0.16	459	459	459
3/1/2003		<DL	459	459	459
3/1/2004		<DL	424	424	424
3/1/2005		<DL	424	424	424
3/1/2006		<DL	388	388	388
2/1/2007		0.74	353	352	352
3/1/2008		<DL	318	318	318
6/1/1997	S11	<DL	<DL	0	0
2/1/2000		<DL	<DL	0	0
3/1/2005	S14	<DL	<DL	0	0
3/1/2006		<DL	<DL	0	0
2/1/2007		0.47	<DL	0	0
3/1/2008		<DL	<DL	0	0

Notes:

<DL = sample result reported below the detection limit
PCE = tetrachloroethene

Table 6. Mean Error and Mean Absolute Error for Monitoring Wells

Monitoring Well	Model Layer	Mean Error	Mean Absolute Error	Mean Absolute Error Category
C1	3	0	0	0-200
C2	3	423.6	423.6	200-500
C3	3	74.6	113.3	0-200
C4	5	0	0	0-200
C5	3	882.9	882.9	500-2,000
C9	3	-6.1	6.1	0-200
C10	5	77	77	0-200
C12	3	170.7	170.7	0-200
C13	3	-567.7	567.7	500-2,000
C14	3	-885	885	500-2,000
C15-D	3	-1.1	1.1	0-200
C15-S	3	-3.8	3.8	0-200
C16	3	-0.2	0.2	0-200
C17-D	3	-0.4	0.4	0-200
C17-S	3	-0.7	0.7	0-200
C18	3	70	70	0-200
FWC-11	3	688.6	688.6	500-2,000
FWS-12	1	176.4	176.4	0-200
FWS-13	1	693	693	500-2,000
RWC-1	3	242.1	243.6	200-500
RWC-2	3	-1817.9	1817.9	500-2,000
RWS-1A	1	141.8	141.8	0-200
RWS-2A	1	190.2	190.2	0-200
RWS-3A	1	-179.2	193.8	0-200
RWS-4A	1	-1677.6	1786.9	500-2,000
S1	1	-0.5	0.5	0-200
S2	1	-86.3	111.9	0-200
S3	1	246.2	253.1	200-500
S4	1	40.4	40.4	0-200
S5	1	462.2	462.2	200-500
S6	1	0	0	0-200
S7	1	7.6	8.1	0-200
S8	1	0	0	0-200
S9	1	16.1	16.1	0-200
S10	1	435.5	435.5	200-500
S11	1	0	0	0-200
S14	1	-0.1	0.1	0-200

Notes:

Northing and easting values are given in NAD 1983 HARN North Carolina State Plane FIPS 3200 (US Feet).

Exhibit 1

Resume for R. Jeffrey Davis

R. Jeffrey Davis, P.E., CGWP

Principal, Water Resources

(385) 955-5184

Salt Lake City, UT

jdavis@integral-corp.com

Mr. Jeff Davis is a licensed civil and environmental engineer, hydrogeologist, and certified groundwater professional with almost 30 years of global experience working on every continent except Antarctica. He currently serves on the Board of Directors for the National Ground Water Association. Mr. Davis has supported numerous litigation cases involving groundwater impacts and has experience as an expert witness. He has spent much of his career solving complicated water problems involving mining, oil and gas, and water resources. These projects include the clean water supply side as well as the remediation of contaminated sites. The contaminated sites include coal combustion residual (CCR) landfills and other waste impoundments, mining remediation sites, and industrial cleanup sites—both RCRA and CERCLA sites. In working with per- and polyfluoroalkyl substance (PFAS) compounds, MTBE, chlorinated solvents, hydrocarbons, nitrates, and road salt, he has developed and used numerous groundwater models for the mining, energy, chemical, and agricultural industries. Other projects have involved environmental impact statements, environmental assessments, water management, groundwater–surface water contamination, dewatering, and water supply and treatment. He has extensive knowledge of groundwater flow-and-transport principles and has taught numerous workshops and classes in the U.S. and around the world. His current focus is on water and groundwater sustainability and drought resiliency. Mr. Davis has extensive experience in the design and implementation of aquifer storage and recovery (ASR) projects across the country.

Education & Credentials

M.S., Civil & Environmental Engineering, Brigham Young University, Provo, Utah, 1998

B.S., Civil & Environmental Engineering, Brigham Young University, Provo, Utah, 1993

Professional Engineer, Utah (License No. 189690-2202), Texas (License No. 125406), Florida (License No. 74838), Colorado (License No. 0051575), Alabama (License No. PE52096), Idaho (License No. P-21839), Oregon (License No. 104270PE)

Certified Groundwater Professional, NGWA (2023)

Continuing Education

Certificate of Specialization in Leadership and Management, Harvard Business School Online (2023)

MSHA certified (2020)

First Aid and CPR certified (2020)

Professional Affiliations

National Ground Water Association

Utah Groundwater Association

Groundwater Resources Association of California

Relevant Experience

WATER MANAGEMENT

ASR Feasibility, Utah County, Utah — Served as principal investigator for a feasibility study for an ASR project. During the spring runoff of 2023, the team measured the runoff in several rivers, creeks, and ditches, and constructed a new infiltration basin, all in an effort to advance aquifer storage projects within the county.

ASR Feasibility, Utah County, Utah — Served as principal for a feasibility study for an ASR project. Former agricultural water rights were converted for industrial use and the effluent was being considered for aquifer replenishment. Both infiltration and direct injection of the treated water were considered as part of the feasibility study.

Provo ASR, Provo, Utah — Served as the project manager and engineer of record for the current Provo ASR project. Five sites (three infiltration and two direct injection) are currently permitted for pilot studies that have been ongoing since 2020. Final engineering design and permitting have been completed for all five sites.

Water Reuse and Aquifer Sustainability, Eagle Mountain, Utah — Served as the client manager and engineer of record for the current Eagle Mountain City, Utah, water-reuse planning and aquifer sustainability project. Water rights for Eagle Mountain were evaluated along with the groundwater system to understand aquifer sustainability for the city, which is expecting tremendous future growth, including large industrial water demands.

ASR Evaluation, Weber County, Utah — Served as the project manager and engineer of record for the current evaluation of the Weber Basin Water Conservancy District, Utah, ASR project. This project has been actively operating for more than 10 years. Hired to evaluate the storage capacity of the program and obtain greater recovery volumes from the system, working with the Utah Division of Water Rights.

Drainage Reuse Initiative, Harris County, Texas — Served as part of a team for the development of the Drainage Reuse Initiative for Harris County Flood Control District in Harris County, Texas. The project investigated the feasibility of alternative methods of flood mitigation by conveying stormwater to the subsurface, including natural infiltration to groundwater, enhanced infiltration or injection into aquifers, and mechanical injection to deep aquifers.

Roseville ASR, Roseville, California — Served as one of the groundwater leads for the development of an ASR program for the city of Roseville, California. Initial efforts involved developing a regional- scale conceptualization for the major portion of the Central Valley area. Developed a subsequent regional multilayer groundwater model, followed by a number of local-scale transport models to simulate pilot tests and understand the ASR process.

COAL COMBUSTION FACILITIES

Coal Combustion Residual Waste and Disposal, Bonanza, Utah — Served as the engineer of record for a coal power plant. Oversaw all efforts related to the monitoring and compliance of the facility's CCR waste and disposal. This included semiannual reporting, development of alternative source demonstrations, and annual groundwater monitoring reports.

Hexavalent Chromium Investigation, United States — Served as the principal investigator for a study to understand and evaluate the proposed EPA changes to hexavalent chromium (Cr(VI)) as it would apply to the monitoring and management of CCR landfill facilities. The work included examining potential regulatory levels from a human health perspective.

Alternate Water Sources Investigation, United States — Served as the principal investigator for a study to understand and evaluate differences at CCR facilities between upgradient and downgradient sources, and locate potential evidence of alternate sources using isotopes and microbial fingerprinting. After development of a sampling and analysis plan, advanced statistical and multivariate methods were used to document analyses that show potential for distinguishing source water from alternate sources.

OIL AND GAS WASTE MANAGEMENT

Oil and Gas Waste Facility, De Beque, Colorado — Served as the principal engineer for the permitting and operating of an 800-acre oil-and-gas waste-disposal facility southeast of De Beque, Colorado. Involved in several aspects of the permitting process, including the hydrogeological study and groundwater investigations; stormwater design; pond liner design and construction; closure certification; and submittal of the revised engineering design and operation plan.

Remedial Investigation, Billings, Montana — Served as the groundwater lead for the Yale Oil of South Dakota Facility in Billings, Montana. The Superfund site facility is in the remedial investigation phase; the risk-assessment work plan has been submitted to the Montana Department of Environmental Quality, and the client is waiting for comments before proceeding with the risk assessment.

EPA Study, Washington, DC — Served as participant and technical reviewer for EPA's "Study of Hydraulic Fracturing for Oil and Gas and Its Potential Impact on Drinking Water Resources." Participated in technical roundtables and technical workshops and completed a peer review of the EPA's five retrospective case studies.

Fate and Transport Modeling, Texas — Served as groundwater lead for fate-and-transport modeling and analysis of chloride contamination in southern Texas near the Gulf of Mexico. As part of the site mitigation phase, modeling was used to determine the potential migration of the chloride through the shallow aquifer system and nearby receptors.

Lockwood Solvent Groundwater Plume Site, Billings, Montana — Served as one of the groundwater leads performing groundwater modeling for the Lockwood Solvent Groundwater Plume site, an EPA Superfund site in Billings, Montana. The site spans 580 acres, and much of the groundwater there is contaminated with volatile organic compounds, including tetrachloroethene, trichloroethene, cis-1,2- dichloroethene, and vinyl chloride.

PLANNING AND PERMITTING

Beverage Can Manufacturing and Filling, Salt Lake City, Utah — Served as principal investigator for wastewater, stormwater, and Utah Pollutant Discharge Elimination System permitting, monitoring, and compliance for an aluminum can manufacturing and filling facility. Worked closely with the client, its operations team, and state and municipal regulators to regularly monitor and report all discharges from the facility.

Ely Energy Center EIS, White Pine County, Nevada — Served as principal lead for the development of a regional groundwater model for Steptoe Valley in White Pine County, Nevada. The investigation and model were part of the EIS for construction of the Ely Energy Center.

Haile Gold Mine EIS, Kershaw, South Carolina — Served as groundwater lead as the third-party contractor developing an EIS for the proposed Haile Gold Mine near Kershaw, South Carolina. The EIS analyzed the potential direct, indirect, and cumulative environmental effects of the proposed project and its alternatives. Work included project-team coordination for geology, groundwater, and surface water resources areas; review of applicant-supplied information; agency coordination; and public involvement.

Four Corners Power Plant EIS, Farmington, New Mexico — Served as groundwater lead as the third- party contractor in developing an EIS for the Four Corners Power Plant and Navajo coal mine in Farmington, New Mexico. The EIS analyzed the potential direct, indirect, and cumulative environmental effects of the proposed project and its alternatives. The groundwater portion included analyzing field investigations, pump tests, conceptual and numerical modeling of the project and surrounding area, and remediation and reclamation activities.

Iron Ore Operations Cumulative Impact Assessment, Pilbara, Western Australia — Served as one of the groundwater leads for a cumulative impact assessment for a proposed expansion of iron ore operations in the Pilbara in Western Australia. Work included identifying the methodology and developing the conceptual models to perform the assessment. The groundwater modeling included both quantitative and qualitative approaches.

LITIGATION SUPPORT

Expert Witness for PFAS Litigation, Martin County, Florida — Served as the groundwater expert witness for a litigation case in Martin County. The multidistrict litigation bellwether case involved PFAS contamination of groundwater affecting public drinking water. Opinions were given regarding PFAS sourcing, and fate and transport in groundwater, and regarding public water supply planning.

Water Resources Litigation, Grand County, Colorado — Served as principal investigator for a litigation case involving flooding damages caused by a canal breach. Surface water modeling was used to determine amount and extent of erosion and sedimentation from the flooding.

Water Resources Litigation, Northwest Minnesota — Served as principal investigator and expert witness for a litigation case involving agricultural water rights and pumping near tribal lands. Developed a conceptual model to understand the hydrogeological conditions and constructed a groundwater model to determine possible impacts due to the agriculture activities.

Groundwater Litigation, Ventura County, California — Served as the groundwater expert for a litigation case in Ventura County. The case includes the development of a basin-wide groundwater- surface water model, not only for purposes of litigation but also for compliance with Sustainable Groundwater Management Act requirements. The groundwater basin in question is currently listed as a priority basin by the State of California.

Pipeline Spill Litigation, Williston, North Dakota — Provided litigation services for groundwater and surface water contamination from a pipeline spill in North Dakota. A large spill of produced water (brine) impacted surface streams as well as the shallow aquifer system. Work included groundwater modeling, field investigations, and remedial strategies.

Road Salt Contamination Litigation, Vandalia, Ohio — Performed fate-and-transport modeling and analysis of sodium chloride contamination of an aquifer in Vandalia, Ohio. Stored road salt caused limited contamination of a shallow aquifer that supplied drinking water to nearby residential homes. The groundwater model included the local domestic pumping wells, which helped determine the possible extent of chloride impacts. Largely due to the conceptual site model and transport modeling results, litigation was settled out of court to the satisfaction of the client.

GROUNDWATER MODELING

Subsidence Monitoring/Modeling, Fort Bend and Harris Counties, Texas — Served as the groundwater lead and engineer on several groundwater development projects in Fort Bend and Harris counties. Groundwater withdrawals are strictly curtailed due to historical subsidence. The Subsidence Districts have installed GPS Port-A-Measure (PAM) units and used InSAR mapping. Using this data plus the output from the models PRESS and MODFLOW-SUB to measure subsidence impacts.

Groundwater Model Development, New Jersey — Led a team of hydrogeologists to construct a groundwater flow and fate and transport model of perfluorononanoic acid and other contaminants. The model will be used to design a pump and treat system and possible aquifer replenishment with the treated groundwater.

Hydrogeological Services, Montgomery County, Texas — Provided modeling and hydrogeological consulting services for the Lone Star Ground-water Conservation District's (Montgomery County, Texas) update of its desired future conditions and groundwater management plans. Also provided litigation services for the district.

Groundwater Model Development, Havana, Florida — Provided consulting services for Northwest Florida Water Management District as it updated its regional groundwater model—an integrated groundwater-surface water model that provides regulatory control of the groundwater withdrawals and manages saltwater intrusion in the Floridan aquifer due to pumping.

Crop Production Services, Various Locations, U.S. — Served as the groundwater lead to provide modeling and hydrogeological consulting services for a number of crop production services legacy sites. The groundwater at the sites was contaminated with nitrates from long-term fertilizer use. Groundwater modeling was used to determine the fate and transport of the nitrates and to develop a remedial strategy for cleanup.

Legacy Way Tunnel Design, Brisbane, Australia — Provided senior oversight and technical review for all hydrogeologic assessments related to the Legacy Way tunnel design project, a 4.6 km underground tunnel in northern Brisbane, Australia. Work included evaluating field tests, preparing geotechnical and environmental reports, and modeling the entire project area.

Mercury Fate and Transport, Cincinnati, Ohio — Served as the groundwater lead for performing fate and-transport modeling and analysis of a mercury spill at a municipal landfill in Cincinnati, Ohio. As part of the project management phase, modeling was used to determine the potential migration of mercury through the landfill to the leachate collection system. Modeling efforts examined both the spatial distribution and the temporal component of the mercury transport.

Due Diligence Environmental Review, Pascagoula, Mississippi — Served as the environmental lead for performing an environmental assessment at a chemical plant in Pascagoula, Mississippi, as part of a due diligence effort. A number of groundwater and surface water contamination issues due to spills, leaks, and storage of hazardous materials were addressed. The location of the plant on the Gulf of Mexico makes possible environmental impacts from operation of the chemical plant a sensitive issue.

MINING

Bingham Canyon Mine Closure Planning, Copperton, Utah — Completed an independent third-party audit for a closure-plan pit-lake study for Bingham Canyon Mine. Reviewed the consultant scope of work for the pit-lake study and discussed the study, methodology, and pathway to completion with consultant staff. An independent audit report was compiled and submitted to the client.

Hooker Prairie Mine, Bartow, Florida — Served as the model expert to develop a contaminant and water budget and management model for the Hookers Prairie Mine in Florida using the GoldSim modeling software. The purpose of the model was to evaluate the probabilities of the mine meeting its current and future nutrient NPDES loading limits for certain contaminants. The project also included an evaluation of current monitoring data within the mine operations and at discharge locations, and the development of a complete monitoring plan integrated into a GIS as part of the model calibration and validation.

Bridger Coal Mine Investigation, Rock Springs, Wyoming — Served on a technical team to reevaluate groundwater conditions, and treatment and discharge alternatives at the Bridger coal mine in southwest Wyoming. Previous studies' predicted maximum flows into the mine had been exceeded. Reassessed the situation and provided solutions.

EMERGENCY RESPONSE

Emergency Response to Battery Fire, Confidential Location — Served as the principal in charge leading a team of multidisciplinary scientists, engineers, toxicologists, and risk assessors for an environmental emergency response at a large-scale battery power storage unit at a solar farm. A thermal incident where several cargo container boxes caught fire and burned required immediate action to assess the environmental and human health impacts.

ECOLOGICAL RESTORATION

Ecological Restoration, Northeast Idaho — Serves as the principal in charge leading a team of scientists, engineers, and ecologists for an ecological restoration effort in northeast Idaho. The project has involved restoring flow to a creek and working with a number of state and federal agencies to develop and implement a conceptual restoration plan and a mitigation and monitoring plan. The project will also include obtaining the necessary permits and overseeing the restoration in an area of critical habitat.

PROJECT MANAGEMENT

GMS Software Development, Utah — Served as chief engineer for the original development of the software Groundwater Modeling System (GMS) at the Environmental Modeling Research Laboratory at Brigham Young University. A sophisticated graphical environment for groundwater model pre- and post-processing, 3-dimensional site characterization, and geostatistics, GMS is the official groundwater application of the U.S. Department of Defense and is also used by the U.S. Department of Energy, EPA, and thousands of users across the world.

NATURAL RESOURCE DAMAGE ASSESSMENT

Natural Resources Damage Assessment, Southeastern Idaho — Served as the groundwater expert determining groundwater damages in southeastern Idaho due to decades of phosphate mining. Led a team of hydrogeologists evaluating the impacts of selenium and other contaminants and changes in natural groundwater flows across the entire region. The damage assessment included a number of mining areas as well as the facilities where the phosphate material was processed.

Presentations / Posters

Davis, R.J. 2023. Challenges limiting managed aquifer recharge (MAR) adoption in the West. National Ground Water Association Groundwater Summit. December 5–7. Las Vegas, NV.

Davis, R.J. 2023. Water, AI, and us: What does the future hold for solving Utah's water challenges. Hint: It can't be solved without you and me. Salt Lake County Watershed Symposium. November 15–16. Salt Lake City, UT.

Davis, R.J. 2023. Building climate resilience through sustainable remediation in the western region. Groundwater Resources Association of California Western Groundwater Congress. September 12–14. Burbank, CA.

Davis, R.J. 2023. Water in Utah: Navigating the present and shaping the future. American Groundwater Trust. August 14–15. Provo, Utah.

Davis, R.J. 2023. More managed aquifer recharge and saving the Great Salt Lake—A balancing act. Idaho Water Users Association. June 12–13. Sun Valley, ID.

Davis, R.J. 2023. More managed aquifer recharge: Deliberate resiliency to combat droughts and climate change in the West. Association for Environmental Health of Soils. March 20–23. San Diego, CA.

Davis, R.J. 2023. Resilient and sustainable remediation. ESG|Climate Resilient & Sustainable Remediation Symposium. Groundwater Resources Association of California Western Groundwater Congress. February 6–7. San Diego, CA.

Davis, R.J. 2022. More managed aquifer recharge: Solutions to combat droughts and climate change in the West. National Ground Water Association Groundwater Summit. December 6–8. Las Vegas, NV.

Davis, R.J. 2022. Saving our aquifers: Climate change and managed aquifer recharge. Salt Lake County Watershed Symposium. November 16–17. Salt Lake City, UT.

Davis, R.J. 2022. More managed aquifer recharge—A solution to combat droughts and climate change in the West. Groundwater Resources Association of California Western Groundwater Congress. September 21–23. Sacramento, CA.

Davis, R.J. 2022. Saving our aquifers—Climate change, sustainability, and managed aquifer recharge. International Water Holdings. August 24–25. Salt Lake City, UT.

Davis, R.J. 2022. More managed aquifer recharge (MMAR) a solution to combat droughts and climate change in the West. Groundwater Protection Council Annual Forum. June 21–23. Salt Lake City, UT.

Davis, R.J. 2022. Aquifer storage and recovery—Hydrogeologic considerations. American Water Resources Association. May 17. Salt Lake City, UT.

Davis, R.J. 2022. Utah hydrology—What you do and don't know about Utah hydrogeology. National Ground Water Association. May 4, 2022. Virtual.

Davis, R.J. and B. Lemon. 2022. Provo, Utah: From planning to pilot to a final aquifer storage and recovery (ASR) program. Utah Water Users Workshop. March 21–23. St. George, UT.

Davis, R.J. 2021. Provo, Utah, from planning to pilot to a final managed aquifer recharge (MAR) program. National Ground Water Association Groundwater Summit. December 7–8. Virtual.

Davis, R.J. 2021. Provo City aquifer storage and recovery project. Ground Water Protection Council Annual Forum, September 27–29. Virtual.

Davis, R.J. 2021. Provo, Utah, from planning to pilot to a final managed aquifer recharge (MAR) program. American Public Works Association Utah Section Annual Conference. September 21–22. Sandy, UT.

Davis, R.J. 2021. Provo City aquifer storage and recovery project. Utah Water Users Workshop. May 17–19. St. George, UT.

Davis, R.J. 2021. Provo, Utah: From planning to pilot to a final managed aquifer recharge (MAR) program. ASR for Texas, Virtual Webinar. May 4–5.

Davis, R.J. 2021. Provo aquifer storage and recovery—From planning to pilot. American Water Works Association Virtual Summit on Sustainable Water, PFAS, Waterborne Pathogens. February 10–11.

Davis, R.J. 2020. Update on Provo's aquifer storage and recovery program. American Water Works Association Virtual Intermountain Section Annual Conference. October 21–23. Sun Valley, ID.

Davis, R.J. 2020. Are you prepared for the new federal permit process for CCR facilities? Second Annual Coal Ash and Combustion Residual Management Webinar, October 7–8. Virtual.

Invited Participant, Expert Panels, and Workshops

Bulk Water Innovation Partnership (BWIP): More managed aquifer recharge: Deliberate resiliency to combat droughts and climate change in the West. December 6, 2023. Virtual.

Rocky Mountain Association of Environmental Professionals (RMAEP): Great Salt Lake of Utah: watershed, legislative, and community issues surrounding it. September 20, 2023.

Salt Lake Chamber: Utah Water Outlook. April 13, 2022.

EDCUtah Webinar: Water: Constraints and Opportunities for Development in Utah panel. June 11, 2021.

ULI Utah: Trends Conference—Water: Constraints and Opportunities for Development in Utah panel. October 27, 2021.

Exhibit 2

Resume for Norman L. Jones

Norman L. Jones, Ph.D.

Professor
Department of Civil & Construction Engineering
Brigham Young University

Education

Ph.D. Civil Engineering, University of Texas at Austin, 1990
M.S. Civil Engineering, University of Texas at Austin, 1988
B.S. Civil Engineering, Brigham Young University, 1986

Academic Experience

Department Chair, Civil & Construction Engineering, Brigham Young University (BYU), 2018-2024
Professor, Civil & Construction Engineering, BYU, 2002–present
Associate Professor, Civil & Environmental Engineering, BYU, 1997–2002
Assistant Professor, Civil & Environmental Engineering, BYU, 1991–1996

Current Membership in Professional Organizations

American Society of Civil Engineers (ASCE)
American Water Resources Association (AWRA)
National Ground Water Association (NGWA)
American Geophysical Union (AGU)

Professional Committees

AWRA 2014 GIS in Water Resources Technical Program Chair
NGWA Groundwater Modeling Interest Group Committee
American Society of Civil Engineers
EWRI Groundwater Management Committee
EWRI Emerging Technologies Committee
International Editorial Board for the Journal of HydroInformatics
Editor of AQUAmundi Journal
Great Salt Lake Basin Integrated Plan - Groundwater Technical Advisory Team
Tethys Geoscience Foundation - Board Member

Selected Honors and Awards

2001 Walter L. Huber Civil Engineering Research Prize
2002 College of Engineering & Technology Special Commendation Award
2003 Brigham Young University Technology Transfer Award
2007 Utah Engineering Educator of the Year – ACEC
2012 Brigham Young University Karl G. Maeser Research and Creative Arts Award
2016 AWRA Educator of the Year – Utah Section
2021 NGWA John Hem Award for Science and Engineering
2023 Brigham Young University Sponsored Research Award

University Courses Taught

CE En 101 - Introduction to Civil and Environmental Engineering
CE En 201 - Infrastructure
CE En 270 – Computer Methods in Civil Engineering
CE En 341 – Elementary Soil Mechanics
CE En 540 – Geo-Environmental Engineering
CE EN 544 - Seepage and Slope Stability Analysis
CCE 547 – Ground Water Modeling

CE En 641 – Advanced Soil Mechanics

Software

Led the development of the Groundwater Modeling System (GMS) software. GMS is a state-of-the-art three-dimensional environment for ground water model construction and visualization. It includes tools for site characterization including geostatistics and solid modeling of soil stratigraphy. GMS is the most comprehensive and sophisticated groundwater modeling software available and is used by over 10,000 organizations in over 100 countries. Currently managed and distributed by Aquaveo, LLC, a company I co-founded in 2007.

External Research Grants

1. Automated Mesh Generation For the TABS-2 System, $19,000, 2/90 - 11/90, U.S. Army Engineer Waterways Experiment Station
2. A Geometry Pre-Processor for HEC-1 Employing Triangulated Irregular Networks, $20,048, 3/91 - 10/91, U.S. Army Engineer Waterways Experiment Station
3. Real-Time Visualization for the TABS-2 Modelling System, $14,123, 4/91 - 8/91, U.S. Army Engineer Waterways Experiment Station
4. An Investigation of X-Windows Interface Tools, $49,556, 1/92 - 8/92, U.S. Army Engineer Waterways Experiment Station
5. Descriptive Geometry and Solid Rendering, $24,000, 1/92 - 10/92, U.S. Army Engineer Waterways Experiment Station
6. An Investigation of Automated Pre-processing Schemes for TIN-Based Drainage Analysis, $34,750, 4/92-10/92, U.S. Army Engineer Waterways Experiment Station
7. A Comprehensive Graphical User Environment for Groundwater Flow and Transport Modeling, $246,526, 6/93-9/94, U.S. Army Engineer Waterways Experiment Station
8. An Integrated Surface Flow Modeling System, $131,848, 1/94-1/95, U.S. Army Engineer Waterways Experiment Station
9. Productivity and Management Tools for Groundwater Flow and Transport Modeling, $207,404, 5/94-4/95, U.S. Army Engineer Waterways Experiment Station
10. Enhanced Tools for Quality Control in Automated Groundwater Transport Modeling, $246,553, 1/95-12/95, U.S. Army Engineer Waterways Experiment Station
11. Visualization for Two-Dimensional Surface Runoff Modeling, $98,221, 1/95-10/95, U.S. Army Engineer Waterways Experiment Station
12. Visualization Tools for Two-Dimensional Finite Element Hydrologic Modeling, $93,933, 11/95-10/96, U.S. Army Engineer Waterways Experiment Station
13. A Graphical Environment for Multi-Dimensional Surface Water Modeling, $49,789, 3/96-9/96, U.S. Army Engineer Waterways Experiment Station
14. A Conceptual Modeling Approach to Pre-processing of Groundwater Models, $475,743, 11/95-11/97, U.S. Army Engineer Waterways Experiment Station
15. Hydrosystems Modeling, $2,458,083, 5/97-4/02, U.S. Army Engineer Waterways Experiment Station
16. Second Generation Hydroinformatics Research, $4,958,127. U.S. Army Engineer Research and Development Center.
17. Flux Calculations and 3D Visualization for the SCAPS Piezocone and GeoViz System, $34,931, U.S. Navy.
18. Development of modeling methods and tools for predicting coupled reactive transport processes in porous media under multiple scales. $949,000. US Dept. of Energy. 1/07-12/09.
19. CI-WATER: Cyberinfrastructure to Advance High Performance Water Resource Modeling, $3,435,873. National Science Foundation - EPSCoR. 9/11-8/14.

20. Comprehensive Streamflow Prediction and Visualization to Support Integrated Water Managment, $599,823. NASA SERVIR, 8/16-8/19.
21. Daniel P. Ames, E. James Nelson, Norman L. Jones, An AmeriGEOSS Cloud-based Platform for Rapid Deployment of GEOGLOWS Water and Food Security Decision Support Apps, $540,658, NASA GEO, 1/2018-12/2020
22. Geospatial Information Tools That Use Machine-Learning to Enable Sustainable Groundwater Management in West Africa, $657,232. NASA SERVIR, 11/19-11/22.
23. Advancing the NASA GEOGloWS Toolbox for Regional Water Resources Management and Decision Support. $1.2M. NASA GEOGLOWS. 2022-2025. Dan Ames, Jim Nelson, Gus Williams, Norm Jones.
24. CIROH: National Cyberinfrastructure Framework for Engaging the Hydrologic Community (NCF). $1,822,418. National Oceanographic and Atmospheric Administration. 2022-2025. Dan Ames, Jim Nelson, Gus Williams, Norm Jones.
25. CIROH: Advancing Science to Better Characterize Drought and Groundwater-Driven Low-Flow Conditions in NOAA and USGS National-Scale Models. $801,221. 2023-2025. Norm Jones, Gus Williams, T. Prabhakar Clement, Donna Rizzo.
26. Improved Hydrologic Prediction Services for Resilience with GEOGLOWS, $1,889,627, National Oceanic and Atmospheric Administration (NOAA), 4/1/2024-3/31/2027. Norm Jones, Jim Nelson, Andrew South.

Summary: PI or Co-PI on 26 projects totaling $22,026,639.

Peer-Reviewed Publications in the Past 10 Years

1. Jones, N., Nelson, J., Swain, N., Christensen, S., Tarboton, D. Dash, P. Tethys: A Software Framework for Web-Based Modeling and Decision Support Applications. In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15-19, San Diego, California, USA. ISBN: 978-88-9035-744-2
2. Jones, N., Griffiths, T., Lemon, A., Kudlas, S. Automated Well Permitting in Virginia's Coastal Plain Using SEAWAT and GIS Geoprocessing Tools. In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15-19, San Diego, California, USA. ISBN: 978-88-9035-744-2
3. Y. Fan, S. Richard, R. S. Bristol, S. E. Peters, S. E. Ingebritsen, N. Moosdorf, A. Packman, T. Gleeson, I. Zaslavsky, S. Peckham, L. Murdoch, M. Fienen, M. Cardiff, D. Tarboton, N. Jones, R. Hooper, J. Arrigo, D. Gochis, J. Olson and D. Wolock (2014), DigitalCrust – a 4D data system of material properties for transforming research on crustal fluid flow, *GeoFluids*, Article first published online: 7 OCT 2014 | DOI: 10.1111/gfl.12114.
4. Swain, N.R., K. Latu, S.D. Christensen, N.L. Jones, E.J. Nelson, D.P. Ames, G.P. Williams (2015). "A review of open source software solutions for developing water resources web applications." Environmental Modeling & Software 67: 108-117.
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6. Dolder, H., Jones, N., and Nelson, E. (2015). "Simple Method for Using Precomputed Hydrologic Models in Flood Forecasting with Uniform Rainfall and Soil Moisture Pattern." *J. Hydrol. Eng.,*10.1061/(ASCE)HE.1943-5584.0001232 , 04015039.
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	All	Since 2019
Citations	3287	1507
h-index	27	19
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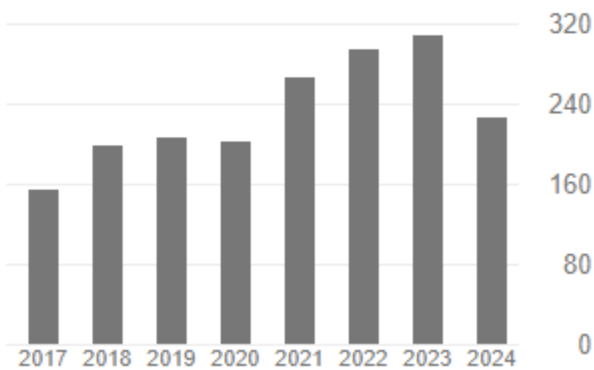

Complete CV: https://www.et.byu.edu/~njones/vita/

EXHIBIT 17

Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit

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January 14, 2025

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ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
PCE	tetrachloroethylene
GMS	Groundwater Modeling System
MAE	mean absolute error
ME	mean error
NGWA	National Groundwater Association

1 SUMMARY OF OPINIONS

The opinions presented in this report are in response to the portion of the Alexandros Spiliotopoulos report related to the post-audit we performed on the Agency for Toxic Substances and Disease Registry (ATSDR) flow and transport models for Tarawa Terrace. Our opinions are as follows:

Opinion 1: The Spiliotopoulos report exaggerated and distorted the model bias in the post-audit results.

Opinion 2: The calibration target of ±0.5 order of magnitude used in the original ATSDR transport study was arbitrary and too narrow to use as a basis for evaluating the post-audit results.

Opinion 3: Spiliotopoulos did not effectively refute our qualitative assessment of the overall plume behavior.

Opinion 4: The numerical roundoff errors found by Spiliotopoulos were minor and did not significantly impact the model results.

Opinion 5: The pumping rate error and the mass loading termination date error found by Spiliotopoulos were both minor and did not significantly impact the model results.

Opinion 6: Nothing in the Spiliotopoulos report contradicts our overall conclusion about the post-audit results. The model effectively simulates long-term trends in contaminant migration, and we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model.

All of the opinions expressed in this rebuttal report are held by both of us. Our opinions are based on our review of the report of Dr. Spiliotopoulos, the ATSDR published reports, the references listed in this report and our Oct. 2024 report, our post-audit, and our experience and expertise in the fields of hydrogeology and groundwater modeling. We hold these opinions to a reasonable degree of scientific and engineering certainty.

2 INTRODUCTION

Our names are Norman L. Jones and R. Jeffrey Davis, and we have been asked to provide a rebuttal to a set of expert reports issued on December 9, 2024, related to the Camp Lejeune Water Litigation. Based on our review of these reports, we have reached the conclusions and opinions set forth below. A list of all materials considered to form the opinions in this rebuttal will be produced within seven days of the report's submittal. Our conclusions are subject to any new materials, data, or other information provided to us prior to depositions or trial, at which time our opinions and conclusions may be updated.

In July 2007, ATSDR, U.S. Department of Health and Human Services, published a report on a groundwater flow and transport model of the Tarawa Terrace region of the Camp Lejeune military base (Maslia et al. 2007; Faye and Valenzuela 2008; Faye 2008). The model was developed to simulate groundwater flow in the aquifers beneath Tarawa Terrace and to simulate the migration of tetrachloroethylene (PCE)[1] in the aquifers resulting from the release of PCE by ABC One-Hour Cleaners, which is directly adjacent to the northern boundary of the Tarawa Terrace property. The original Tarawa Terrace flow model was designed to simulate flow conditions over a period from 1951 to 1994. Output from the model was used to estimate the PCE concentration at the Tarawa Terrace Water Treatment Plant as part of an epidemiological study.

In 2024, we were tasked with performing a post-audit of the Tarawa Terrace flow and transport model.[2] The objective of the post-audit was to extend the range of the groundwater flow and transport model from 1995 to 2008 and compare the output of the transport model with concentrations sampled at monitoring wells in Tarawa Terrace during the 1995–2008 period to assess the performance of the model as an interpretive and predictive tool. This comparison involved both a quantitative analysis of simulated versus observed concentrations and a qualitative analysis of the shape and migration of the simulated PCE plume over that period. On October 25, 2024, we submitted a report of this effort titled *Tarawa Terrace Flow and Transport Model Post-Audit* (Jones and Davis, 2024). After performing the post-audit, we concluded:

> *In summary, this post-audit found that the original Tarawa Terrace groundwater flow and transport models were developed using sound methodology and continue to provide reliable insights into the migration of PCE contamination. Despite the inherent challenges in simulating complex subsurface conditions and dealing with incomplete data, the model effectively simulates long-term trends in contaminant migration. Based on this*

[1] PCE is also known by other names, including tetrachloroethene. In this report we refer to it as PCE.

[2] The Tarawa Terrace groundwater model consists of a MODFLOW model to simulate flow and a coupled MT3DMS model to simulate PCE transport in the aquifer. Depending on context, in this report we will occasionally refer to the coupled MODFLOW/MT3DMS simulations as a singular "model" and in some cases we will refer to the two simulations as "models."

> *post-audit, we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model.*

On December 9, 2024, we were provided with the following three reports by experts hired by the U.S. Department of Justice:

1. Expert Report of **Alexandros Spiliotopoulos**, PhD. In the United States District Court for the Eastern District of North Carolina. No. 7:23-cv-897. In Re: Camp Lejeune Water Litigation. S.S. Papadopulos & Associates, Inc. December 9, 2024.

2. Expert Report of **Remy J.-C. Hennet**. In the United States District Court for the Eastern District of North Carolina. No. 7:23-cv-897. In Re: Camp Lejeune Water Litigation. S.S. Papadopulos & Associates, Inc. December 9, 2024.

3. Expert Report of **Jay L. Brigham**, PhD. In the United States District Court for the Eastern District of North Carolina Southern Division. Case No.: 7:23-CV-897. Camp Lejeune Water Litigation. Morgan, Angel, Brigham and Associates, LLC. December 9, 2024.

Of the three reports, the only one that directly referenced our 2024 post-audit was the Spiliotopoulos report. The objective of this document is to respond to issues raised in relation to our post-audit. Therefore, we will only reference the Spiliotopoulos report in the following sections.

3 RESPONSE TO SPECIFIC ITEMS IN THE ALEXANDROS SPILIOTOPOULOS REPORT

3.1 ASSESSING THE PERFORMANCE OF CONTAMINANT TRANSPORT MODELS

Before responding to specific issues raised in the Spiliotopoulos report, it would be useful to review some basic facts related to evaluating the performance of groundwater models in general, and more specifically to contaminant transport models.

3.1.1 Accuracy, Precision, and Model Fitting

In Section 3 of the Spiliotopoulos report, there is a discussion of general principles of model calibration, sensitivity, and uncertainty analysis. In the context of the discussion, the graphic shown in Figure 1 was presented (referenced as Figure 2 of the Spiliotopoulos report). This graphic was reproduced from a document produced by the National Oceanic and Atmospheric Administration to illustrate the concepts of "precision" and "accuracy" as they relate to natural sciences (NOAA 2024).

While this graphic may apply to some concepts of natural sciences, it presents a grossly unrealistic standard for the modeling of physical phenomena that exhibit a high degree of variance, as is the case with PCE concentrations at a contaminated site. For such cases, the graphics in our Figure 2 represent a more appropriate and realistic depiction of the modeling process. The red dots shown in Figure 2(a) represent a set of observations sampled in the field representing some physical phenomenon. The sample values are on the y-axis and the x-axis represents a variable such as distance or time. The red data points exhibit a high degree of scatter or variance. This could be the result of sampling error or variability, or some kind of local-scale heterogeneity that is a natural byproduct of the phenomenon in question. Despite the variance, the points show a general trend of decreasing y-values as the x-values increase. The blue line in Figure 2(a) represents a simple model that accurately captures the behavior of the phenomenon. The green dashed line in Figure 2(b) represents an alternative model that attempts to model the phenomenon represented by the red dots with a high degree of precision. This is a classic case of what is referred to as "model overfitting." Even though it has less "precision," the blue line in Figure 2(a) is a much more appropriate model. For example, if a second set of samples were obtained over the same x-domain, one would expect to see the same downward trend, but the data points would be different. The blue line in Figure 2(a) would still be a good fit to the second data set, but the green dashed line in Figure 2(b) would be a very poor fit.

The dangers of model overfitting and the importance of finding a balance between simple and complicated models in the field of groundwater modeling has been highlighted by a number of respected groundwater researchers, including Carrera and Neuman (1986), Hill (2006), Hunt, et al. (2020), Yeh and Yoon (1981), Wali et al. (2024), and Zatlakovic et al. (2023). Hunt et al. (2020, p. 176) stated:

> *The highly parameterized approach often achieves an excellent fit but can also "overfit," where the parameter estimation chases noise in the observations and yields unrealistic parameter values and distributions (e.g., parameter "bullseyes," or hotspots).*

Mary Hill's research in particular underscores the importance of balancing model complexity with the risk of overfitting (Hill 1998, 2006, 2010). She advocates for starting with simpler models and gradually increasing complexity, allowing for a more accurate representation of the system without capturing extraneous noise. This approach not only aids in avoiding overfitting but also enhances the model's predictive reliability.

3.1.2 Contaminant Concentrations Exhibit High Variance

The concepts illustrated in Figure 2 are important to understand in the context of a post-audit of the ATSDR Tarawa Terrace model. The PCE concentrations measured at the Tarawa Terrace site exhibit a high degree of variance. Figure 3 illustrates a histogram of the observed PCE values taken from observations wells at Tarawa Terrace used in the post-audit. The histogram is based on log-transformed values, indicating that data are log-normally distributed and vary over 5 orders of magnitude. Furthermore, as we explained in Section 4.2 of our post-audit report, a careful analysis of the observed concentrations from Tarawa Terrace shows high variance in the form of temporal and spatial anomalies. Some samples collected at similar times in wells separated by a short distance showed a high degree of variance. In other cases, samples taken at the same observation well but separated by a relatively short time also exhibited high variance.

High spatial and temporal variability in observed PCE concentrations results from a number of factors. Variations in sampling methods, equipment, and processing can lead to variation. Aquifer heterogeneity can also have a significant impact. Consider the conceptual diagram shown in Figure 4. At the local-scale, groundwater flow is not uniform. Groundwater preferentially flows through high permeability channels (shown in blue) and there is minimal flow in low permeability zones (shown in brown). Thus, a monitoring well screen that happens to coincide with a preferential flow channel (point B) may sample a substantially different concentration than a sample taken from a monitoring well that happens to be screened in a low permeability zone (point A).

The issue of high variability in PCE concentrations at Camp Lejeune was discussed at length by the Expert Panel convened by ATSDR to assess its methods and analyses for historical reconstruction. It noted that concentration measurements can vary greatly over short periods of time (ATSDR 2009c, p. 216). For example, wellhead concentrations can fluctuate significantly within a 2-week period. One well showed a high of 1,600, followed by 540, and then 300 μg/L in subsequent samples (ATSDR 2009c, p. 121). There were concerns about the representativeness of individual samples due to the limitations of sampling procedures and laboratory analyses (ATSDR 2009b, p. 336; ATSDR 2009c, p. 217). It was noted that some of the observed PCE data may be biased low due to collection activities, and adjustments may be needed (ATSDR 2009c, p. 62). Because of this high variance, the panel suggested that instead of trying to match the model to every data point, it may be more useful to focus on capturing the general trends in the data and suggested using ranges of concentration to convey uncertainty rather than single values (ATSDR 2009d, p. 69).

3.1.3 Transport Models versus Flow Models

The diagram in Figure 2 is representative of the complexities inherent in simulating the transport of contaminants such as PCE in aquifers. By its nature, computer modeling of contaminant transport is substantially different from modeling groundwater flow, and calibrating transport models presents unique challenges (Zheng et al. 2012; Green et al. 2010). For a groundwater flow model, the primary variable simulated is the hydraulic (potentiometric) head. While there is some level of variance in hydraulic head, it is significantly less variable than contaminant concentrations. Heads are normally distributed, not log-normally distributed, and they do not vary by multiple orders of magnitude. The process of sampling heads at observation wells has a much lower possibility of error, and heads are much less sensitive to local-scale heterogeneity. For these reasons, when calibrating a flow model or assessing the performance of a flow model, one would expect lower variance in the observations and therefore lower residuals (difference between simulated and observed heads) at observation wells. Zheng et al. (2012, p. 1551) state:

> *To users of MT3DMS, the term "model calibration" generally describes a process in which the model structure and parameter values are adjusted, either manually or by using formal mathematical optimization procedures, until the model output satisfactorily matches a set of targets (Zheng and Bennett, 2002). The suggestion by Hill and Tiedeman (2007) that "satisfactory" needs to be considered in the context of data errors and model limitations is important to users of MT3DMS because of difficulties associated with simulating subsurface transport. Difficulties include the inaccessibility of subsurface systems and the many order of magnitude range of concentration values that can occur in the data set for a single site.*

Another difference between flow models and transport models is that a flow model simulates the spatial and temporal distribution of hydraulic heads throughout the entire saturated zone of an aquifer. By contrast, a transport model simulates the migration of a contaminant plume that occupies a small fraction of the spatial extent of the aquifer. For the majority of the aquifer, the concentration is equal to zero. Simulated concentrations can vary from high concentrations inside the plume to zero concentrations outside the plume. Thus, if the spatial extent of the simulated plume differs from the spatial extent of the actual plume at certain locations due to issues such as local-scale aquifer heterogeneity, the residuals can be large even though the general shape, trajectory, and timing of the plume is reasonably accurate.

3.1.4 Qualitative and Quantitative Assessment of Model Performance

For all of these reasons, when conducting an assessment of the performance of a transport model, one has to factor in the high variance of the concentration measurements and the unique nature of contaminant transport models. As we explained in our post-audit report, it is important to assess transport models using a qualitative analysis in addition to a quantitative analysis. A quantitative analysis may show high variance in the model residuals, but does the model do a reasonable job of simulating the overall shape, magnitude, and movement of the plume? This can be assessed by analyzing maps of plume migration versus time to see if the residuals are balanced spatially and temporally as we did in Section 5.2 of the post-audit report. Furthermore, examining the average error over the entire simulation can be a way of assessing the overall fit. If this error is low, the model has done a reasonable job of fitting the highly variable observation data, similar to the fit of the blue line in Figure 2(a).

3.2 OPINION 1—BIAS IN POST-AUDIT RESULTS

One of the primary claims made by Spiliotopoulos about the post-audit results is that the post-audit showed that the model has a high positive bias, indicating that the model-simulated concentrations are generally higher than those observed at the observation wells (see Section 4.1.5.1 of the Spiliotopoulos report). In our original post-audit report, we presented data relating to how well the extended simulation matched the larger set of PCE observations collected after the original ATSDR study. These data included tables of simulated and observed PCE concentrations at observation wells, the overall mean residual error (simulated – observed concentrations), scatter plots of simulated versus observed concentrations at individual wells, a scatter plot of all of the simulated versus observed data pairs, simulated versus observed time series at individual wells, and a series of plume maps showing the temporal and spatial distribution of residual error. However, in arguing for high bias, Spiliotopoulos seemed to focus primarily on a qualitative assessment of Figure 6 from the post-audit report, which is the simulated versus observed scatter plot. This figure is repeated in the left panel of Figure 5. The Spiliotopoulos report also noted some issues in the post-audit with model inputs and post-processing, which we respond to in detail below in Sections 3.5 and 3.6. Two of these issues relate to minor errors in the model inputs, which we corrected and then produced an updated simulation, as described in Section 3.7, below. The other issue was with the truncation of numerical precision in the simulated PCE results. This issue also had a relatively small impact on the overall model results. However, one artifact of the truncation error is that all simulated PCE concentrations lower than ~17 μg/L were truncated to 0 μg/L, which accounts for the lack of scatter points in the lower half of the original scatter plot shown in the left panel of Figure 5. Using the updated simulation results and ensuring that the results were processed at full precision, we recreated the scatter plot, and the results are shown in the right panel of

Figure 5. While the numbers indicate a high degree of variance, they are visually more balanced than the results we originally presented in the post-audit report.

In Section 4.1.5.1 of the Spiliotopoulos report, he generated a new plot of the post-audit results in an attempt to highlight model bias. This was presented in his report as Figure 19, and it was a ranked order plot where simulated and observed pairs were plotted using a sample ranking method where the pairs are ranked from high to low in terms of the observed value (reproduced here as Figure 6). The right side of this plot showed a large number of simulated values greater than the observed values, especially for a number of locations where the observed values are equal to zero. We have recreated this plot in the upper panel of Figure 7 using the same methodology used by Spiliotopoulos, but in this case, we used the updated simulation results with full precision. Once again, the plot shows more simulated values in the 0–17 μg/L range, showing more balance. In addition, we created a second ranked order plot, but this time the ordering was performed in relation to the simulated values, rather than the observed values. The results are shown in Figure 7, lower panel. This plot is visually more balanced than the ranking based on observed values.

In Section 3.1.2, above, we discussed how and why the observed PCE concentrations exhibit a high degree of variance. When comparing model results to an observation data set that exhibits a high variance, one of the most important factors is the overall mean error (ME). The ME is found by calculating the average residual error (simulated PCE – observed PCE) for the entire data set. For the original post-audit results we calculated an ME value = 21 μg/L, indicating an extremely balanced fit with only a small high bias. For the updated post-audit results, the ME = 48 μg/L, indicating a small increase in the bias, but still relatively well balanced overall. This balance indicated by the ME value was largely ignored by Spiliotopoulos.

The objective of the original model was to simulate the aggregate concentration of PCE at the Tarawa Terrace Water Treatment Plant over a 30-year period. Matching highly-variable observed PCE concentrations at specific points in time and space will result in high residuals. However, if the overall model fit is balanced, the simulated concentrations, which are drawn from water pumped from a significant portion of the aquifer over a long period of time, should exhibit much lower variability.

Spiliotopoulos also noted that the simulated versus observed data set for the post-audit model includes many simulated-observed pairs where either a) the observed value is zero and the simulated value is non-zero, or b) the simulated value is zero and the observe value is non-zero. This result is not surprising for several reasons. First, as described in our post-audit report, there are several cases in the observed PCE concentration data set where two samples taken at the same time but only separated by a short spatial distance exhibited significantly different values, including a zero value for one sample and a large value for the other sample. In other cases, samples taken at the same observation well but separated by a few months in time, exhibited similar differences. These anomalies could be due to local-scale aquifer heterogeneity, sampling error, etc. Furthermore, a transport model generates a solution over a numerical grid consisting of cells with representative averaged parameter values. This approach inherently smooths the simulated results. The actual contaminant plume might follow preferential flow paths, resulting in zones where the sample values are zero, whereas the simulated plume is more continuous due to the smoothing effect of the grid. This does not indicate that the model is inaccurate, but that the model is representing an aggregate condition of the aquifer using representative parameter values.

Opinion 1: The Spiliotopoulos report exaggerated and distorted the model bias in the post-audit results.

3.3 OPINION 2—CALIBRATION TARGETS AND VARIABILITY

In several of the simulated versus observed plots generated by Spiliotopoulos, he overlaid lines creating a narrow band around the line of equality corresponding to a calibration target of 0.5 order of magnitude (see Figure 6 for an example), and implied that the post-audit results indicate a poor fit because many of the simulated versus observed PCE values do not fall within this window. Before discussing that specific calibration target, it is helpful to review the concept of a calibration target in general.

When calibrating a groundwater model, it is customary to define a calibration target. For a flow model, this would be defined in terms of piezometric head (water table elevation). For example, a calibration target of 5 m would mean that the goal would be to have the simulated heads within ±5 m of the observed heads. This could be evaluated both in terms of simulated versus observed heads for each observation or for global error norms (mean absolute error [MAE], root-mean squared error, etc.). For a transport simulation, it is more customary to define calibration targets in terms of orders of magnitude due to the high variance in both simulated and observed values. For example, a 1.5 order of magnitude calibration target would mean that residual errors are computed in terms of log-transformed concentrations and the interval is ±1.5 orders of magnitude (log scales).

The concept of a calibration target is based on a recognition that it is impractical for a groundwater simulation to exactly match field observations for several reasons. First of all, the observations themselves are subject to variability resulting from measurement errors, differences in methods for processing lab samples, uncertainty in monitoring well elevations, errors in sampling methodology, etc. Furthermore, the interval also takes into account that constructing a computer model involves a large number of simplifying assumptions. It is impossible to fully characterize and incorporate all parameters and complexities of a real aquifer system in a discretized computer model. Given these considerations, the determination of an appropriate calibration target would theoretically require a) an accurate assessment of the uncertainty or variability of the sampling error, and b) an accurate characterization of the numerical impact of the simplifying assumptions and uncertainties of the model parameters used to build the model. One could then use these numbers to develop a calibration target perfectly tailored to the modeling exercise at hand. In practice, both of these numbers are impossible to obtain. Therefore, a calibration target is ultimately a subjective “goal” for the calibration exercise derived as an educated guess by the modeling team. Ultimately, the calibration process continues until additional adjustments to the modeling parameters no longer improve the goodness of fit between the simulated and observed values (the overall error cannot be reduced further). Whether or not the calibration target was met is generally a secondary concern.

While the original ATSDR model was calibrated using a target of ±0.5 order of magnitude, there was no indication of how this target was developed, and ultimately many of the PCE concentration residuals were outside the range of the calibration target (53%). For the transport model, the calibration process was continued until a good overall balance was achieved. The resulting simulated concentrations at the Tarawa Terrace Water Treatment Plant were compared with the measured concentrations, and a reasonable agreement was found. The National Research Council review of the ATSDR modeling studies noted that the calibration target was arbitrary:

> *The modeling studies did not include any formal analysis to account for the temporal or spatial data-averaging effects. Instead, in the analysis presented by Faye (2008), the point measurements were used to set a "calibration target range" for constraining the model predictions; the range was arbitrarily set at about half the order of magnitude of the detected point measurements (Faye 2008).*
> *(*NRC 2009, p. 46*)*

> *The basis used for setting the values of the "calibration target range" was unclear.*
> (NRC 2009, p. 49)

Furthermore, during the 2009 expert panel assessment of the ATSDR study there were comments provided by panel members regarding the approach of setting calibration targets (ATSDR 2009d). Panel member, Dr. Mary Hill said:

> *There is no one set of established guidelines, but there has been much effort internationally in pursuit of such guidelines.*
> *(*ATSDR 2009d*, p. 96)*

> *In the DON review it is noted that the ASTM guidelines mention a priori definition of a model fit criteria. To my knowledge it is not common in practice and is not a practice I would recommend. For the TT model, it seems to me that a priori definition of a model fit criteria lead to unrealistic expectations of model accuracy."*
> *(*ATSDR 2009d, p. 96*)*

Panel member, Dr. Rao Govindaraju stated:

> *To the best of my knowledge, there are no accepted protocols for setting calibration targets. Typically, one sets calibration targets* based on the available data and the goals of the study. Since the purpose of this modeling exercise is to reconstruct concentration

histories for use in an epidemiological *study, the modeling study should provide an estimate of human exposure. Ideally, this goal should decide the calibration targets." (ATSDR 2009d, p. 85)*

Panel member, Dr. Konikow stated:

> *Overall, there are no standards and probably should not be any. Such targets are inevitably arbitrary and to some extent meaningless. They tend to distract from the quality of the calibration process and shift focus to the arbitrary goal. It is a "red herring." Not achieving a predetermined calibration target should not disqualify a model, nor does that prove a model is not valuable or useful. Conversely, meeting such a predetermined calibration target does not prove that the model is a good one or that it meets the needs of the particular study or that its calculations and predictions are accurate and/or reliable.*
>
> *In my opinion, the use of specific calibration targets should be abandoned.* They have no real value in the context of hydrogeology, and can only serve to provide a false or meaningless image of the quality of the developed model.
> *(ATSDR 2009d, p. 101)*

Ultimately, the ATSDR Expert Panel recommended against the use of a calibration target:

> *Overall, the panelists did not agree with the calibration criterion ATSDR planned to use. The panel suggested ATSDR not pre-specify numerical values of calibration targets. There was consensus among panel members that emphasis should be placed on more objectively estimating model parameters than on trying to closely match observed water-level or concentration data with model-simulated results for model calibration."*
> (ATSDR 2009d, p. 2)

The U.S. Navy said the following in its review of the ATSDR study:

> *Navy recognizes the variability in the field data, and this kind of variability is expected. In our experience at many hundreds of sites across the country, measured concentrations of contaminants in groundwater vary significantly and somewhat unpredictably over time."*
> (U.S. Navy 2009, p. 4)

In the ATSDR response to the U.S. Navy review, it noted a similar study on chlorinated organic compounds at U.S. Naval Air Station in Jacksonville, Florida (ATSDR 2009a). This study was peer-reviewed by the U.S. Geologic Survey (Davis 2003). In this case, even though the model was calibrated and later used as a predictive tool (Davis 2007), no calibration target was ever established or used to gauge the accuracy of the model, consistent with our point above that calibration targets are generally arbitrary.

Opinion 2: The calibration target of ±0.5 order of magnitude used in the original ATSDR transport study was arbitrary and too narrow to use as a basis for evaluating the post-audit results.

3.4 OPINION 3—QUALITATIVE ASSESSMENT OF PLUME BEHAVIOR

One of the main conclusions of our original post-audit report was that given the high variability in observed PCE concentrations, it is important to assess the overall behavior of the simulated PCE plume relative to the observations. Specifically,

> *Given these challenges, it is important to qualitatively assess the overall behavior of the simulated plume in addition to quantitatively analyzing the differences in simulated and observed concentrations at specific times and locations. A qualitative evaluation helps ensure that the model captures the key processes governing plume migration, such as its general direction, spread, and interaction with sources, sinks, and aquifer boundaries. This broader perspective can offer valuable insights into the overall value of the model as an interpretive or predictive tool.*
> (Jones and Davis 2024, p. 5-1.)

One of the methods we used to achieve this was to overlay the residual errors for the observation points with plume maps at multiple model layers and at multiple points in time. With the exception of a few wells with known anomalies, this analysis indicated a good overall agreement between the simulated PCE plume and the observed concentrations over the range of the extended simulation.

This point was largely ignored by Spiliotopoulos. He addressed it only briefly and superficially at the bottom of p. 63 of his report. He critiqued our qualitative assessment of plume behavior, stating it is "unhelpful" due to significant discrepancies between observed and simulated concentrations, the small area of comparison, and the lack of data to evaluate the overall plume extents. This critique is limited and weak because it ignores the inherent challenges of contaminant transport modeling and dismisses a valuable approach to model evaluation.

The Spiliotopoulos report claims that comparisons are drawn within a very small area compared to the overall plume extents. However, the observation wells are concentrated in the area around the extraction wells used to feed the water treatment plant, which is also the area where the main part of the PCE plume is located. As our report states, this is the area where the concentrations ultimately impact the concentrations at the water treatment plant, making it the most important area from which to have observations. It is not necessary to have observations covering the entire modeling domain, which is impractical and cost prohibitive.

The Spiliotopoulos report notes that no data are available to evaluate whether the overall extents of the simulated plume are realistic. However, the lack of data outside the primary area of concern is a common challenge in contaminant transport modeling. It does not invalidate the model's usefulness for assessing the plume behavior in the area of interest, which is where the impact on human health is most likely. Our post-audit used the available data to assess model performance, which is a valid approach and based on sound scientific methodology and accepted within the scientific community.

Opinion 3: Spiliotopoulos did not effectively refute our qualitative assessment of the overall plume behavior.

3.5 OPINION 4—ISSUES WITH POST-PROCESSED RESULTS

In Section 4.1.5.2 of his report, Spiliotopoulos also identified some anomalies with the post-processed results. Specifically, he noticed that for some wells we reported identical concentrations over a series of observation dates. He also recreated simulated concentrations at well RWC-2 and overlaid the simulated PCE concentrations for selected dates and showed that our simulated concentrations were of the right overall magnitude but exhibited a stair-step behavior. He also noted that in Figure 11 of our original report, we showed well S9 as being on the fringe but still inside the simulated PCE plume, yet we reported a zero concentration for well S9 at the date corresponding to the plume map (3/1/2003).

We investigated this issue and discovered the cause of the anomaly. In one of the steps we used to post-process the simulated PCE values, we inadvertently truncated the PCE values down to a low number of significant digits. This resulted in a "round-off" error where some of the simulated PCE values were too high and some were too low. This error only applied to the simulated PCE values at the observation well locations and not to the overall MT3DMS simulation results as shown in the PCE plume maps in Figures 9–16 in the post-audit report.

We reprocessed our original post-audit simulation results and the full precision numbers are shown in Table 1 along with the original truncated values. Fortunately, the magnitude of the roundoff error was relatively small and mostly balanced. The mean truncation error was −1.47 μg/L, the maximum absolute truncation error was 17.5 μg/L, and the mean absolute truncation error was 7.2 μg/L. The mean residual error from the original set of truncated values was 21 μg/L, and for the full precision data set, the recalculated mean residual error was 22 μg/L, indicating a minimal overall impact as the residual errors are still balanced.

One artifact of the truncation error is that it was most pronounced with the low magnitude concentrations. As a result, any simulated concentration lower than ~17.5 μg/L was truncated to zero. This caused our simulated versus observed PCE concentration plot to show fewer simulated–observed points below the line of equality in Figure 6 of the post-audit report, as described above. This also explains the discrepancy noted by Spiliotopoulos for well S9 in the plume map shown in Figure 11 of our post-audit report. We reported a simulated PCE value of zero for 3/1/2003, but the full precision value = 15.7 μg/L, which is why it plotted as inside the PCE plume in Figure 11 of the post-audit report.

Opinion 4: The numerical roundoff errors found by Spiliotopoulos were minor and did not significantly impact the model results.

3.6 OPINION 5—MODEL INPUT ERRORS

In Section 4.1.5.2 of his report, Spiliotopoulos identified an issue with two of the inputs to our post-audit model files.

3.6.1 Extended Model Timeframe

Spiliotopoulos noted that our report indicates that the source term in the extended model terminates in December 1983, and he checked the extended model input files to confirm that the source term in the input files indeed matched that date. He is correct that the original ATSDR report on the Tarawa Terrace MT3DMS simulation (Faye 2008) states that the source term was terminated in December 1984. This was an error in Source-Sink Mixing (SSM) package input file to the extended MT3DMS simulation used in the post-audit. We corrected the error and ran a new simulation. The updated simulation results are discussed in Section 3.6.3 below.

3.6.2 Pumping Rate for Well RWC-2

Spiliotopoulos also noted that Table 2 of our post-audit report stated a pumping rate of 40 gallons per minute (gpm) for well RWC-2 from 3/7/2004 through 12/16/2004. However, the input files for the extended simulation show a pumping rate of 20 gpm for this well for this time period. This was an error in the Well Package input file to the extended MODFLOW simulation used in the post-audit. We corrected the error and ran a new simulation. The updated simulation results are discussed in Section 3.6.3 below.

3.6.3 Updated Simulation Results

We have corrected both input errors and generated new MODFLOW and MT3DMS simulations. Table 2 shows the simulated PCE values at each monitoring well location from the original model, the simulated PCE concentrations from the updated model, and the difference between the two. The updated PCE concentrations are processed at the full numerical precision as discussed in Section 3.5, which accounts for a portion of the concentration differences.

The pumping rate error was small and only impacted a few months in 2004. Correcting the termination of the mass loading by changing it from the end of December 1983 to the end of December 1984 had a larger impact and increased the PCE concentration to some degree at most of the well locations. The average increase was 27 μg/L. Accordingly, the mean residual error increased from 21 to 48 μg/L. This indicates a small high bias, but the overall errors are still reasonably balanced.

To further illustrate the magnitude of the differences between the two simulations, we have generated a PCE time series for the grid cell containing well TT-26 using the original and updated post-audit results (Figure 8). The updated simulation has slightly higher concentrations from about 1990 onward.

We have also generated new versions of each of the tables and figures from our original post-audit report featuring simulated PCE values, using the updated post-audit simulation results, processed at full precision. These results are presented in Appendix A. The differences in the tables and figures relative to the original report are relatively minor overall. The differences are summarized as follows:

Appendix	Post-Audit	Differences
Table A1	Table 5	Mean increase of 27 mg/L as explained above.
Table A2	Table 6	Modest increase in ME and MAE. Of the 37 sites, 5 changed categories (see explanation below for Figures A10, A11, and A12).
Figure A1	Figure 2	No significant differences.
Figure A2	Figure 6	Differences noted previously in Section 3.2.
Figure A3	Figure 7	Various differences, mostly minor. See summary in Table 2.
Figure A4	Figure 8	Various differences, mostly minor. See summary in Table 2.
Figure A5	Figure 9	June 1997 plume map. Of 20 observations, 2 changed categories: S2 changed from green to yellow (141 μg/L → 208 μg/L), and S1 changed from yellow to red (494 μg/L → 505 μg/L).
Figure A6	Figure 10	February 2000 plume map. Of 21 observations, 1 changed category: S10 changed from yellow to red (494 μg/L → 503 μg/L).
Figure A7	Figure 11	March 2003. Of 27 observations, 3 changed categories: RWS-1A changed from green to yellow (171 μg/L → 265 μg/L), RWS-2A changed from green to yellow (148 μg/L → 280 μg/L), and S3 changed from green to yellow (164 μg/L → 256 μg/L).
Figure A8	Figure 12	March 2006. There were 30 observations. No changes.
Figure A9	Figure 13	March 2008. Of 26 observations, 1 changed category: FWC-11 changed from yellow to red (494 μg/L → 515 μg/L).

Appendix	Post-Audit	Differences
Figure A10	Figure 14	December 2008 (overall MAE) – layer 1. Of 18 sites, 4 changed categories: FWS-12 changed from green to yellow (176 µg/L → 218 µg/L), RWS-1A changed from green to yellow (142 µg/L → 207 µg/L), RWS-2A changed from green to yellow (190 µg/L → 301 µg/L), and S5 changed from yellow to red (462 µg/L → 528 µg/L).
Figure A11	Figure 15	December 2008 (overall MAE) – layer 3. Of 17 sites, 1 changed category: C2 changed from yellow to red (423 µg/L → 519 µg/L).
Figure A12	Figure 16	December 2008 (overall MAE) – layer 5. There were 2 sites. No changes.

Opinion 5: The pumping rate error and the mass loading termination date error found by Spiliotopoulos were both minor and did not significantly impact the model results.

3.7 OPINION 6—POST-AUDIT ROBUSTNESS

In summary, while Spiliotopoulos did correctly point out some issues with our post-processing and model inputs for the original post-audit results, the impact of these errors was relatively minor. Spiliotopoulos exaggerated the magnitude of the model bias and ignored the fact that the errors are mostly balanced. His use of the ±0.5 order of magnitude calibration is arbitrary and overly restrictive.

This rebuttal underscores the robustness of the original post-audit findings for the Tarawa Terrace Flow and Transport Model. Despite critiques raised by Spiliotopoulos, the analyses validate that the extended model continues to reliably simulate the migration of PCE contamination over the extended period from 1995 to 2008. Our qualitative and quantitative assessments demonstrate that the model captures the key dynamics of PCE plume migration while accommodating the inherent complexities and high variances in observed concentrations. These findings support our original conclusion that the ATSDR model was developed using a methodology that is scientifically sound and accepted within the scientific community, and it remains a reliable tool for assessing the impacts of PCE contamination at Tarawa Terrace.

Opinion 6: Nothing in the Spiliotopoulos report contradicts our overall conclusion about the post-audit results. The model effectively simulates long-term trends in contaminant migration, and we can find no significant evidence that would invalidate the analyses performed by ATSDR with the original model.

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5 QUALIFICATIONS

I, **R. Jeffrey Davis**, P.E., CGWP, have almost 30 years of experience with civil and environmental engineering, hydrogeology, groundwater fate and transport modeling, and software and model development. I have both undergraduate and graduate degrees from Brigham Young University in civil engineering. I currently serve on the board of directors for the National Ground Water Association (NGWA), as well as on NGWA's per- and polyfluoroalkyl substances and Managed Aquifer Recharge advisory groups. I was one of the leads for NGWA's Groundwater Modeling Advisory Panel. I have developed and used numerous groundwater models for the agricultural industry and the mining industry, including projects involving environmental impact statements, environmental assessments, water management, groundwater–surface water interaction and contamination, dewatering, and water treatment. I also have extensive experience with the oil and gas industry, including water supply, hydraulic fracturing, and groundwater protection for the upstream market, and worked on a variety of oil release projects. I have extensive knowledge of groundwater flow-and-transport principles and have led numerous workshops and classes in the United States and around the world. I have taught several classes and workshops in association with NGWA and other professional organizations and universities for the past 3 decades. I also share my research and project work regularly with the professional societies with which I am affiliated. I frequently use groundwater models to explain fate and transport of contaminants or groundwater supplies and availability. Recent such examples include groundwater impacts from agricultural activities in Minnesota; aqueous film-forming foam contamination impacts to groundwater in Martin County, Florida; a pipeline of produced water spill in North Dakota; and groundwater availability and surface water impacts in Ventura County, California. I am regularly asked to provide opinions or participate on panels to discuss groundwater, water supply, or contaminated groundwater issues.

I, **Norman L. Jones**, Ph.D., have 33 years of experience in civil and environmental engineering. I graduated with a B.S. degree in civil engineering from Brigham Young University and with M.S. and Ph.D. degrees in civil engineering from the University of Texas at Austin. I have been a faculty member in the Civil and Construction Engineering Department at Brigham Young University since January 1991 where I currently hold the rank of Professor. I have taught university courses in a variety of subjects, including computer programming, soil mechanics, seepage and slope stability analysis, and groundwater modeling. The primary focus of my research has been groundwater flow and transport modeling, software development, remote sensing, groundwater sustainability analysis, and hydroinformatics. I was the original developer of the Groundwater Modeling System (GMS) software, which is a graphical user interface for MODFLOW and MT3DMS and is used by thousands of organizations all over the world. GMS is now developed and maintained by Aquaveo, LLC in Provo, Utah, a company that I helped found in 2007. I have taught numerous short courses on groundwater flow and transport modeling over my career. I am a member of the Hydroinformatics Research Laboratory at Brigham Young University. I have been the principal or co-investigator on more than $20M of externally funded research. I have authored 179 technical publications, including 88 peer-reviewed journal articles, and 1 book. I am a recipient of the Walter L. Huber Civil Engineering Research Prize from the American Society of Civil Engineers and the John Hem Award for Science and Engineering from NGWA. I have been involved in a number of consulting projects, including work as a technical expert in litigation cases. I am an active member of the American Water Resources Association, the NGWA, the American Geophysical Union, and the American Society of Civil Engineers.

6 COMPENSATION

My, **R. Jeffrey Davis**, experience is summarized in my resume, which is included as Exhibit 1. I am being compensated at a rate of $498 an hour for my time in preparation of this report and $498 an hour for my deposition and trial testimony, if necessary. My compensation is not contingent upon the opinions I developed or the outcome of this litigation case.

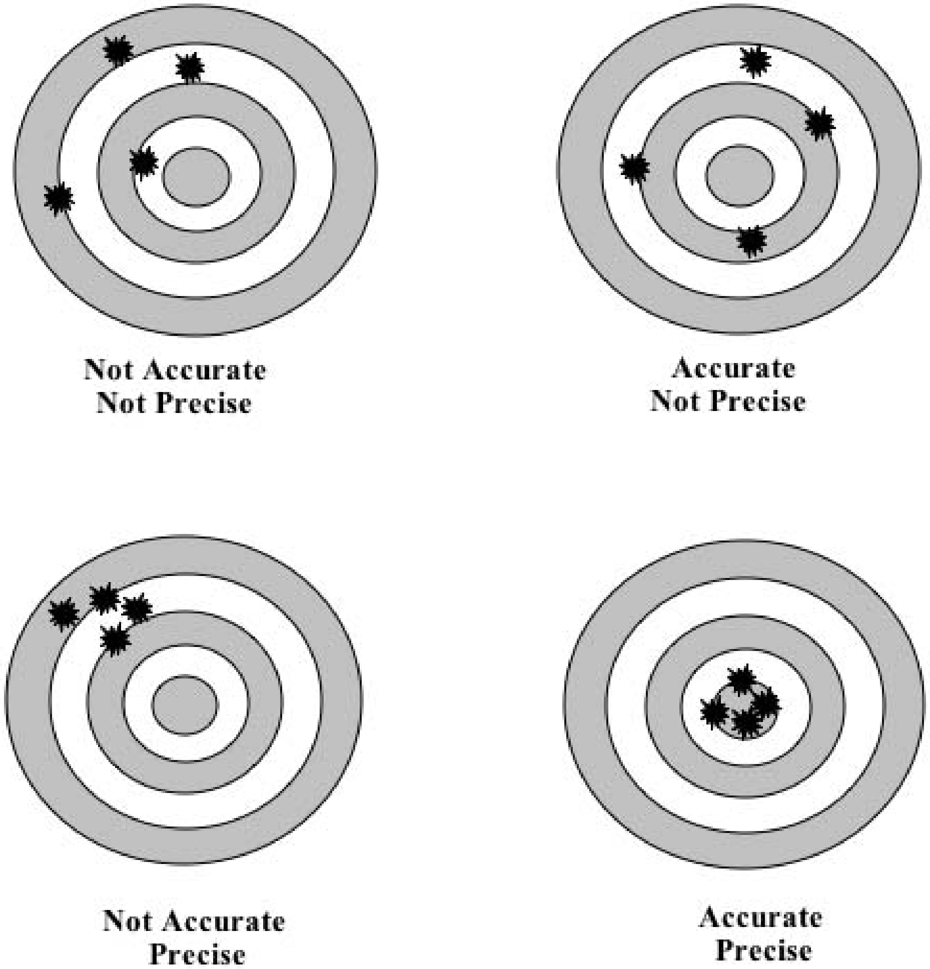
My, **Norman L. Jones**, experience is summarized in my resume, which is included as Exhibit 2. I am being compensated at a rate of $500 an hour for my time in preparation of this report and $1,000 an hour for my deposition and trial testimony, if necessary. My compensation is not contingent upon the opinions I developed or the outcome of this litigation case.

7 PREVIOUS TESTIMONY

I, **R. Jeffrey Davis**, have not given any deposition or trial testimony in the last 4 years.

I, **Norman L. Jones**, gave deposition testimony on October 20, 2021, in MICHAEL YATES and NORMAN L. JONES vs TRAEGER PELLET GRILLS LLC, in the United States District Court for the District of Utah Central Division, Case No. 2:19-cv-00723-BSJ. With the exception of this case, I have not given any deposition or trial testimony in the last 4 years.

Figures



Source: https://celebrating200years.noaa.gov/magazine/tct/tct_side1.html

integral

Figure 1.
Accuracy vs. Precision Graphic
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit

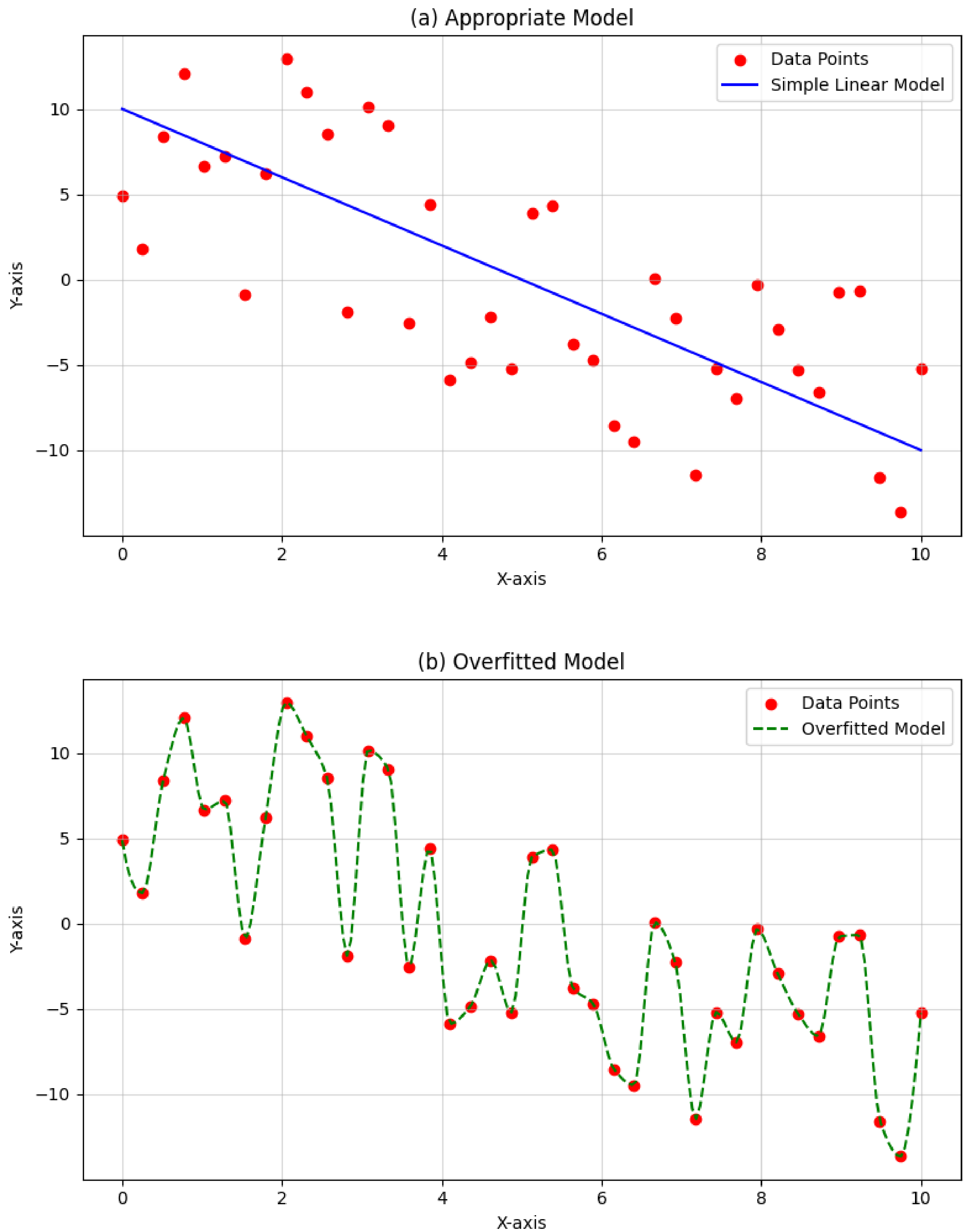
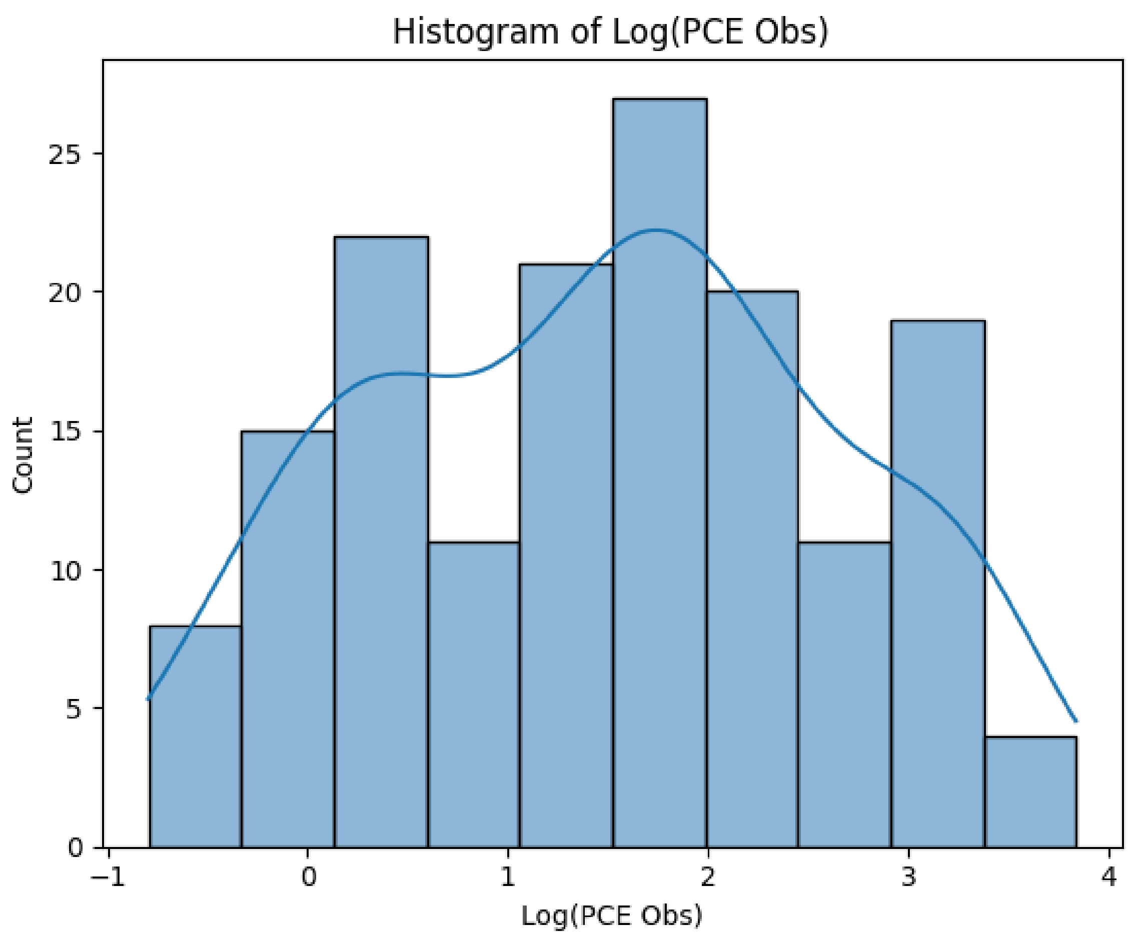


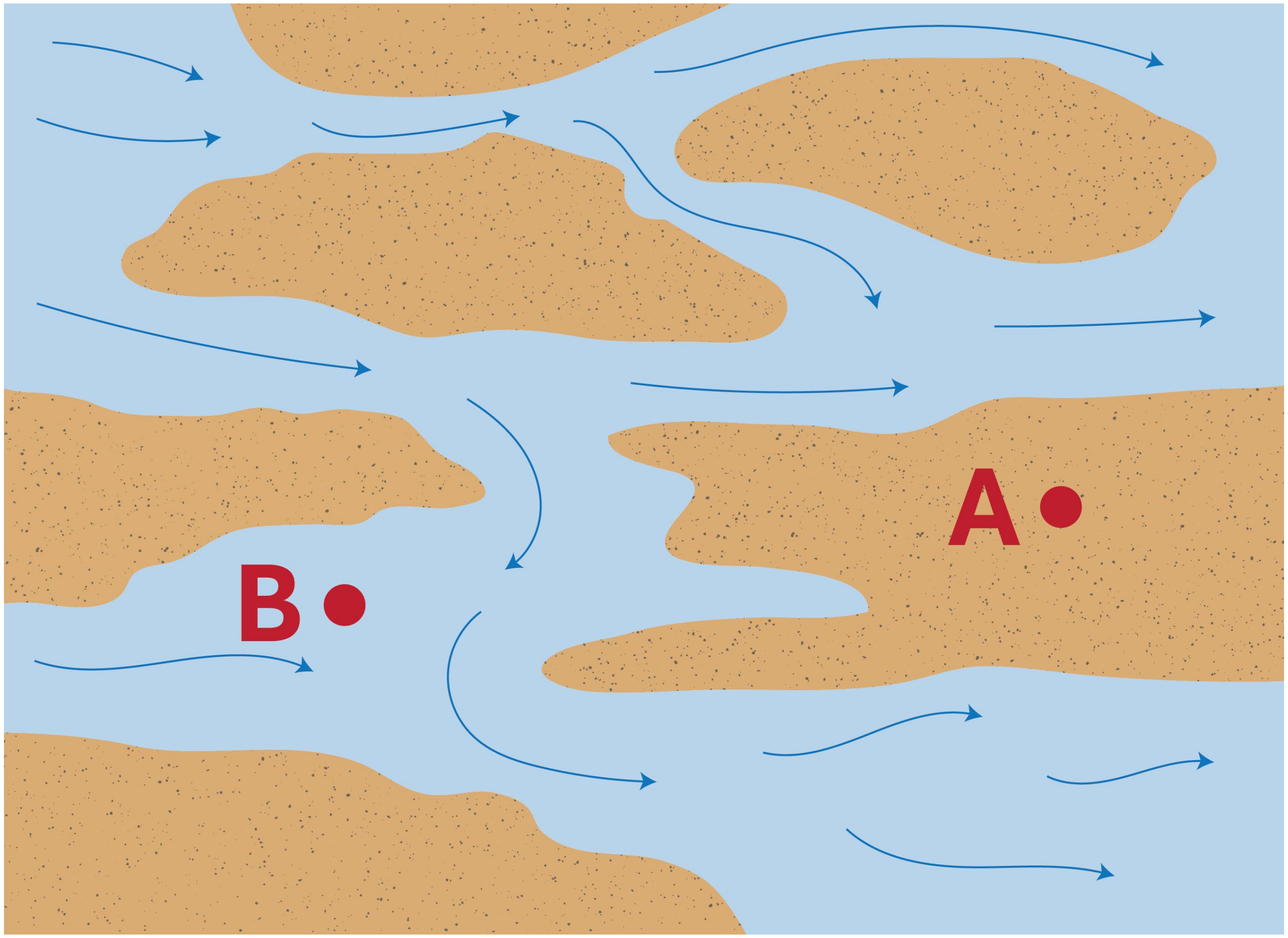
Figure 2.
Model Fitting of High Variance Data
Rebuttal Report Regarding Tarawa Terrace
Flow and Transport Model Post-Audit



Note:
Log PCE observations are provided in µg/L.
PCE = tetrachloroethylene

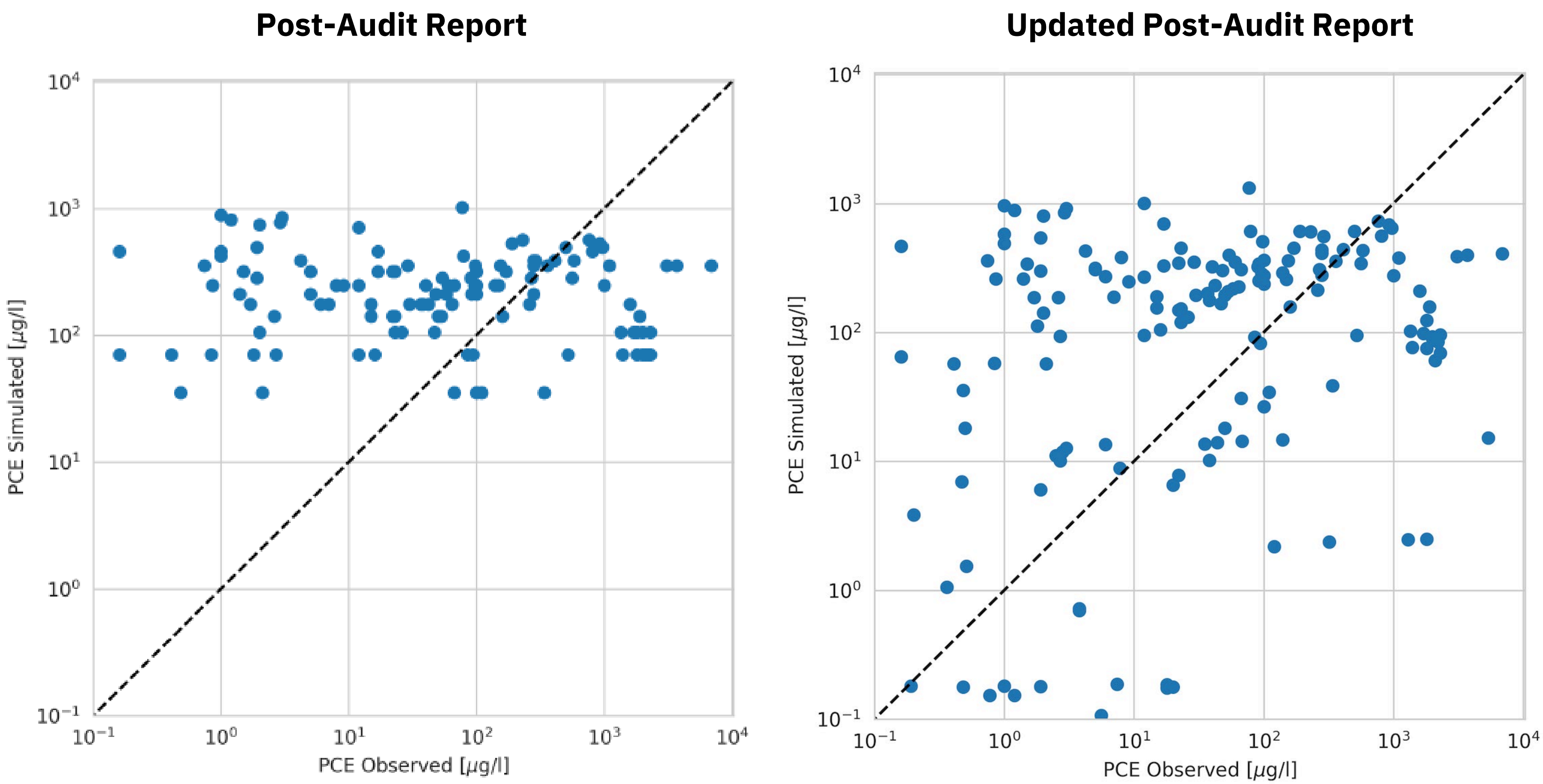
integral

Figure 3.
Histogram of Log-Transformed PCE in Observation Wells at Tarawa Terrace
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit



integral

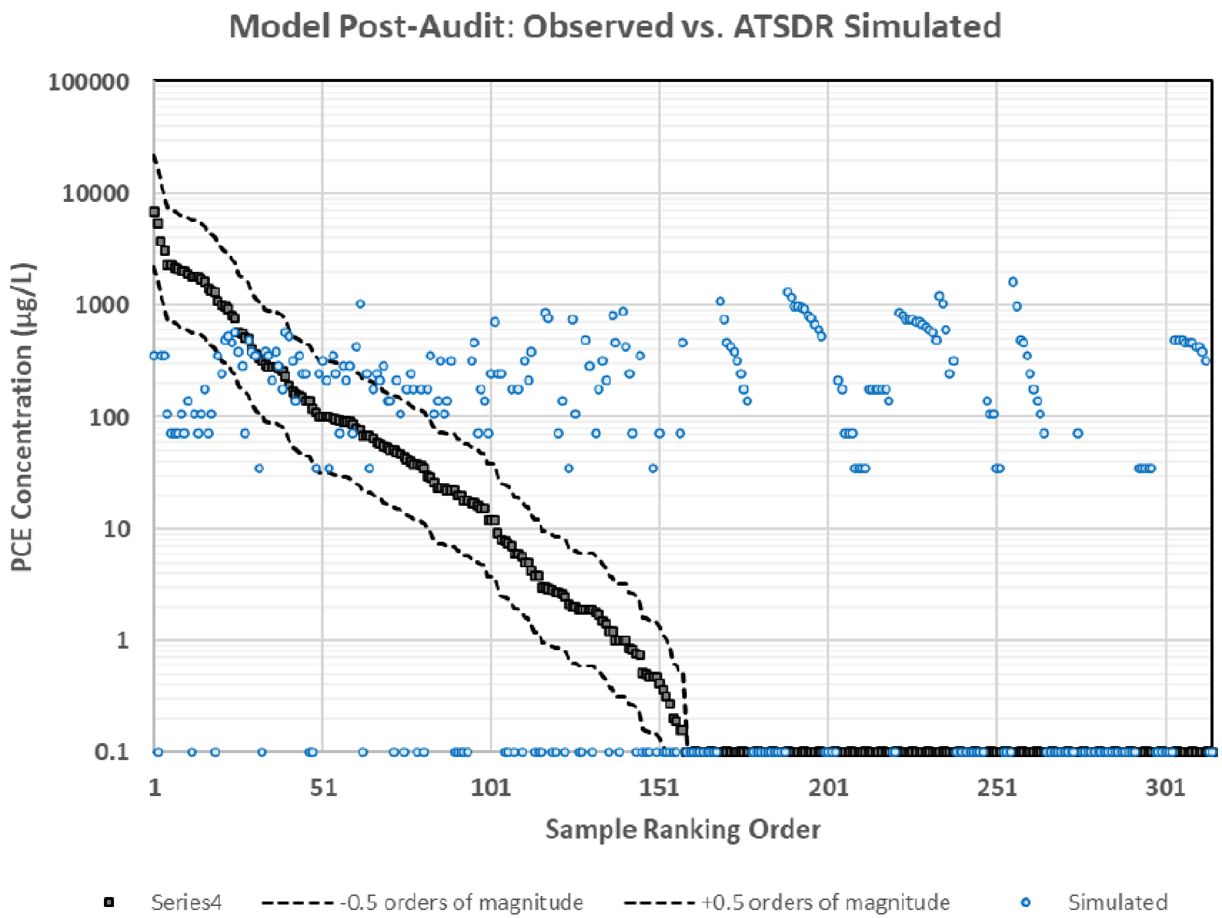
Figure 4.
Conceptual Representation of Local-Scale Aquifer Heterogeneity
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit



Note:
PCE = tetrachloroethylene

integral

Figure 5.
Simulated vs. Observed PCE Concentrations
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit

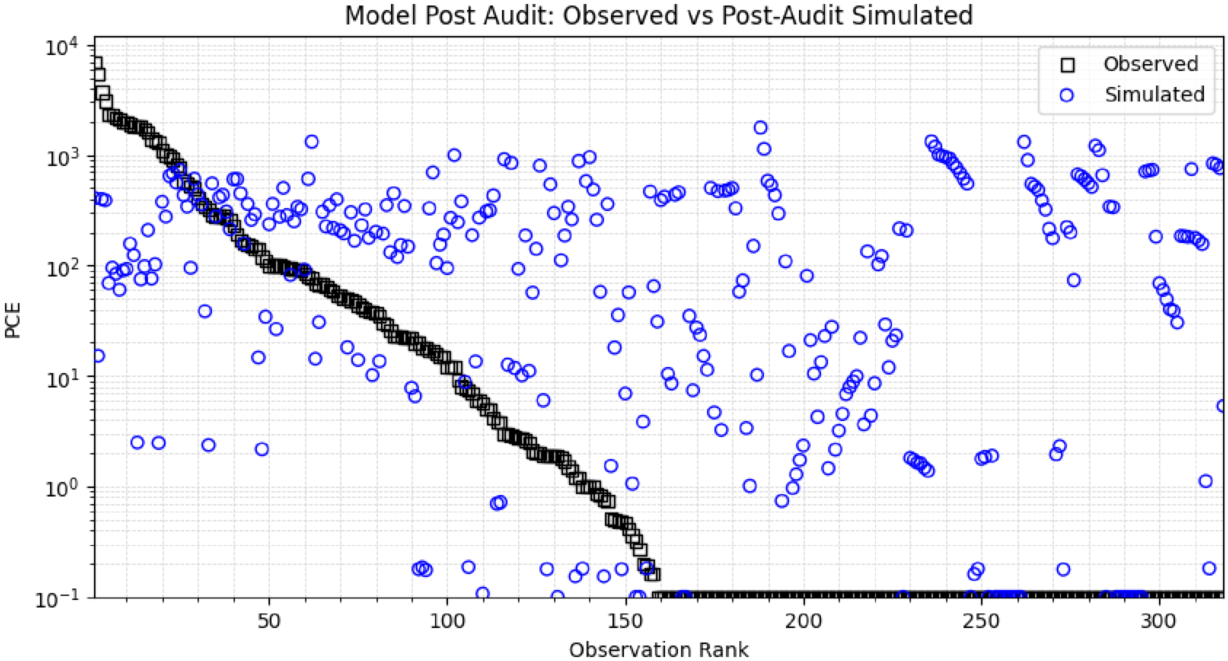


Notes:
PCE = tetrachloroethylene
Source: Spiliotopoulos Report, Figure 19

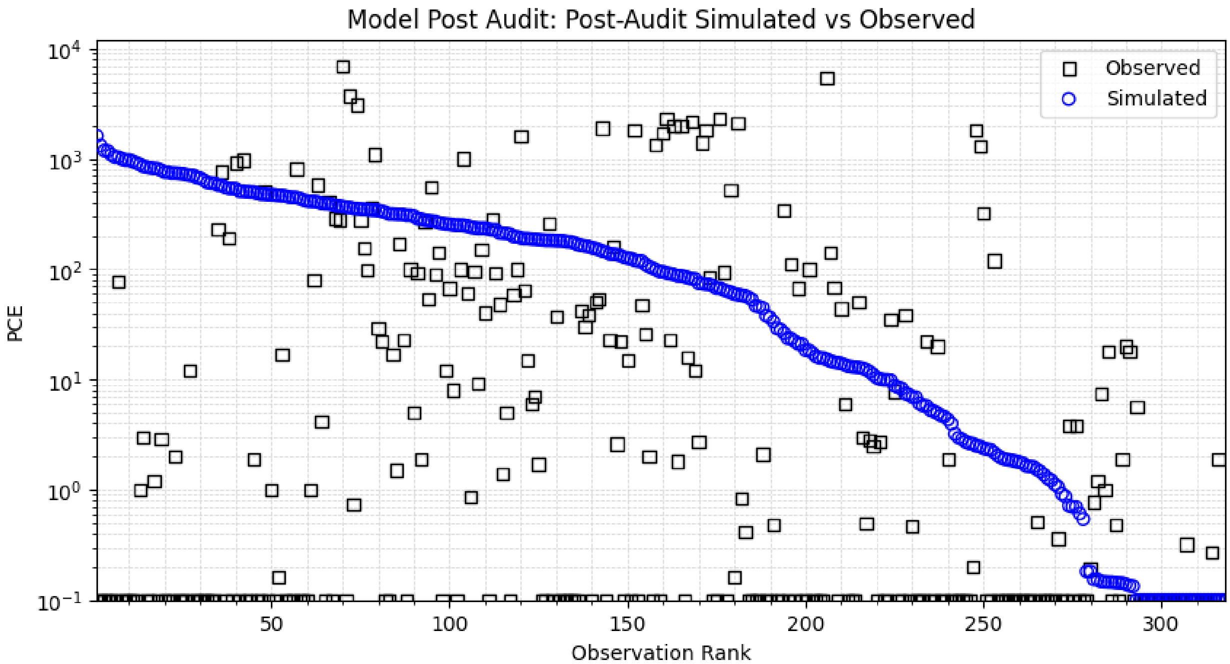
integral

Figure 6.
Ranked Order Plot Produced by Spiliotopoulos Using the Original Post-Audit Data
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit

Decreasing Observed Value



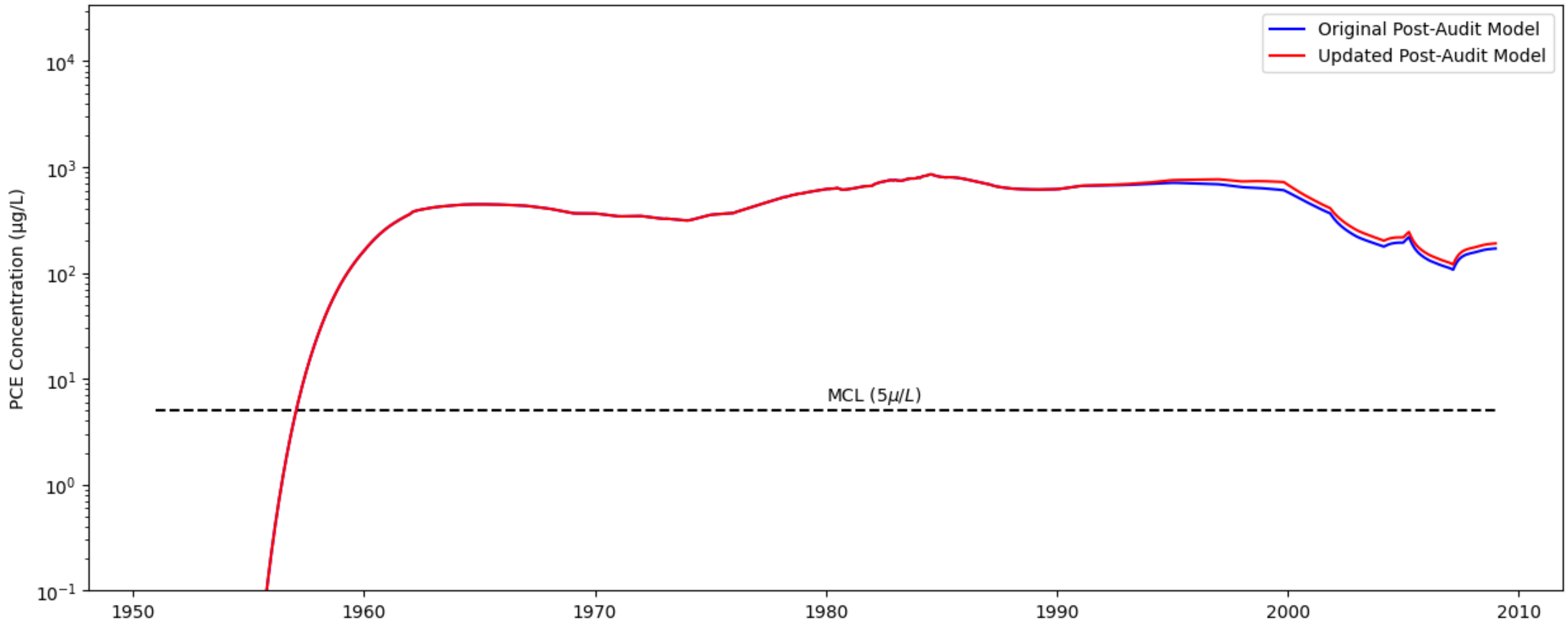
Decreasing Simulated Value



Notes:
All PCE results are shown in µg/L.
The upper panel shows ranked order plot using the updated post-audit results in order of decreasing observed value.
The lower panel shows ranked order plot using the updated post-audit results in order of decreasing simulated value.
PCE = tetrachloroethylene

integral

Figure 7.
Rank Order Plots Using Updated Post-Audit Results
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit



Note:
PCE = tetrachloroethylene

integral

Figure 8.
PCE Concentration in the Cell Containing Well TT-26 for Original Post-Audit Model and Updated Post-Audit Model
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit

Tables

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
2/1/2000	C1	0	0.03	0.03
5/1/2002	C1	0	0.03	0.03
8/1/2002	C1	0	0.03	0.03
11/1/2002	C1	0	0.03	0.03
3/1/2003	C1	0	0.03	0.03
3/1/2004	C1	0	0.02	0.02
3/1/2005	C1	0	0.02	0.02
3/1/2006	C1	0	0.02	0.02
2/1/2007	C1	0	0.02	0.02
3/1/2008	C1	0	0.02	0.02
6/1/1997	C2	1095	1091.49	-3.26
2/1/2000	C2	742	738.91	-2.7
5/1/2002	C2	459	472.77	13.68
8/1/2002	C2	459	446.65	-12.44
11/1/2002	C2	424	422.03	-1.74
3/1/2003	C2	388	392.26	3.8
3/1/2004	C2	318	315.82	-2.01
3/1/2005	C2	247	260.53	13.32
3/1/2006	C2	212	211.45	-0.44
2/1/2007	C2	177	173.13	-3.44
3/1/2008	C2	141	142.83	1.57
6/1/1997	C3	388	406.01	17.55
2/1/2000	C3	388	391.14	2.68
5/1/2002	C3	283	279.11	-3.41
8/1/2002	C3	247	264.07	16.86
11/1/2002	C3	247	250.33	3.12
3/1/2003	C3	247	234.33	-12.88
3/1/2004	C3	212	197.19	-14.7
3/1/2005	C3	177	181.38	4.81
3/1/2006	C3	177	160.07	-16.51
2/1/2007	C3	141	137.45	-3.81
3/1/2008	C3	141	132.76	-8.5
6/1/1997	C4	0	1.96	1.96
2/1/2000	C4	0	2.32	2.32
1/1/2002	C4	0	1.89	1.89
5/1/2002	C4	0	1.84	1.84
8/1/2002	C4	0	1.81	1.81
11/1/2002	C4	0	1.78	1.78
3/1/2003	C4	0	1.74	1.74
3/1/2004	C4	0	1.64	1.64
3/1/2005	C4	0	1.61	1.61
3/1/2006	C4	0	1.53	1.53
2/1/2007	C4	0	1.46	1.46

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
3/1/2008	C4	0	1.37	1.37
6/1/1997	C5	1307	1322.54	15.9
2/1/2000	C5	1165	1180.29	14.9
5/1/2002	C5	989	997.52	8.71
8/1/2002	C5	989	973.25	-15.57
11/1/2002	C5	953	949.25	-4.24
3/1/2003	C5	918	918.45	0.26
3/1/2004	C5	812	827.28	15.04
3/1/2005	C5	777	759.89	-17.03
3/1/2006	C5	671	678.12	7.14
2/1/2007	C5	600	601.5	1.15
3/1/2008	C5	530	539.05	9.33
6/1/1997	C9	0	0.05	0.05
2/1/2000	C9	0	0.13	0.13
5/1/2002	C9	0	0.15	0.15
8/1/2002	C9	0	0.14	0.14
11/1/2002	C9	0	0.14	0.14
3/1/2003	C9	0	0.14	0.14
3/1/2004	C9	0	0.14	0.14
3/1/2005	C9	0	0.15	0.15
3/1/2006	C9	0	0.15	0.15
2/1/2007	C9	0	0.14	0.14
3/1/2008	C9	0	0.14	0.14
6/1/1997	C10	212	207.67	-4.22
2/1/2000	C10	177	177.67	1.09
5/1/2002	C10	71	67.3	-3.33
8/1/2002	C10	71	63.27	-7.36
11/1/2002	C10	71	59.53	-11.1
3/1/2003	C10	71	55.21	-15.42
3/1/2004	C10	35	45.75	10.43
3/1/2005	C10	35	37.75	2.44
3/1/2006	C10	35	36.41	1.1
2/1/2007	C10	35	33.52	-1.8
3/1/2008	C10	35	28.97	-6.34
1/1/2002	C12	177	189.34	12.76
5/1/2002	C12	177	187.07	10.5
8/1/2002	C12	177	185.57	9
11/1/2002	C12	177	184.18	7.61
3/1/2003	C12	177	182.75	6.18
3/1/2004	C12	177	180.99	4.41
3/1/2005	C12	177	180.51	3.94
3/1/2006	C12	177	176.92	0.34
2/1/2007	C12	177	167.45	-9.13

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
3/1/2008	C12	141	155.69	14.43
1/1/2002	C13	0	15.18	15.18
5/1/2002	C13	0	14.67	14.67
8/1/2002	C13	0	14.3	14.3
11/1/2002	C13	0	13.95	13.95
3/1/2003	C13	0	13.54	13.54
3/1/2004	C13	0	12.61	12.61
3/1/2005	C13	0	11.76	11.76
3/1/2006	C13	0	11.04	11.04
2/1/2007	C13	0	10.06	10.06
3/1/2008	C13	0	8.77	8.77
3/1/2005	C14	0	2.5	2.5
3/1/2006	C14	0	2.47	2.47
2/1/2007	C14	0	2.37	2.37
3/1/2008	C14	0	2.17	2.17
2/1/2007	C15-D	0	0	0
3/1/2008	C15-D	0	0	0
2/1/2007	C15-S	0	0.7	0.7
3/1/2008	C15-S	0	0.72	0.72
2/1/2007	C16	0	1.06	1.06
3/1/2008	C16	0	1.12	1.12
2/1/2007	C17-D	0	0.15	0.15
3/1/2008	C17-D	0	0.18	0.18
2/1/2007	C17-S	0	0.15	0.15
3/1/2008	C17-S	0	0.18	0.18
2/1/2007	C18	71	57.2	-13.43
3/1/2008	C18	71	57.85	-12.78
6/1/1997	FWC-11	848	840.1	-7.45
2/1/2000	FWC-11	812	814.04	1.8
1/1/2002	FWC-11	742	758.42	16.81
5/1/2002	FWC-11	742	744.37	2.77
8/1/2002	FWC-11	742	733.6	-8.01
11/1/2002	FWC-11	706	722.82	16.53
3/1/2003	FWC-11	706	708.92	2.62
3/1/2004	FWC-11	671	667.79	-3.19
3/1/2005	FWC-11	636	638.38	2.72
3/1/2006	FWC-11	600	598.3	-2.05
2/1/2007	FWC-11	565	552.3	-12.74
3/1/2008	FWC-11	494	510.69	16.28
6/1/1997	FWS-12	565	577.02	11.99
2/1/2000	FWS-12	530	540.71	10.99
1/1/2002	FWS-12	318	307.21	-10.62
5/1/2002	FWS-12	283	286.97	4.45

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
8/1/2002	FWS-12	283	270.99	-11.52
11/1/2002	FWS-12	247	255.68	8.48
3/1/2003	FWS-12	247	237.34	-9.87
3/1/2004	FWS-12	212	196.5	-15.39
3/1/2005	FWS-12	177	189.46	12.88
3/1/2006	FWS-12	177	161.56	-15.01
2/1/2007	FWS-12	106	110.59	4.65
3/1/2008	FWS-12	71	81.32	10.69
6/1/1997	FWS-13	1201	1188.33	-12.37
2/1/2000	FWS-13	1024	1040.89	16.77
1/1/2002	FWS-13	883	892.95	10.08
5/1/2002	FWS-13	848	852.77	5.22
8/1/2002	FWS-13	812	820.69	8.46
11/1/2002	FWS-13	777	787.96	11.04
3/1/2003	FWS-13	742	743.93	2.33
3/1/2004	FWS-13	600	609.43	9.08
3/1/2005	FWS-13	494	499.76	5.36
3/1/2006	FWS-13	388	394.47	6.01
2/1/2007	FWS-13	318	314.12	-3.71
3/1/2008	FWS-13	247	239.71	-7.49
5/1/2002	RWC-1	353	349.08	-4.06
8/1/2002	RWC-1	353	344.46	-8.68
11/1/2002	RWC-1	353	339.59	-13.55
3/1/2003	RWC-1	318	333.25	15.42
3/1/2004	RWC-1	318	315.77	-2.06
3/1/2005	RWC-1	318	302.14	-15.69
3/1/2006	RWC-1	283	285.52	3
2/1/2007	RWC-1	247	257.03	9.83
3/1/2008	RWC-1	247	234.51	-12.7
2/1/2000	RWC-2	106	120.26	14.32
1/1/2002	RWC-2	106	98.78	-7.17
5/1/2002	RWC-2	106	94.91	-11.03
8/1/2002	RWC-2	106	92.26	-13.68
11/1/2002	RWC-2	106	89.8	-16.14
3/1/2003	RWC-2	71	87.15	16.52
3/1/2004	RWC-2	71	81.63	11
3/1/2005	RWC-2	71	73.83	3.2
3/1/2006	RWC-2	71	72.89	2.26
2/1/2007	RWC-2	71	67.26	-3.37
3/1/2008	RWC-2	71	58.75	-11.88
5/1/2002	RWS-1A	247	252.3	5.1
8/1/2002	RWS-1A	247	230.07	-17.13
11/1/2002	RWS-1A	212	210.56	-1.33

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
3/1/2003	RWS-1A	177	187.77	11.2
3/1/2004	RWS-1A	141	135.71	-5.54
3/1/2005	RWS-1A	106	105.51	-0.44
3/1/2006	RWS-1A	71	87.15	16.52
2/1/2007	RWS-1A	71	74.44	3.81
3/1/2008	RWS-1A	35	44.53	9.21
5/1/2002	RWS-2A	424	410.56	-13.22
1/1/2002	RWS-2A	459	463.7	4.61
8/1/2002	RWS-2A	388	376.75	-11.71
11/1/2002	RWS-2A	353	347.03	-6.12
3/1/2003	RWS-2A	318	313.2	-4.64
3/1/2004	RWS-2A	247	234.28	-12.92
3/1/2005	RWS-2A	177	163.89	-12.68
3/1/2006	RWS-2A	141	153.47	12.21
2/1/2007	RWS-2A	141	126.41	-14.85
3/1/2008	RWS-2A	71	83.48	12.85
1/1/2002	RWS-3A	565	576.44	11.4
5/1/2002	RWS-3A	530	537.69	7.97
8/1/2002	RWS-3A	494	508.57	14.17
11/1/2002	RWS-3A	494	480.11	-14.29
3/1/2003	RWS-3A	459	445.13	-13.96
3/1/2004	RWS-3A	353	351.52	-1.63
3/1/2005	RWS-3A	283	273.41	-9.11
3/1/2006	RWS-3A	212	226.94	15.06
2/1/2007	RWS-3A	177	182.61	6.04
3/1/2008	RWS-3A	141	136.94	-4.32
1/1/2002	RWS-4A	388	376.18	-12.28
5/1/2002	RWS-4A	353	370.51	17.36
8/1/2002	RWS-4A	353	363.18	10.03
11/1/2002	RWS-4A	353	354.54	1.39
3/1/2003	RWS-4A	353	343.27	-9.88
3/1/2004	RWS-4A	318	307.24	-10.59
3/1/2005	RWS-4A	247	249	1.79
3/1/2006	RWS-4A	212	226.94	15.05
2/1/2007	RWS-4A	177	191.67	15.1
3/1/2008	RWS-4A	141	144.9	3.64
6/1/1997	S1	0	0.07	0.07
2/1/2000	S1	0	0.04	0.04
5/1/2002	S1	0	0.02	0.02
8/1/2002	S1	0	0.02	0.02
11/1/2002	S1	0	0.02	0.02
3/1/2003	S1	0	0.02	0.02
3/1/2004	S1	0	0.01	0.01

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
3/1/2005	S1	0	0.01	0.01
3/1/2006	S1	0	0.01	0.01
2/1/2007	S1	0	0.01	0.01
3/1/2008	S1	0	0	0
6/1/1997	S2	141	124.51	-16.75
2/1/2000	S2	71	61.79	-8.84
5/1/2002	S2	35	26.24	-9.08
8/1/2002	S2	35	23.48	-11.83
11/1/2002	S2	35	21.07	-14.25
3/1/2003	S2	35	18.38	-16.93
3/1/2004	S2	0	12.8	12.8
3/1/2005	S2	0	9.8	9.8
3/1/2006	S2	0	7.46	7.46
2/1/2007	S2	0	5.77	5.77
3/1/2008	S2	0	4.94	4.94
6/1/1997	S3	1024	1037.81	13.68
2/1/2000	S3	706	713.61	7.31
5/1/2002	S3	318	312.68	-5.15
8/1/2002	S3	283	275.86	-6.66
11/1/2002	S3	247	245.39	-1.82
3/1/2003	S3	212	212.9	1.01
3/1/2004	S3	141	149.53	8.27
3/1/2005	S3	106	118.13	12.18
3/1/2006	S3	106	91.02	-14.93
2/1/2007	S3	71	72.79	2.16
3/1/2008	S3	71	64.85	-5.77
6/1/1997	S4	106	102.11	-3.84
2/1/2000	S4	106	118.47	12.53
3/1/2004	S4	35	28.26	-7.05
3/1/2005	S4	35	22.1	-13.22
3/1/2006	S4	0	16.19	16.19
2/1/2007	S4	0	12.9	12.9
3/1/2008	S4	0	9.89	9.89
6/1/1997	S5	1624	1614.87	-9.61
2/1/2000	S5	989	974.99	-13.82
5/1/2002	S5	494	489.5	-4.9
8/1/2002	S5	459	448.69	-10.4
11/1/2002	S5	424	411.03	-12.75
3/1/2003	S5	353	365.41	12.27
3/1/2004	S5	247	250.4	3.19
3/1/2005	S5	177	182.23	5.65
3/1/2006	S5	141	128.28	-12.98
2/1/2007	S5	106	95	-10.94

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
3/1/2008	S5	71	70.59	-0.04
6/1/1997	S6	0	13.15	13.15
2/1/2000	S6	0	6.87	6.87
8/1/2002	S6	0	2.87	2.87
11/1/2002	S6	0	2.6	2.6
3/1/2003	S6	0	2.3	2.3
3/1/2004	S6	0	1.62	1.62
3/1/2005	S6	0	1.22	1.22
3/1/2006	S6	0	0.92	0.92
2/1/2007	S6	0	0.7	0.7
3/1/2008	S6	0	0.54	0.54
6/1/1997	S7	71	85.53	14.91
8/1/2002	S7	0	15.71	15.71
11/1/2002	S7	0	14.1	14.1
3/1/2003	S7	0	12.29	12.29
3/1/2004	S7	0	8.28	8.28
3/1/2005	S7	0	6.06	6.06
3/1/2006	S7	0	4.33	4.33
2/1/2007	S7	0	3.21	3.21
3/1/2008	S7	0	2.72	2.72
6/1/1997	S8	0	17.28	17.28
2/1/2000	S8	0	13.01	13.01
5/1/2002	S8	0	5.78	5.78
8/1/2002	S8	0	5.15	5.15
11/1/2002	S8	0	4.6	4.6
3/1/2003	S8	0	3.97	3.97
3/1/2004	S8	0	2.64	2.64
3/1/2005	S8	0	1.87	1.87
3/1/2006	S8	0	1.27	1.27
2/1/2007	S8	0	0.87	0.87
3/1/2008	S8	0	0.61	0.61
6/1/1997	S9	35	46.58	11.27
2/1/2000	S9	35	52.71	17.39
5/1/2002	S9	35	23.64	-11.67
8/1/2002	S9	35	20.85	-14.47
11/1/2002	S9	35	18.39	-16.92
3/1/2003	S9	0	15.66	15.66
3/1/2004	S9	0	9.92	9.92
3/1/2005	S9	0	7.29	7.29
3/1/2006	S9	0	4.7	4.7
2/1/2007	S9	0	2.96	2.96
3/1/2008	S9	0	2.04	2.04
6/1/1997	S10	494	505.03	10.62

Table 1. Comparison of Simulated PCE Values with Original Truncated Precision and Corrected Full Precision

Date	Well	Simulated PCE Concentration (µg/L) Original Truncated Precision	Simulated PCE Concentration (µg/L) Corrected Full Precision	Difference
2/1/2000	S10	494	501.67	7.27
1/1/2002	S10	494	481.5	-12.91
5/1/2002	S10	459	475.01	15.92
8/1/2002	S10	459	470.05	10.96
11/1/2002	S10	459	465.03	5.94
3/1/2003	S10	459	457.9	-1.19
3/1/2004	S10	424	435.43	11.65
3/1/2005	S10	424	414.73	-9.04
3/1/2006	S10	388	386.07	-2.39
2/1/2007	S10	353	356.43	3.28
3/1/2008	S10	318	325.82	7.99
6/1/1997	S11	0	0	0
2/1/2000	S11	0	0	0
3/1/2005	S14	0	10.36	10.36
3/1/2006	S14	0	8.5	8.5
2/1/2007	S14	0	6.89	6.89
3/1/2008	S14	0	5.29	5.29

Note:
PCE = tetrachloroethylene

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
2/1/2000	C1	0	0.04	0.04
5/1/2002	C1	0	0.03	0.03
8/1/2002	C1	0	0.03	0.03
11/1/2002	C1	0	0.03	0.03
3/1/2003	C1	0	0.03	0.03
3/1/2004	C1	0	0.03	0.03
3/1/2005	C1	0	0.03	0.03
3/1/2006	C1	0	0.02	0.02
2/1/2007	C1	0	0.02	0.02
3/1/2008	C1	0	0.02	0.02
6/1/1997	C2	1095	1316.4	221.64
2/1/2000	C2	742	900.8	159.19
5/1/2002	C2	459	580.6	121.51
8/1/2002	C2	459	548.86	89.77
11/1/2002	C2	424	518.92	95.15
3/1/2003	C2	388	482.65	94.19
3/1/2004	C2	318	389.28	71.45
3/1/2005	C2	247	321.59	74.38
3/1/2006	C2	212	261.33	49.44
2/1/2007	C2	177	214.18	37.61
3/1/2008	C2	141	176.88	35.63
6/1/1997	C3	388	434.52	46.06
2/1/2000	C3	388	439.84	51.37
5/1/2002	C3	283	307.28	24.76
8/1/2002	C3	247	290.84	43.64
11/1/2002	C3	247	275.9	28.7
3/1/2003	C3	247	258.55	11.35
3/1/2004	C3	212	218.29	6.41
3/1/2005	C3	177	201.45	24.87
3/1/2006	C3	177	177.93	1.36
2/1/2007	C3	141	153.16	11.9
3/1/2008	C3	141	148.59	7.33
6/1/1997	C4	0	1.96	1.96
2/1/2000	C4	0	2.32	2.32
1/1/2002	C4	0	1.9	1.9
5/1/2002	C4	0	1.85	1.85
8/1/2002	C4	0	1.81	1.81
11/1/2002	C4	0	1.78	1.78
3/1/2003	C4	0	1.74	1.74
3/1/2004	C4	0	1.64	1.64
3/1/2005	C4	0	1.62	1.62
3/1/2006	C4	0	1.54	1.54
2/1/2007	C4	0	1.47	1.47
3/1/2008	C4	0	1.38	1.38
6/1/1997	C5	1307	1326.87	20.22
2/1/2000	C5	1165	1190.26	24.87
5/1/2002	C5	989	1009.86	21.05
8/1/2002	C5	989	985.68	-3.13

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
11/1/2002	C5	953	961.76	8.27
3/1/2003	C5	918	931.03	12.85
3/1/2004	C5	812	839.91	27.67
3/1/2005	C5	777	772.91	-4.02
3/1/2006	C5	671	690.68	19.7
2/1/2007	C5	600	613.37	13.02
3/1/2008	C5	530	551.21	21.48
6/1/1997	C9	0	0.06	0.06
2/1/2000	C9	0	0.16	0.16
5/1/2002	C9	0	0.18	0.18
8/1/2002	C9	0	0.18	0.18
11/1/2002	C9	0	0.18	0.18
3/1/2003	C9	0	0.18	0.18
3/1/2004	C9	0	0.18	0.18
3/1/2005	C9	0	0.19	0.19
3/1/2006	C9	0	0.19	0.19
2/1/2007	C9	0	0.18	0.18
3/1/2008	C9	0	0.17	0.17
6/1/1997	C10	212	222.31	10.42
2/1/2000	C10	177	199.93	23.36
5/1/2002	C10	71	73.7	3.07
8/1/2002	C10	71	69.19	-1.44
11/1/2002	C10	71	65.02	-5.61
3/1/2003	C10	71	60.18	-10.45
3/1/2004	C10	35	49.48	14.17
3/1/2005	C10	35	40.32	5
3/1/2006	C10	35	38.86	3.54
2/1/2007	C10	35	35.65	0.33
3/1/2008	C10	35	30.46	-4.85
1/1/2002	C12	177	190.3	13.73
5/1/2002	C12	177	188.12	11.55
8/1/2002	C12	177	186.68	10.1
11/1/2002	C12	177	185.33	8.76
3/1/2003	C12	177	183.96	7.39
3/1/2004	C12	177	182.37	5.8
3/1/2005	C12	177	181.97	5.4
3/1/2006	C12	177	178.52	1.94
2/1/2007	C12	177	169.07	-7.51
3/1/2008	C12	141	157.22	15.96
1/1/2002	C13	0	15.21	15.21
5/1/2002	C13	0	14.7	14.7
8/1/2002	C13	0	14.34	14.34
11/1/2002	C13	0	13.98	13.98
3/1/2003	C13	0	13.57	13.57
3/1/2004	C13	0	12.66	12.66
3/1/2005	C13	0	11.81	11.81
3/1/2006	C13	0	11.1	11.1
2/1/2007	C13	0	10.12	10.12

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
3/1/2008	C13	0	8.83	8.83
3/1/2005	C14	0	2.5	2.5
3/1/2006	C14	0	2.48	2.48
2/1/2007	C14	0	2.37	2.37
3/1/2008	C14	0	2.17	2.17
2/1/2007	C15-D	0	0	0
3/1/2008	C15-D	0	0	0
2/1/2007	C15-S	0	0.7	0.7
3/1/2008	C15-S	0	0.72	0.72
2/1/2007	C16	0	1.06	1.06
3/1/2008	C16	0	1.12	1.12
2/1/2007	C17-D	0	0.15	0.15
3/1/2008	C17-D	0	0.18	0.18
2/1/2007	C17-S	0	0.15	0.15
3/1/2008	C17-S	0	0.18	0.18
2/1/2007	C18	71	57.22	-13.41
3/1/2008	C18	71	57.87	-12.76
6/1/1997	FWC-11	848	840.57	-6.98
2/1/2000	FWC-11	812	815.82	3.58
1/1/2002	FWC-11	742	760.83	19.22
5/1/2002	FWC-11	742	746.89	5.28
8/1/2002	FWC-11	742	736.19	-5.41
11/1/2002	FWC-11	706	725.49	19.19
3/1/2003	FWC-11	706	711.68	5.39
3/1/2004	FWC-11	671	670.83	-0.15
3/1/2005	FWC-11	636	641.83	6.16
3/1/2006	FWC-11	600	601.95	1.6
2/1/2007	FWC-11	565	556.03	-9.01
3/1/2008	FWC-11	494	514.79	20.38
6/1/1997	FWS-12	565	605.2	40.17
2/1/2000	FWS-12	530	607.3	77.58
1/1/2002	FWS-12	318	362.09	44.26
5/1/2002	FWS-12	283	340.91	58.4
8/1/2002	FWS-12	283	323.49	40.97
11/1/2002	FWS-12	247	306.42	59.22
3/1/2003	FWS-12	247	285.52	38.31
3/1/2004	FWS-12	212	236.65	24.76
3/1/2005	FWS-12	177	226.34	49.76
3/1/2006	FWS-12	177	194.09	17.52
2/1/2007	FWS-12	106	131.8	25.86
3/1/2008	FWS-12	71	94.64	24.01
6/1/1997	FWS-13	1201	1215.23	14.53
2/1/2000	FWS-13	1024	1107.38	83.25
1/1/2002	FWS-13	883	959.83	76.97
5/1/2002	FWS-13	848	917.47	69.92
8/1/2002	FWS-13	812	883.55	71.31
11/1/2002	FWS-13	777	848.85	71.92
3/1/2003	FWS-13	742	802.06	60.45

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (μg/L) Original	Simulated PCE Concentration (μg/L) Updated	Difference
3/1/2004	FWS-13	600	658.46	58.11
3/1/2005	FWS-13	494	543.52	49.12
3/1/2006	FWS-13	388	429.96	41.5
2/1/2007	FWS-13	318	341.03	23.2
3/1/2008	FWS-13	247	259.6	12.4
5/1/2002	RWC-1	353	360.92	7.77
8/1/2002	RWC-1	353	356.8	3.65
11/1/2002	RWC-1	353	352.36	-0.79
3/1/2003	RWC-1	318	346.48	28.64
3/1/2004	RWC-1	318	329.75	11.92
3/1/2005	RWC-1	318	316.15	-1.69
3/1/2006	RWC-1	283	298.96	16.44
2/1/2007	RWC-1	247	270	22.8
3/1/2008	RWC-1	247	246.9	-0.3
2/1/2000	RWC-2	106	124.38	18.44
1/1/2002	RWC-2	106	102.55	-3.39
5/1/2002	RWC-2	106	98.4	-7.54
8/1/2002	RWC-2	106	95.58	-10.36
11/1/2002	RWC-2	106	92.98	-12.97
3/1/2003	RWC-2	71	90.16	19.53
3/1/2004	RWC-2	71	84.29	13.66
3/1/2005	RWC-2	71	76.21	5.58
3/1/2006	RWC-2	71	75.2	4.57
2/1/2007	RWC-2	71	69.28	-1.35
3/1/2008	RWC-2	71	60.39	-10.24
5/1/2002	RWS-1A	247	380.65	133.45
8/1/2002	RWS-1A	247	342.01	94.81
11/1/2002	RWS-1A	212	308.75	96.86
3/1/2003	RWS-1A	177	270.86	94.29
3/1/2004	RWS-1A	141	187.28	46.02
3/1/2005	RWS-1A	106	141.68	35.73
3/1/2006	RWS-1A	71	111.86	41.23
2/1/2007	RWS-1A	71	93.16	22.53
3/1/2008	RWS-1A	35	56.99	21.68
5/1/2002	RWS-2A	424	609.72	185.95
1/1/2002	RWS-2A	459	697.9	238.81
8/1/2002	RWS-2A	388	554.12	165.66
11/1/2002	RWS-2A	353	505.35	152.2
3/1/2003	RWS-2A	318	450	132.17
3/1/2004	RWS-2A	247	322.81	75.61
3/1/2005	RWS-2A	177	231.7	55.12
3/1/2006	RWS-2A	141	195.03	53.78
2/1/2007	RWS-2A	141	155.12	13.87
3/1/2008	RWS-2A	71	105.2	34.57
1/1/2002	RWS-3A	565	734.63	169.59
5/1/2002	RWS-3A	530	685.63	155.91
8/1/2002	RWS-3A	494	647.45	153.04
11/1/2002	RWS-3A	494	609.53	115.12

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
3/1/2003	RWS-3A	459	562.36	103.27
3/1/2004	RWS-3A	353	435.76	82.61
3/1/2005	RWS-3A	283	342.42	59.9
3/1/2006	RWS-3A	212	277.36	65.47
2/1/2007	RWS-3A	177	213.69	37.12
3/1/2008	RWS-3A	141	157.95	16.7
1/1/2002	RWS-4A	388	413.29	24.83
5/1/2002	RWS-4A	353	406.97	53.83
8/1/2002	RWS-4A	353	399.1	45.95
11/1/2002	RWS-4A	353	389.75	36.6
3/1/2003	RWS-4A	353	377.41	24.26
3/1/2004	RWS-4A	318	337.47	19.64
3/1/2005	RWS-4A	247	276.72	29.52
3/1/2006	RWS-4A	212	251.29	39.41
2/1/2007	RWS-4A	177	209.57	33
3/1/2008	RWS-4A	141	157.5	16.24
6/1/1997	S1	0	0.11	0.11
2/1/2000	S1	0	0.06	0.06
5/1/2002	S1	0	0.03	0.03
8/1/2002	S1	0	0.03	0.03
11/1/2002	S1	0	0.03	0.03
3/1/2003	S1	0	0.02	0.02
3/1/2004	S1	0	0.02	0.02
3/1/2005	S1	0	0.01	0.01
3/1/2006	S1	0	0.01	0.01
2/1/2007	S1	0	0.01	0.01
3/1/2008	S1	0	0.01	0.01
6/1/1997	S2	141	207.79	66.53
2/1/2000	S2	71	95.18	24.55
5/1/2002	S2	35	38.63	3.31
8/1/2002	S2	35	34.41	-0.9
11/1/2002	S2	35	30.73	-4.58
3/1/2003	S2	35	26.65	-8.67
3/1/2004	S2	0	18.16	18.16
3/1/2005	S2	0	13.62	13.62
3/1/2006	S2	0	10.18	10.18
2/1/2007	S2	0	7.79	7.79
3/1/2008	S2	0	6.57	6.57
6/1/1997	S3	1024	1321.69	297.57
2/1/2000	S3	706	1001.42	295.12
5/1/2002	S3	318	451.57	133.73
8/1/2002	S3	283	397.13	114.62
11/1/2002	S3	247	352.03	104.83
3/1/2003	S3	212	303.81	91.92
3/1/2004	S3	141	207.92	66.66
3/1/2005	S3	106	167.82	61.88
3/1/2006	S3	106	119.56	13.62
2/1/2007	S3	71	91.67	21.04

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
3/1/2008	S3	71	82.39	11.76
6/1/1997	S4	106	102.72	-3.23
2/1/2000	S4	106	121.75	15.8
3/1/2004	S4	35	29.29	-6.02
3/1/2005	S4	35	22.94	-12.38
3/1/2006	S4	0	16.81	16.81
2/1/2007	S4	0	13.37	13.37
3/1/2008	S4	0	10.24	10.24
6/1/1997	S5	1624	1773.95	149.47
2/1/2000	S5	989	1136.51	147.7
5/1/2002	S5	494	584.04	89.63
8/1/2002	S5	459	534.73	75.64
11/1/2002	S5	424	489.23	65.46
3/1/2003	S5	353	434.22	81.08
3/1/2004	S5	247	295.95	48.74
3/1/2005	S5	177	216.07	39.5
3/1/2006	S5	141	150.33	9.08
2/1/2007	S5	106	109.32	3.37
3/1/2008	S5	71	80.8	10.17
6/1/1997	S6	0	21.11	21.11
2/1/2000	S6	0	10.5	10.5
8/1/2002	S6	0	4.26	4.26
11/1/2002	S6	0	3.85	3.85
3/1/2003	S6	0	3.38	3.38
3/1/2004	S6	0	2.35	2.35
3/1/2005	S6	0	1.73	1.73
3/1/2006	S6	0	1.28	1.28
2/1/2007	S6	0	0.97	0.97
3/1/2008	S6	0	0.74	0.74
6/1/1997	S7	71	134.14	63.51
8/1/2002	S7	0	23.27	23.27
11/1/2002	S7	0	20.84	20.84
3/1/2003	S7	0	18.07	18.07
3/1/2004	S7	0	11.97	11.97
3/1/2005	S7	0	8.59	8.59
3/1/2006	S7	0	6.02	6.02
2/1/2007	S7	0	4.38	4.38
3/1/2008	S7	0	3.64	3.64
6/1/1997	S8	0	27.91	27.91
2/1/2000	S8	0	22.16	22.16
5/1/2002	S8	0	9.98	9.98
8/1/2002	S8	0	8.89	8.89
11/1/2002	S8	0	7.93	7.93
3/1/2003	S8	0	6.85	6.85
3/1/2004	S8	0	4.54	4.54
3/1/2005	S8	0	3.2	3.2
3/1/2006	S8	0	2.16	2.16
2/1/2007	S8	0	1.46	1.46

Table 2. Simulated PCE Concentrations for Original and Updated Post-Audit Models

Date	Well	Simulated PCE Concentration (µg/L) Original	Simulated PCE Concentration (µg/L) Updated	Difference
3/1/2008	S8	0	1.01	1.01
6/1/1997	S9	35	57.92	22.6
2/1/2000	S9	35	73.25	37.93
5/1/2002	S9	35	35.02	-0.29
8/1/2002	S9	35	31.03	-4.29
11/1/2002	S9	35	27.5	-7.82
3/1/2003	S9	0	23.55	23.55
3/1/2004	S9	0	15.17	15.17
3/1/2005	S9	0	11.39	11.39
3/1/2006	S9	0	7.41	7.41
2/1/2007	S9	0	4.68	4.68
3/1/2008	S9	0	3.25	3.25
6/1/1997	S10	494	505.27	10.86
2/1/2000	S10	494	503.55	9.15
1/1/2002	S10	494	484.38	-10.02
5/1/2002	S10	459	477.98	18.89
8/1/2002	S10	459	473.09	14
11/1/2002	S10	459	468.13	9.03
3/1/2003	S10	459	461.09	2
3/1/2004	S10	424	438.9	15.12
3/1/2005	S10	424	418.76	-5.02
3/1/2006	S10	388	390.31	1.85
2/1/2007	S10	353	360.66	7.51
3/1/2008	S10	318	330.09	12.26
6/1/1997	S11	0	0	0
2/1/2000	S11	0	0	0
3/1/2005	S14	0	10.43	10.43
3/1/2006	S14	0	8.57	8.57
2/1/2007	S14	0	6.94	6.94
3/1/2008	S14	0	5.34	5.34

Note:
PCE = tetrachloroethylene

Exhibit 1

Resume for R. Jeffrey Davis

R. Jeffrey Davis, P.E., CGWP, CWRE

Principal, Water Resources

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Salt Lake City, UT

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Education & Credentials

M.S., Civil & Environmental Engineering, Brigham Young University, Provo, Utah, 1998

B.S., Civil & Environmental Engineering, Brigham Young University, Provo, Utah, 1993

Professional Engineer, Utah (License No. 189690-2202), Texas (License No. 125406), Florida (License No. 74838), Colorado (License No. 0051575), Alabama (License No. PE52096), Idaho (License No. P-21839), Oregon (License No. 104270PE)

Certified Groundwater Professional, NGWA (2023)

Certified Water Rights Examiner, Oregon (License No. 104270)

Continuing Education

Certificate of Specialization in Leadership and Management, Harvard Business School Online (2023)

MSHA certified (2020)

First Aid and CPR certified (2020)

Professional Affiliations

National Ground Water Association

Mr. Jeff Davis is a licensed civil and environmental engineer, hydrogeologist, and certified groundwater professional with almost 30 years of global experience working on every continent except Antarctica. He currently serves on the Board of Directors for the National Ground Water Association. Mr. Davis has supported numerous litigation cases involving groundwater impacts and has experience as an expert witness. He has spent much of his career solving complicated water problems involving mining, oil and gas, and water resources. These projects include the clean water supply side as well as the remediation of contaminated sites. The contaminated sites include coal combustion residual (CCR) landfills and other waste impoundments, mining remediation sites, and industrial cleanup sites—both RCRA and CERCLA sites. In working with per- and polyfluoroalkyl substance (PFAS) compounds, MTBE, chlorinated solvents, hydrocarbons, nitrates, and road salt, he has developed and used numerous groundwater models for the mining, energy, chemical, and agricultural industries. Other projects have involved environmental impact statements, environmental assessments, sea level rise and groundwater intrusion, water management, groundwater–surface water contamination, dewatering, natural resource damage assessment, and water supply and treatment. He has extensive knowledge of groundwater flow-and-transport principles and has taught numerous workshops and classes in the U.S. and around the world. His current focus is on water and groundwater sustainability and drought resiliency. Mr. Davis has extensive experience in the design and implementation of aquifer storage and recovery (ASR) projects across the country.

Relevant Experience

WATER MANAGEMENT

Water Supply and ASR Feasibility, Sacramento County, California — Served as principal investigator for a proposed land development project that evaluated the feasibility of developing a reliable water supply and implementing an ASR program. Key tasks included constructing a conceptual hydrogeologic model and conducting a geophysical survey to characterize the subsurface. The study provided critical insights into sustainable water management options to support the development while ensuring long-term resource stability.

Water Rights and Supply Analysis, Umatilla County, Oregon — Served as principal investigator for a project that involved a water rights and water supply study for an industrial client in eastern Oregon. The client was facing curtailment of groundwater withdrawals by the Oregon Water

Professional Affiliations (con't.)

Utah Groundwater Association

Groundwater Resources Association of California

Resources Department. The department alleged that the client's pumping was impacting nearby stream flows, prompting a detailed analysis of hydrogeologic data and monitoring records. The study demonstrated minimal to no connection between the groundwater pumping and river flows, providing critical evidence to support the client's continued water use.

ASR Feasibility, Ada County, Idaho — Served as principal investigator for a feasibility study for an ASR project. Ada County owns and operates Hubbard Reservoir, which receives irrigation water from the New York Canal. The project included building a conceptual model of the site and refining an existing groundwater model to analyze the effects of recharge from the reservoir.

ASR Feasibility and Piloting, Utah County, Utah — Served as principal investigator for a feasibility study for an ASR project. During the spring runoff of 2023, the team measured the runoff in several rivers, creeks, and ditches, and constructed a new infiltration basin, all in an effort to advance aquifer storage projects within the county. The project has continued with permitting and the implementation of a pilot project for the constructed infiltration basin.

ASR Feasibility, Utah County, Utah — Served as principal for a feasibility study for an ASR project. Former agricultural water rights were converted for industrial use and the effluent was being considered for aquifer replenishment. Both infiltration and direct injection of the treated water were considered as part of the feasibility study.

Provo ASR, Provo, Utah — Served as the project manager and engineer of record for the current Provo ASR project. Five sites (three infiltration and two direct injection) are currently permitted for pilot studies that have been ongoing since 2020. Final engineering design and permitting have been completed for all five sites.

Water Reuse and Aquifer Sustainability, Eagle Mountain, Utah — Served as the client manager and engineer of record for the current Eagle Mountain City, Utah, water-reuse planning and aquifer sustainability project. Water rights for Eagle Mountain were evaluated along with the groundwater system to understand aquifer sustainability for the city, which is expecting tremendous future growth, including large industrial water demands.

ASR Evaluation, Weber County, Utah — Served as the project manager and engineer of record for the current evaluation of the Weber Basin Water Conservancy District, Utah, ASR project. This project has been actively operating for more than 10 years. Hired to evaluate the storage capacity of the program and obtain greater recovery volumes from the system, working with the Utah Division of Water Rights.

Drainage Reuse Initiative, Harris County, Texas — Served as part of a team for the development of the Drainage Reuse Initiative for Harris County Flood Control District in Harris County, Texas. The project investigated the feasibility of alternative methods of flood mitigation by conveying stormwater to the subsurface, including natural infiltration to groundwater, enhanced infiltration or injection into aquifers, and mechanical injection to deep aquifers.

Roseville ASR, Roseville, California — Served as one of the groundwater leads for the development of an ASR program for the city of Roseville, California. Initial efforts involved developing a regional- scale conceptualization for the major portion of the Central Valley area.

Developed a subsequent regional multilayer groundwater model, followed by a number of local-scale transport models to simulate pilot tests and understand the ASR process.

COAL COMBUSTION FACILITIES

Coal Combustion Residual Waste and Disposal, Bonanza, Utah — Served as the engineer of record for a coal power plant. Oversaw all efforts related to the monitoring and compliance of the facility's CCR waste and disposal. This included semiannual reporting, development of alternative source demonstrations, and annual groundwater monitoring reports.

Hexavalent Chromium Investigation, United States — Served as the principal investigator for a study to understand and evaluate the proposed EPA changes to hexavalent chromium (Cr(VI)) as it would apply to the monitoring and management of CCR landfill facilities. The work included examining potential regulatory levels from a human health perspective.

Alternate Water Sources Investigation, United States — Served as the principal investigator for a study to understand and evaluate differences at CCR facilities between upgradient and downgradient sources, and locate potential evidence of alternate sources using isotopes and microbial fingerprinting. After development of a sampling and analysis plan, advanced statistical and multivariate methods were used to document analyses that show potential for distinguishing source water from alternate sources.

OIL AND GAS WASTE MANAGEMENT

Oil and Gas Waste Facility, De Beque, Colorado — Served as the principal engineer for the permitting and operating of an 800-acre oil-and-gas waste-disposal facility southeast of De Beque, Colorado. Involved in several aspects of the permitting process, including the hydrogeological study and groundwater investigations; stormwater design; pond liner design and construction; closure certification; and submittal of the revised engineering design and operation plan.

Remedial Investigation, Billings, Montana — Served as the groundwater lead for the Yale Oil of South Dakota Facility in Billings, Montana. The Superfund site facility is in the remedial investigation phase; the risk-assessment work plan has been submitted to the Montana Department of Environmental Quality, and the client is waiting for comments before proceeding with the risk assessment.

EPA Study, Washington, DC — Served as participant and technical reviewer for EPA's "Study of Hydraulic Fracturing for Oil and Gas and Its Potential Impact on Drinking Water Resources." Participated in technical roundtables and technical workshops and completed a peer review of the EPA's five retrospective case studies.

Fate and Transport Modeling, Texas — Served as groundwater lead for fate-and-transport modeling and analysis of chloride contamination in southern Texas near the Gulf of Mexico. As part of the site mitigation phase, modeling was used to determine the potential migration of the chloride through the shallow aquifer system and nearby receptors.

Lockwood Solvent Groundwater Plume Site, Billings, Montana — Served as one of the groundwater leads performing groundwater modeling for the Lockwood Solvent Groundwater

Plume site, an EPA Superfund site in Billings, Montana. The site spans 580 acres, and much of the groundwater there is contaminated with volatile organic compounds, including tetrachloroethene, trichloroethene, *cis*-1,2- dichloroethene, and vinyl chloride.

PLANNING AND PERMITTING

Beverage Can Manufacturing and Filling, Salt Lake City, Utah — Served as principal investigator for wastewater, stormwater, and Utah Pollutant Discharge Elimination System permitting, monitoring, and compliance for an aluminum can manufacturing and filling facility. Worked closely with the client, its operations team, and state and municipal regulators to regularly monitor and report all discharges from the facility.

Ely Energy Center EIS, White Pine County, Nevada — Served as principal lead for the development of a regional groundwater model for Steptoe Valley in White Pine County, Nevada. The investigation and model were part of the EIS for construction of the Ely Energy Center.

Haile Gold Mine EIS, Kershaw, South Carolina — Served as groundwater lead as the third-party contractor developing an EIS for the proposed Haile Gold Mine near Kershaw, South Carolina. The EIS analyzed the potential direct, indirect, and cumulative environmental effects of the proposed project and its alternatives. Work included project-team coordination for geology, groundwater, and surface water resources areas; review of applicant-supplied information; agency coordination; and public involvement.

Four Corners Power Plant EIS, Farmington, New Mexico — Served as groundwater lead as the third- party contractor in developing an EIS for the Four Corners Power Plant and Navajo coal mine in Farmington, New Mexico. The EIS analyzed the potential direct, indirect, and cumulative environmental effects of the proposed project and its alternatives. The groundwater portion included analyzing field investigations, pump tests, conceptual and numerical modeling of the project and surrounding area, and remediation and reclamation activities.

Iron Ore Operations Cumulative Impact Assessment, Pilbara, Western Australia — Served as one of the groundwater leads for a cumulative impact assessment for a proposed expansion of iron ore operations in the Pilbara in Western Australia. Work included identifying the methodology and developing the conceptual models to perform the assessment. The groundwater modeling included both quantitative and qualitative approaches.

LITIGATION SUPPORT

Road Salt Contamination Litigation, Boise County, Idaho — Served as the principal lead to support litigation related to road salt contamination of a drinking water aquifer serving private wells in Lowman, Idaho. The contamination was traced to negligent storage practices by the Idaho Department of Transportation, with a conceptual model developed to demonstrate the source and migration of the salt into the aquifer. Provided recommendations to mitigate the contamination, restore groundwater quality, and prevent future impacts to the community's drinking water supply.

PCE Contamination Litigation, Onslow County, North Carolina — Served as a testifying expert for a project involving PCE-contaminated groundwater impacting a public water supply. Performed a post-audit of an existing groundwater fate and transport model to assess its accuracy and reliability and extended the model's time domain to evaluate its performance against updated concentration data from multiple monitoring wells.

ASR Well Design and Construction Litigation, Washington County, Oregon — Served as a testifying expert in a litigation case involving allegations of design and construction failures in an ASR well. The client, accused of lacking standard of care in its engineering services, required a technical review of the well design, construction practices, and operational performance. The analysis provided an expert evaluation of the ASR well' deficiencies and clarified the extent of liability and adherence to professional standards.

Stormwater Pipeline Litigation, Sweetwater County, Wyoming — Served as the engineering expert for a litigation case involving the failure of a stormwater pipeline at a trona ore mining and processing facility, where the client, a construction company, faced accusations of negligence. The work included multiple site visits to assess pipeline conditions and a detailed review of engineering plans to evaluate construction practices and compliance with design specifications. The findings provided critical insights into potential causes of failure and helped clarify the client's responsibilities under standard construction practices.

Expert Witness for PFAS Litigation, Martin County, Florida — Served as the groundwater expert witness for a litigation case in Martin County. The multidistrict litigation bellwether case involved PFAS contamination of groundwater affecting public drinking water. Opinions were given regarding PFAS sourcing, and fate and transport in groundwater, and regarding public water supply planning.

Water Resources Litigation, Grand County, Colorado — Served as principal investigator for a litigation case involving flooding damages caused by a canal breach. Surface water modeling was used to determine amount and extent of erosion and sedimentation from the flooding.

Water Resources Litigation, Northwest Minnesota — Served as principal investigator and expert witness for a litigation case involving agricultural water rights and pumping near tribal lands. Developed a conceptual model to understand the hydrogeological conditions and constructed a groundwater model to determine possible impacts due to the agriculture activities.

Groundwater Litigation, Ventura County, California — Served as the groundwater expert for a litigation case in Ventura County. The case includes the development of a basin-wide groundwater- surface water model, not only for purposes of litigation but also for compliance with Sustainable Groundwater Management Act requirements. The groundwater basin in question is currently listed as a priority basin by the State of California.

Pipeline Spill Litigation, Williston, North Dakota — Provided litigation services for groundwater and surface water contamination from a pipeline spill in North Dakota. A large spill of produced water (brine) impacted surface streams as well as the shallow aquifer system. Work included groundwater modeling, field investigations, and remedial strategies.

Road Salt Contamination Litigation, Vandalia, Ohio — Performed fate-and-transport modeling and analysis of sodium chloride contamination of an aquifer in Vandalia, Ohio. Stored road salt caused limited contamination of a shallow aquifer that supplied drinking water to nearby residential homes. The groundwater model included the local domestic pumping wells, which helped determine the possible extent of chloride impacts. Largely due to the conceptual site model and transport modeling results, litigation was settled out of court to the satisfaction of the client.

CLIMATE IMPACT ASSESSMENT

Sea Level Rise Groundwater Intrusion Modeling, Alameda County, California — Served as the principal groundwater lead and engineer for a project that supported a climate adaptation initiative for the Port of Oakland addressing the impacts of sea level rise on subsurface conditions. The work involved detailed subsurface characterization and groundwater intrusion modeling to assess the potential for rising seawater to affect infrastructure and operations. The analysis provided critical data to inform resilience strategies and adaptation measures for long-term sustainability.

Sea Level Rise Groundwater Intrusion Monitoring, Ventura County, California — Served as the principal groundwater lead and engineer for a project that supported a climate adaptation program for the naval facility at Point Mugu by evaluating groundwater intrusion risks associated with sea level rise. Analyzed groundwater monitoring data to identify trends and data gaps critical for assessing potential impacts on infrastructure and operations as well as habitat. The results informed targeted monitoring and adaptation strategies to enhance the facility's resilience to future climate-related challenges.

Sea Level Rise Groundwater Intrusion Assessment, Santa Barbara County, California — Served as the principal groundwater lead and engineer for a proposed coastal hotel expansion in Santa Barbara County. The project involved reviewing technical studies to assess potential environmental and resource challenges. Critically evaluated key reports, including a sea level rise hazard study, water resource reports, and stormwater and drainage studies, to identify gaps and raise concerns about the feasibility and sustainability of the development. The analysis provided valuable insights to guide decision-making and ensure compliance with long-term coastal resilience and resource management goals.

GROUNDWATER MODELING

Subsidence Monitoring/Modeling, Fort Bend and Harris Counties, Texas — Served as the groundwater lead and engineer on several groundwater development projects in Fort Bend and Harris counties. Groundwater withdrawals are strictly curtailed due to historical subsidence. The Subsidence Districts have installed GPS Port-A-Measure (PAM) units and used InSAR mapping. Using this data plus the output from the models PRESS and MODFLOW-SUB to measure subsidence impacts.

Groundwater Model Development, New Jersey — Led a team of hydrogeologists to construct a groundwater flow and fate and transport model of perfluorononanoic acid and other contaminants. The model will be used to design a pump and treat system and possible aquifer replenishment with the treated groundwater.

Hydrogeological Services, Montgomery County, Texas — Provided modeling and hydrogeological consulting services for the Lone Star Ground-water Conservation District's (Montgomery County, Texas) update of its desired future conditions and groundwater management plans. Also provided litigation services for the district.

Groundwater Model Development, Havana, Florida — Provided consulting services for Northwest Florida Water Management District as it updated its regional groundwater model—an integrated groundwater-surface water model that provides regulatory control of the groundwater withdrawals and manages saltwater intrusion in the Floridan aquifer due to pumping.

Crop Production Services, Various Locations, U.S. — Served as the groundwater lead to provide modeling and hydrogeological consulting services for a number of crop production services legacy sites. The groundwater at the sites was contaminated with nitrates from long-term fertilizer use. Groundwater modeling was used to determine the fate and transport of the nitrates and to develop a remedial strategy for cleanup.

Legacy Way Tunnel Design, Brisbane, Australia — Provided senior oversight and technical review for all hydrogeologic assessments related to the Legacy Way tunnel design project, a 4.6 km underground tunnel in northern Brisbane, Australia. Work included evaluating field tests, preparing geotechnical and environmental reports, and modeling the entire project area.

Mercury Fate and Transport, Cincinnati, Ohio — Served as the groundwater lead for performing fate and-transport modeling and analysis of a mercury spill at a municipal landfill in Cincinnati, Ohio. As part of the project management phase, modeling was used to determine the potential migration of mercury through the landfill to the leachate collection system. Modeling efforts examined both the spatial distribution and the temporal component of the mercury transport.

Due Diligence Environmental Review, Pascagoula, Mississippi — Served as the environmental lead for performing an environmental assessment at a chemical plant in Pascagoula, Mississippi, as part of a due diligence effort. A number of groundwater and surface water contamination issues due to spills, leaks, and storage of hazardous materials were addressed. The location of the plant on the Gulf of Mexico makes possible environmental impacts from operation of the chemical plant a sensitive issue.

MINING

Bingham Canyon Mine Closure Planning, Copperton, Utah — Completed an independent third-party audit for a closure-plan pit-lake study for Bingham Canyon Mine. Reviewed the consultant scope of work for the pit-lake study and discussed the study, methodology, and pathway to completion with consultant staff. An independent audit report was compiled and submitted to the client.

Hooker Prairie Mine, Bartow, Florida — Served as the model expert to develop a contaminant and water budget and management model for the Hookers Prairie Mine in Florida using the GoldSim modeling software. The purpose of the model was to evaluate the probabilities of the mine meeting its current and future nutrient NPDES loading limits for certain contaminants. The project also included an evaluation of current monitoring data within the mine operations and at discharge locations, and the development of a complete monitoring plan integrated into a GIS as part of the model calibration and validation.

Bridger Coal Mine Investigation, Rock Springs, Wyoming — Served on a technical team to reevaluate groundwater conditions, and treatment and discharge alternatives at the Bridger coal mine in southwest Wyoming. Previous studies' predicted maximum flows into the mine had been exceeded. Reassessed the situation and provided solutions.

EMERGENCY RESPONSE

Emergency Response to Battery Fire, New York — Served as the principal in charge leading a team of multidisciplinary scientists, engineers, toxicologists, and risk assessors for an environmental emergency response at a large-scale battery power storage unit at a solar farm. A thermal incident where several cargo container boxes caught fire and burned required immediate action to assess the environmental and human health impacts.

Emergency Response to Battery Fire, California — Served as the principal in charge leading a team of multidisciplinary scientists, engineers, toxicologists, and risk assessors for an environmental emergency response at a large-scale battery power storage facility. A thermal incident where several cargo container boxes caught fire and burned required immediate action to assess the environmental and human health impacts.

ECOLOGICAL RESTORATION

Ecological Restoration, Northeast Idaho — Serves as the principal in charge leading a team of scientists, engineers, and ecologists for an ecological restoration effort in northeast Idaho. The project has involved restoring flow to a creek and working with a number of state and federal agencies to develop and implement a conceptual restoration plan and a mitigation and monitoring plan. The project will also include obtaining the necessary permits and overseeing the restoration in an area of critical habitat.

PROJECT MANAGEMENT

GMS Software Development, Utah — Served as chief engineer for the original development of the software Groundwater Modeling System (GMS) at the Environmental Modeling Research Laboratory at Brigham Young University. A sophisticated graphical environment for groundwater model pre- and post-processing, 3-dimensional site characterization, and geostatistics, GMS is the official groundwater application of the U.S. Department of Defense and is also used by the U.S. Department of Energy, EPA, and thousands of users across the world.

NATURAL RESOURCE DAMAGE ASSESSMENT

Natural Resource Damage Assessment, Southeastern Idaho — Served as the groundwater expert determining groundwater damages in southeastern Idaho due to decades of phosphate mining. Led a team of hydrogeologists evaluating the impacts of selenium and other contaminants and changes in natural groundwater flows across the entire region. The damage assessment included a number of mining areas as well as the facilities where the phosphate material was processed.

Natural Resource Damage Assessment, Eastern Washington — Served as the groundwater expert determining groundwater damages in eastern Washington due to decades of groundwater contamination. For future development on the site, an ASR program is being considered as part of the restoration and long-term sustainability of the groundwater resources.

Presentations / Posters

Davis, R.J. 2024. Assessing a social value of water in aquifer storage and recovery projects. National Ground Water Association Groundwater Week. December 9–12. Las Vegas, NV.

Davis, R.J. 2024. Assessing a social value of water in aquifer storage and recovery projects. Salt Lake County Watershed Symposium. November 20–21. Salt Lake City, UT.

Davis, R.J. 2024. Great Salt Lake of Utah: Watershed, legislative, and community issues surrounding it. Environmental Professional Industry Charities (EPIC). October 24. Salt Lake City, UT.

Davis, R.J. 2024. Assessing a social value of water in ASR projects. Groundwater Resources Association of California Western Groundwater Congress. October 7–9. Lake Tahoe, NV.

Davis, R.J. 2024. Assessing a social value of water in ASR projects. The Geological Society of America: Connects 2024. September 22–25. Anaheim, CA.

Davis, R.J. 2024. Water in Utah: Continuing to navigate the present and shaping our future water demands. American Groundwater Trust. August 6–7. Salt Lake City, UT.

Davis, R.J. 2024. Assessing a social value of water in ASR projects. Biennial Symposium on Managed Aquifer Recharge. April 4–5. Tucson, AZ.

Davis, R.J. 2023. Challenges limiting managed aquifer recharge (MAR) adoption in the West. National Ground Water Association Groundwater Summit. December 5–7. Las Vegas, NV.

Davis, R.J. 2023. Water, AI, and us: What does the future hold for solving Utah's water challenges. Hint: It can't be solved without you and me. Salt Lake County Watershed Symposium. November 15–16. Salt Lake City, UT.

Davis, R.J. 2023. Building climate resilience through sustainable remediation in the western region. Groundwater Resources Association of California Western Groundwater Congress. September 12–14. Burbank, CA.

Davis, R.J. 2023. Water in Utah: Navigating the present and shaping the future. American Groundwater Trust. August 14–15. Provo, Utah.

Davis, R.J. 2023. More managed aquifer recharge and saving the Great Salt Lake—A balancing act. Idaho Water Users Association. June 12–13. Sun Valley, ID.

Davis, R.J. 2023. More managed aquifer recharge: Deliberate resiliency to combat droughts and climate change in the West. Association for Environmental Health of Soils. March 20–23. San Diego, CA.

Davis, R.J. 2023. Resilient and sustainable remediation. ESG|Climate Resilient & Sustainable Remediation Symposium. Groundwater Resources Association of California Western Groundwater Congress. February 6–7. San Diego, CA.

Davis, R.J. 2022. More managed aquifer recharge: Solutions to combat droughts and climate change in the West. National Ground Water Association Groundwater Summit. December 6–8. Las Vegas, NV.

Davis, R.J. 2022. Saving our aquifers: Climate change and managed aquifer recharge. Salt Lake County Watershed Symposium. November 16–17. Salt Lake City, UT.

Davis, R.J. 2022. More managed aquifer recharge—A solution to combat droughts and climate change in the West. Groundwater Resources Association of California Western Groundwater Congress. September 21–23. Sacramento, CA.

Davis, R.J. 2022. Saving our aquifers—Climate change, sustainability, and managed aquifer recharge. International Water Holdings. August 24–25. Salt Lake City, UT.

Davis, R.J. 2022. More managed aquifer recharge (MMAR) a solution to combat droughts and climate change in the West. Groundwater Protection Council Annual Forum. June 21–23. Salt Lake City, UT.

Davis, R.J. 2022. Aquifer storage and recovery—Hydrogeologic considerations. American Water Resources Association. May 17. Salt Lake City, UT.

Davis, R.J. 2022. Utah hydrology—What you do and don't know about Utah hydrogeology. National Ground Water Association. May 4, 2022. Virtual.

Davis, R.J. and B. Lemon. 2022. Provo, Utah: From planning to pilot to a final aquifer storage and recovery (ASR) program. Utah Water Users Workshop. March 21–23. St. George, UT.

Davis, R.J. 2021. Provo, Utah, from planning to pilot to a final managed aquifer recharge (MAR) program. National Ground Water Association Groundwater Summit. December 7–8. Virtual.

Davis, R.J. 2021. Provo City aquifer storage and recovery project. Ground Water Protection Council Annual Forum, September 27–29. Virtual.

Davis, R.J. 2021. Provo, Utah, from planning to pilot to a final managed aquifer recharge (MAR) program. American Public Works Association Utah Section Annual Conference. September 21–22. Sandy, UT.

Davis, R.J. 2021. Provo City aquifer storage and recovery project. Utah Water Users Workshop. May 17–19. St. George, UT.

Davis, R.J. 2021. Provo, Utah: From planning to pilot to a final managed aquifer recharge (MAR) program. ASR for Texas, Virtual Webinar. May 4–5.

Davis, R.J. 2021. Provo aquifer storage and recovery—From planning to pilot. American Water Works Association Virtual Summit on Sustainable Water, PFAS, Waterborne Pathogens. February 10–11.

integral

Davis, R.J. 2020. Update on Provo's aquifer storage and recovery program. American Water Works Association Virtual Intermountain Section Annual Conference. October 21–23. Sun Valley, ID.

Davis, R.J. 2020. Are you prepared for the new federal permit process for CCR facilities? Second Annual Coal Ash and Combustion Residual Management Webinar, October 7–8. Virtual.

Invited Participant, Expert Panels, and Workshops

Avoiding the Pitfalls in Engaging Expert Consultants, Holland & Hart, March 18, 2024, Salt Lake City, UT.

Managed Aquifer Recharge Guidance, Interstate Technology & Regulatory Council, Managed Aquifer Recharge Team. December 2023.

Bulk Water Innovation Partnership (BWIP): More managed aquifer recharge: Deliberate resiliency to combat droughts and climate change in the West. December 6, 2023. Virtual.

Rocky Mountain Association of Environmental Professionals (RMAEP): Great Salt Lake of Utah: watershed, legislative, and community issues surrounding it. September 20, 2023.

Salt Lake Chamber: Utah Water Outlook. April 13, 2022.

EDCUtah Webinar: Water: Constraints and Opportunities for Development in Utah panel. June 11, 2021.

ULI Utah: Trends Conference—Water: Constraints and Opportunities for Development in Utah panel. October 27, 2021.

Exhibit 2

Resume for Norman L. Jones

Norman L. Jones, Ph.D.
Professor
Department of Civil & Construction Engineering
Brigham Young University

Education

Ph.D. Civil Engineering, University of Texas at Austin, 1990
M.S. Civil Engineering, University of Texas at Austin, 1988
B.S. Civil Engineering, Brigham Young University, 1986

Academic Experience

Department Chair, Civil & Construction Engineering, Brigham Young University (BYU), 2018-2024
Professor, Civil & Construction Engineering, BYU, 2002–present
Associate Professor, Civil & Environmental Engineering, BYU, 1997–2002
Assistant Professor, Civil & Environmental Engineering, BYU, 1991–1996

Current Membership in Professional Organizations

American Society of Civil Engineers (ASCE)
American Water Resources Association (AWRA)
National Ground Water Association (NGWA)
American Geophysical Union (AGU)

Professional Committees

AWRA 2014 GIS in Water Resources Technical Program Chair
NGWA Groundwater Modeling Interest Group Committee
American Society of Civil Engineers
EWRI Groundwater Management Committee
EWRI Emerging Technologies Committee
International Editorial Board for the Journal of HydroInformatics
Editor of AQUAmundi Journal
Great Salt Lake Basin Integrated Plan - Groundwater Technical Advisory Team
Tethys Geoscience Foundation - Board Member

Selected Honors and Awards

2001 Walter L. Huber Civil Engineering Research Prize
2002 College of Engineering & Technology Special Commendation Award
2003 Brigham Young University Technology Transfer Award
2007 Utah Engineering Educator of the Year – ACEC
2012 Brigham Young University Karl G. Maeser Research and Creative Arts Award
2016 AWRA Educator of the Year – Utah Section
2021 NGWA John Hem Award for Science and Engineering
2023 Brigham Young University Sponsored Research Award

University Courses Taught

CE En 101 - Introduction to Civil and Environmental Engineering
CE En 201 - Infrastructure
CE En 270 – Computer Methods in Civil Engineering
CE En 341 – Elementary Soil Mechanics
CE En 540 – Geo-Environmental Engineering
CE EN 544 - Seepage and Slope Stability Analysis
CCE 547 – Ground Water Modeling

CE En 641 – Advanced Soil Mechanics

Software

Led the development of the Groundwater Modeling System (GMS) software. GMS is a state-of-the-art three-dimensional environment for ground water model construction and visualization. It includes tools for site characterization including geostatistics and solid modeling of soil stratigraphy. GMS is the most comprehensive and sophisticated groundwater modeling software available and is used by over 10,000 organizations in over 100 countries. Currently managed and distributed by Aquaveo, LLC, a company I co-founded in 2007.

External Research Grants

1. Automated Mesh Generation For the TABS-2 System, $19,000, 2/90 - 11/90, U.S. Army Engineer Waterways Experiment Station
2. A Geometry Pre-Processor for HEC-1 Employing Triangulated Irregular Networks, $20,048, 3/91 - 10/91, U.S. Army Engineer Waterways Experiment Station
3. Real-Time Visualization for the TABS-2 Modelling System, $14,123, 4/91 - 8/91, U.S. Army Engineer Waterways Experiment Station
4. An Investigation of X-Windows Interface Tools, $49,556, 1/92 - 8/92, U.S. Army Engineer Waterways Experiment Station
5. Descriptive Geometry and Solid Rendering, $24,000, 1/92 - 10/92, U.S. Army Engineer Waterways Experiment Station
6. An Investigation of Automated Pre-processing Schemes for TIN-Based Drainage Analysis, $34,750, 4/92-10/92, U.S. Army Engineer Waterways Experiment Station
7. A Comprehensive Graphical User Environment for Groundwater Flow and Transport Modeling, $246,526, 6/93-9/94, U.S. Army Engineer Waterways Experiment Station
8. An Integrated Surface Flow Modeling System, $131,848, 1/94-1/95, U.S. Army Engineer Waterways Experiment Station
9. Productivity and Management Tools for Groundwater Flow and Transport Modeling, $207,404, 5/94-4/95, U.S. Army Engineer Waterways Experiment Station
10. Enhanced Tools for Quality Control in Automated Groundwater Transport Modeling, $246,553, 1/95-12/95, U.S. Army Engineer Waterways Experiment Station
11. Visualization for Two-Dimensional Surface Runoff Modeling, $98,221, 1/95-10/95, U.S. Army Engineer Waterways Experiment Station
12. Visualization Tools for Two-Dimensional Finite Element Hydrologic Modeling, $93,933, 11/95-10/96, U.S. Army Engineer Waterways Experiment Station
13. A Graphical Environment for Multi-Dimensional Surface Water Modeling, $49,789, 3/96-9/96, U.S. Army Engineer Waterways Experiment Station
14. A Conceptual Modeling Approach to Pre-processing of Groundwater Models, $475,743, 11/95-11/97, U.S. Army Engineer Waterways Experiment Station
15. Hydrosystems Modeling, $2,458,083, 5/97-4/02, U.S. Army Engineer Waterways Experiment Station
16. Second Generation Hydroinformatics Research, $4,958,127. U.S. Army Engineer Research and Development Center.
17. Flux Calculations and 3D Visualization for the SCAPS Piezocone and GeoViz System, $34,931, U.S. Navy.
18. Development of modeling methods and tools for predicting coupled reactive transport processes in porous media under multiple scales. $949,000. US Dept. of Energy. 1/07-12/09.
19. CI-WATER: Cyberinfrastructure to Advance High Performance Water Resource Modeling, $3,435,873. National Science Foundation - EPSCoR. 9/11-8/14.

20. Comprehensive Streamflow Prediction and Visualization to Support Integrated Water Managment, $599,823. NASA SERVIR, 8/16-8/19.
21. Daniel P. Ames, E. James Nelson, Norman L. Jones, An AmeriGEOSS Cloud-based Platform for Rapid Deployment of GEOGLOWS Water and Food Security Decision Support Apps, $540,658, NASA GEO, 1/2018-12/2020
22. Geospatial Information Tools That Use Machine-Learning to Enable Sustainable Groundwater Management in West Africa, $657,232. NASA SERVIR, 11/19-11/22.
23. Advancing the NASA GEOGloWS Toolbox for Regional Water Resources Management and Decision Support. $1.2M. NASA GEOGLOWS. 2022-2025. Dan Ames, Jim Nelson, Gus Williams, Norm Jones.
24. CIROH: National Cyberinfrastructure Framework for Engaging the Hydrologic Community (NCF). $1,822,418. National Oceanographic and Atmospheric Administration. 2022-2025. Dan Ames, Jim Nelson, Gus Williams, Norm Jones.
25. CIROH: Advancing Science to Better Characterize Drought and Groundwater-Driven Low-Flow Conditions in NOAA and USGS National-Scale Models. $801,221. 2023-2025. Norm Jones, Gus Williams, T. Prabhakar Clement, Donna Rizzo.
26. Improved Hydrologic Prediction Services for Resilience with GEOGLOWS, $1,889,627, National Oceanic and Atmospheric Administration (NOAA), 4/1/2024-3/31/2027. Norm Jones, Jim Nelson, Andrew South.

Summary: PI or Co-PI on 26 projects totaling $22,026,639.

Peer-Reviewed Publications in the Past 10 Years

1. Jones, N., Nelson, J., Swain, N., Christensen, S., Tarboton, D. Dash, P. Tethys: A Software Framework for Web-Based Modeling and Decision Support Applications. In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15-19, San Diego, California, USA. ISBN: 978-88-9035-744-2
2. Jones, N., Griffiths, T., Lemon, A., Kudlas, S. Automated Well Permitting in Virginia's Coastal Plain Using SEAWAT and GIS Geoprocessing Tools. In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15-19, San Diego, California, USA. ISBN: 978-88-9035-744-2
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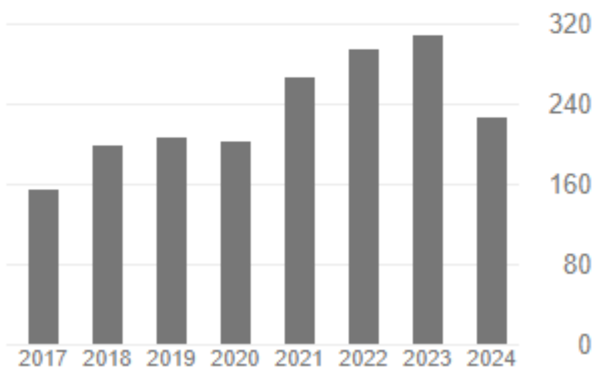
Summary: 88 total peer-reviewed publications.

Books

Strassberg, G., Jones, N., Maidment, D. (2011). Arc Hydro Groundwater: GIS for Hydrology. ESRI Press, Redlands, California, 250 pp.

Google Scholar Metrics

	All	Since 2019
Citations	3287	1507
h-index	27	19
i10-index	51	30



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Appendix A

Updated Tables and Figures

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
2/1/2000	C1	<DL	0.04	0.04	0.04
5/1/2002	C1	<DL	0.03	0.03	0.03
8/1/2002	C1	<DL	0.03	0.03	0.03
11/1/2002	C1	<DL	0.03	0.03	0.03
3/1/2003	C1	<DL	0.03	0.03	0.03
3/1/2004	C1	<DL	0.03	0.03	0.03
3/1/2005	C1	<DL	0.03	0.03	0.03
3/1/2006	C1	<DL	0.02	0.02	0.02
2/1/2007	C1	<DL	0.02	0.02	0.02
3/1/2008	C1	<DL	0.02	0.02	0.02
6/1/1997	C2	<DL	1316.4	1316.4	1316.4
2/1/2000	C2	<DL	900.8	900.8	900.8
5/1/2002	C2	1	580.6	579.6	579.6
8/1/2002	C2	<DL	548.86	548.86	548.86
11/1/2002	C2	<DL	518.92	518.92	518.92
3/1/2003	C2	<DL	482.65	482.65	482.65
3/1/2004	C2	<DL	389.28	389.28	389.28
3/1/2005	C2	<DL	321.59	321.59	321.59
3/1/2006	C2	1.4	261.33	259.93	259.93
2/1/2007	C2	<DL	214.18	214.18	214.18
3/1/2008	C2	<DL	176.88	176.88	176.88
6/1/1997	C3	580	434.52	-145.48	145.48
2/1/2000	C3	410	439.84	29.84	29.84
5/1/2002	C3	270	307.28	37.28	37.28
8/1/2002	C3	140	290.84	150.84	150.84
11/1/2002	C3	100	275.9	175.9	175.9
3/1/2003	C3	150	258.55	108.55	108.55
3/1/2004	C3	58	218.29	160.29	160.29
3/1/2005	C3	37	201.45	164.45	164.45
3/1/2006	C3	38	177.93	139.93	139.93
2/1/2007	C3	23	153.16	130.16	130.16
3/1/2008	C3	22	148.59	126.59	126.59
6/1/1997	C4	<DL	1.96	1.96	1.96
2/1/2000	C4	<DL	2.32	2.32	2.32
1/1/2002	C4	<DL	1.9	1.9	1.9
5/1/2002	C4	<DL	1.85	1.85	1.85
8/1/2002	C4	<DL	1.81	1.81	1.81
11/1/2002	C4	<DL	1.78	1.78	1.78
3/1/2003	C4	<DL	1.74	1.74	1.74
3/1/2004	C4	<DL	1.64	1.64	1.64
3/1/2005	C4	<DL	1.62	1.62	1.62
3/1/2006	C4	0.51	1.54	1.03	1.03
2/1/2007	C4	<DL	1.47	1.47	1.47
3/1/2008	C4	<DL	1.38	1.38	1.38
6/1/1997	C5	<DL	1326.87	1326.87	1326.87
2/1/2000	C5	<DL	1190.26	1190.26	1190.26
5/1/2002	C5	<DL	1009.86	1009.86	1009.86
8/1/2002	C5	<DL	985.68	985.68	985.68

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
11/1/2002	C5	<DL	961.76	961.76	961.76
3/1/2003	C5	<DL	931.03	931.03	931.03
3/1/2004	C5	<DL	839.91	839.91	839.91
3/1/2005	C5	<DL	772.91	772.91	772.91
3/1/2006	C5	<DL	690.68	690.68	690.68
2/1/2007	C5	<DL	613.37	613.37	613.37
3/1/2008	C5	<DL	551.21	551.21	551.21
6/1/1997	C9	<DL	0.06	0.06	0.06
2/1/2000	C9	<DL	0.16	0.16	0.16
5/1/2002	C9	1	0.18	-0.82	0.82
8/1/2002	C9	<DL	0.18	0.18	0.18
11/1/2002	C9	0.48	0.18	-0.3	0.3
3/1/2003	C9	<DL	0.18	0.18	0.18
3/1/2004	C9	1.9	0.18	-1.72	1.72
3/1/2005	C9	7.4	0.19	-7.21	7.21
3/1/2006	C9	18	0.19	-17.81	17.81
2/1/2007	C9	20	0.18	-19.82	19.82
3/1/2008	C9	18	0.17	-17.83	17.83
6/1/1997	C10	<DL	222.31	222.31	222.31
2/1/2000	C10	<DL	199.93	199.93	199.93
5/1/2002	C10	<DL	73.7	73.7	73.7
8/1/2002	C10	<DL	69.19	69.19	69.19
11/1/2002	C10	0.16	65.02	64.86	64.86
3/1/2003	C10	<DL	60.18	60.18	60.18
3/1/2004	C10	<DL	49.48	49.48	49.48
3/1/2005	C10	<DL	40.32	40.32	40.32
3/1/2006	C10	<DL	38.86	38.86	38.86
2/1/2007	C10	0.48	35.65	35.17	35.17
3/1/2008	C10	<DL	30.46	30.46	30.46
1/1/2002	C12	15	190.3	175.3	175.3
5/1/2002	C12	7	188.12	181.12	181.12
8/1/2002	C12	1.7	186.68	184.98	184.98
11/1/2002	C12	<DL	185.33	185.33	185.33
3/1/2003	C12	<DL	183.96	183.96	183.96
3/1/2004	C12	<DL	182.37	182.37	182.37
3/1/2005	C12	<DL	181.97	181.97	181.97
3/1/2006	C12	<DL	178.52	178.52	178.52
2/1/2007	C12	<DL	169.07	169.07	169.07
3/1/2008	C12	<DL	157.22	157.22	157.22
1/1/2002	C13	5400	15.21	-5384.79	5384.79
5/1/2002	C13	140	14.7	-125.3	125.3
8/1/2002	C13	68	14.34	-53.66	53.66
11/1/2002	C13	44	13.98	-30.02	30.02
3/1/2003	C13	6	13.57	7.57	7.57
3/1/2004	C13	3	12.66	9.66	9.66
3/1/2005	C13	2.8	11.81	9.01	9.01
3/1/2006	C13	2.5	11.1	8.6	8.6

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
2/1/2007	C13	2.7	10.12	7.42	7.42
3/1/2008	C13	7.8	8.83	1.03	1.03
3/1/2005	C14	1800	2.5	-1797.5	1797.5
3/1/2006	C14	1300	2.48	-1297.52	1297.52
2/1/2007	C14	320	2.37	-317.63	317.63
3/1/2008	C14	120	2.17	-117.83	117.83
2/1/2007	C15-D	1.9	0	-1.9	1.9
3/1/2008	C15-D	0.27	0	-0.27	0.27
2/1/2007	C15-S	3.8	0.7	-3.1	3.1
3/1/2008	C15-S	3.8	0.72	-3.08	3.08
2/1/2007	C16	0.36	1.06	0.7	0.7
3/1/2008	C16	<DL	1.12	1.12	1.12
2/1/2007	C17-D	0.77	0.15	-0.62	0.62
3/1/2008	C17-D	<DL	0.18	0.18	0.18
2/1/2007	C17-S	1.2	0.15	-1.05	1.05
3/1/2008	C17-S	0.19	0.18	-0.01	0.01
2/1/2007	C18	0.41	57.22	56.81	56.81
3/1/2008	C18	0.84	57.87	57.03	57.03
6/1/1997	FWC-11	<DL	840.57	840.57	840.57
2/1/2000	FWC-11	<DL	815.82	815.82	815.82
1/1/2002	FWC-11	<DL	760.83	760.83	760.83
5/1/2002	FWC-11	<DL	746.89	746.89	746.89
8/1/2002	FWC-11	<DL	736.19	736.19	736.19
11/1/2002	FWC-11	<DL	725.49	725.49	725.49
3/1/2003	FWC-11	<DL	711.68	711.68	711.68
3/1/2004	FWC-11	<DL	670.83	670.83	670.83
3/1/2005	FWC-11	<DL	641.83	641.83	641.83
3/1/2006	FWC-11	<DL	601.95	601.95	601.95
2/1/2007	FWC-11	<DL	556.03	556.03	556.03
3/1/2008	FWC-11	<DL	514.79	514.79	514.79
6/1/1997	FWS-12	230	605.2	375.2	375.2
2/1/2000	FWS-12	190	607.3	417.3	417.3
1/1/2002	FWS-12	100	362.09	262.09	262.09
5/1/2002	FWS-12	92	340.91	248.91	248.91
8/1/2002	FWS-12	90	323.49	233.49	233.49
11/1/2002	FWS-12	67	306.42	239.42	239.42
3/1/2003	FWS-12	96	285.52	189.52	189.52
3/1/2004	FWS-12	100	236.65	136.65	136.65
3/1/2005	FWS-12	64	226.34	162.34	162.34
3/1/2006	FWS-12	30	194.09	164.09	164.09
2/1/2007	FWS-12	26	131.8	105.8	105.8
3/1/2008	FWS-12	12	94.64	82.64	82.64
6/1/1997	FWS-13	<DL	1215.23	1215.23	1215.23
2/1/2000	FWS-13	<DL	1107.38	1107.38	1107.38
1/1/2002	FWS-13	1	959.83	958.83	958.83
5/1/2002	FWS-13	3	917.47	914.47	914.47
8/1/2002	FWS-13	1.2	883.55	882.35	882.35

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
11/1/2002	FWS-13	2.9	848.85	845.95	845.95
3/1/2003	FWS-13	2	802.06	800.06	800.06
3/1/2004	FWS-13	<DL	658.46	658.46	658.46
3/1/2005	FWS-13	1.9	543.52	541.62	541.62
3/1/2006	FWS-13	4.2	429.96	425.76	425.76
2/1/2007	FWS-13	1.5	341.03	339.53	339.53
3/1/2008	FWS-13	0.86	259.6	258.74	258.74
5/1/2002	RWC-1	155	360.92	205.92	205.92
8/1/2002	RWC-1	360	356.8	-3.2	3.2
11/1/2002	RWC-1	29	352.36	323.36	323.36
3/1/2003	RWC-1	22	346.48	324.48	324.48
3/1/2004	RWC-1	17	329.75	312.75	312.75
3/1/2005	RWC-1	5	316.15	311.15	311.15
3/1/2006	RWC-1	1.9	298.96	297.06	297.06
2/1/2007	RWC-1	12	270	258	258
3/1/2008	RWC-1	9.1	246.9	237.8	237.8
2/1/2000	RWC-2	1800	124.38	-1675.62	1675.62
1/1/2002	RWC-2	1350	102.55	-1247.45	1247.45
5/1/2002	RWC-2	1700	98.4	-1601.6	1601.6
8/1/2002	RWC-2	2300	95.58	-2204.42	2204.42
11/1/2002	RWC-2	2000	92.98	-1907.02	1907.02
3/1/2003	RWC-2	2000	90.16	-1909.84	1909.84
3/1/2004	RWC-2	2200	84.29	-2115.71	2115.71
3/1/2005	RWC-2	1400	76.21	-1323.79	1323.79
3/1/2006	RWC-2	1800	75.2	-1724.8	1724.8
2/1/2007	RWC-2	2300	69.28	-2230.72	2230.72
3/1/2008	RWC-2	2100	60.39	-2039.61	2039.61
5/1/2002	RWS-1A	8	380.65	372.65	372.65
8/1/2002	RWS-1A	<DL	342.01	342.01	342.01
11/1/2002	RWS-1A	5	308.75	303.75	303.75
3/1/2003	RWS-1A	6	270.86	264.86	264.86
3/1/2004	RWS-1A	2.6	187.28	184.68	184.68
3/1/2005	RWS-1A	2	141.68	139.68	139.68
3/1/2006	RWS-1A	1.8	111.86	110.06	110.06
2/1/2007	RWS-1A	2.7	93.16	90.46	90.46
3/1/2008	RWS-1A	2.1	56.99	54.89	54.89
5/1/2002	RWS-2A	79	609.72	530.72	530.72
1/1/2002	RWS-2A	17	697.9	680.9	680.9
8/1/2002	RWS-2A	290	554.12	264.12	264.12
11/1/2002	RWS-2A	98	505.35	407.35	407.35
3/1/2003	RWS-2A	170	450	280	280
3/1/2004	RWS-2A	40	322.81	282.81	282.81
3/1/2005	RWS-2A	42	231.7	189.7	189.7
3/1/2006	RWS-2A	50	195.03	145.03	145.03
2/1/2007	RWS-2A	15	155.12	140.12	140.12
3/1/2008	RWS-2A	16	105.2	89.2	89.2
1/1/2002	RWS-3A	760	734.63	-25.37	25.37

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
5/1/2002	RWS-3A	920	685.63	-234.37	234.37
8/1/2002	RWS-3A	970	647.45	-322.55	322.55
11/1/2002	RWS-3A	500	609.53	109.53	109.53
3/1/2003	RWS-3A	810	562.36	-247.64	247.64
3/1/2004	RWS-3A	280	435.76	155.76	155.76
3/1/2005	RWS-3A	560	342.42	-217.58	217.58
3/1/2006	RWS-3A	280	277.36	-2.64	2.64
2/1/2007	RWS-3A	260	213.69	-46.31	46.31
3/1/2008	RWS-3A	160	157.95	-2.05	2.05
1/1/2002	RWS-4A	280	413.29	133.29	133.29
5/1/2002	RWS-4A	6900	406.97	-6493.03	6493.03
8/1/2002	RWS-4A	3700	399.1	-3300.9	3300.9
11/1/2002	RWS-4A	3100	389.75	-2710.25	2710.25
3/1/2003	RWS-4A	1100	377.41	-722.59	722.59
3/1/2004	RWS-4A	<DL	337.47	337.47	337.47
3/1/2005	RWS-4A	1000	276.72	-723.28	723.28
3/1/2006	RWS-4A	92	251.29	159.29	159.29
2/1/2007	RWS-4A	1600	209.57	-1390.43	1390.43
3/1/2008	RWS-4A	1900	157.5	-1742.5	1742.5
6/1/1997	S1	5.6	0.11	-5.49	5.49
2/1/2000	S1	<DL	0.06	0.06	0.06
5/1/2002	S1	<DL	0.03	0.03	0.03
8/1/2002	S1	<DL	0.03	0.03	0.03
11/1/2002	S1	0.32	0.03	-0.29	0.29
3/1/2003	S1	<DL	0.02	0.02	0.02
3/1/2004	S1	<DL	0.02	0.02	0.02
3/1/2005	S1	<DL	0.01	0.01	0.01
3/1/2006	S1	<DL	0.01	0.01	0.01
2/1/2007	S1	<DL	0.01	0.01	0.01
3/1/2008	S1	<DL	0.01	0.01	0.01
6/1/1997	S2	<DL	207.79	207.79	207.79
2/1/2000	S2	520	95.18	-424.82	424.82
5/1/2002	S2	340	38.63	-301.37	301.37
8/1/2002	S2	110	34.41	-75.59	75.59
11/1/2002	S2	67	30.73	-36.27	36.27
3/1/2003	S2	100	26.65	-73.35	73.35
3/1/2004	S2	50	18.16	-31.84	31.84
3/1/2005	S2	35	13.62	-21.38	21.38
3/1/2006	S2	38	10.18	-27.82	27.82
2/1/2007	S2	22	7.79	-14.21	14.21
3/1/2008	S2	20	6.57	-13.43	13.43
6/1/1997	S3	77	1321.69	1244.69	1244.69
2/1/2000	S3	12	1001.42	989.42	989.42
5/1/2002	S3	23	451.57	428.57	428.57
8/1/2002	S3	54	397.13	343.13	343.13
11/1/2002	S3	60	352.03	292.03	292.03
3/1/2003	S3	48	303.81	255.81	255.81

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
3/1/2004	S3	53	207.92	154.92	154.92
3/1/2005	S3	47	167.82	120.82	120.82
3/1/2006	S3	23	119.56	96.56	96.56
2/1/2007	S3	85	91.67	6.67	6.67
3/1/2008	S3	94	82.39	-11.61	11.61
6/1/1997	S4	<DL	102.72	102.72	102.72
2/1/2000	S4	<DL	121.75	121.75	121.75
3/1/2004	S4	<DL	29.29	29.29	29.29
3/1/2005	S4	<DL	22.94	22.94	22.94
3/1/2006	S4	<DL	16.81	16.81	16.81
2/1/2007	S4	<DL	13.37	13.37	13.37
3/1/2008	S4	<DL	10.24	10.24	10.24
6/1/1997	S5	<DL	1773.95	1773.95	1773.95
2/1/2000	S5	<DL	1136.51	1136.51	1136.51
5/1/2002	S5	<DL	584.04	584.04	584.04
8/1/2002	S5	<DL	534.73	534.73	534.73
11/1/2002	S5	1	489.23	488.23	488.23
3/1/2003	S5	<DL	434.22	434.22	434.22
3/1/2004	S5	<DL	295.95	295.95	295.95
3/1/2005	S5	<DL	216.07	216.07	216.07
3/1/2006	S5	<DL	150.33	150.33	150.33
2/1/2007	S5	<DL	109.32	109.32	109.32
3/1/2008	S5	<DL	80.8	80.8	80.8
6/1/1997	S6	<DL	21.11	21.11	21.11
2/1/2000	S6	<DL	10.5	10.5	10.5
8/1/2002	S6	<DL	4.26	4.26	4.26
11/1/2002	S6	0.2	3.85	3.65	3.65
3/1/2003	S6	<DL	3.38	3.38	3.38
3/1/2004	S6	<DL	2.35	2.35	2.35
3/1/2005	S6	<DL	1.73	1.73	1.73
3/1/2006	S6	<DL	1.28	1.28	1.28
2/1/2007	S6	<DL	0.97	0.97	0.97
3/1/2008	S6	<DL	0.74	0.74	0.74
6/1/1997	S7	<DL	134.14	134.14	134.14
8/1/2002	S7	<DL	23.27	23.27	23.27
11/1/2002	S7	<DL	20.84	20.84	20.84
3/1/2003	S7	0.5	18.07	17.57	17.57
3/1/2004	S7	<DL	11.97	11.97	11.97
3/1/2005	S7	<DL	8.59	8.59	8.59
3/1/2006	S7	1.9	6.02	4.12	4.12
2/1/2007	S7	<DL	4.38	4.38	4.38
3/1/2008	S7	<DL	3.64	3.64	3.64
6/1/1997	S8	<DL	27.91	27.91	27.91
2/1/2000	S8	<DL	22.16	22.16	22.16
5/1/2002	S8	<DL	9.98	9.98	9.98
8/1/2002	S8	<DL	8.89	8.89	8.89
11/1/2002	S8	<DL	7.93	7.93	7.93

Table A1. Observed and Simulated PCE Concentrations at Monitoring Well Locations (Compare to Table 5 in Post-Audit Report)

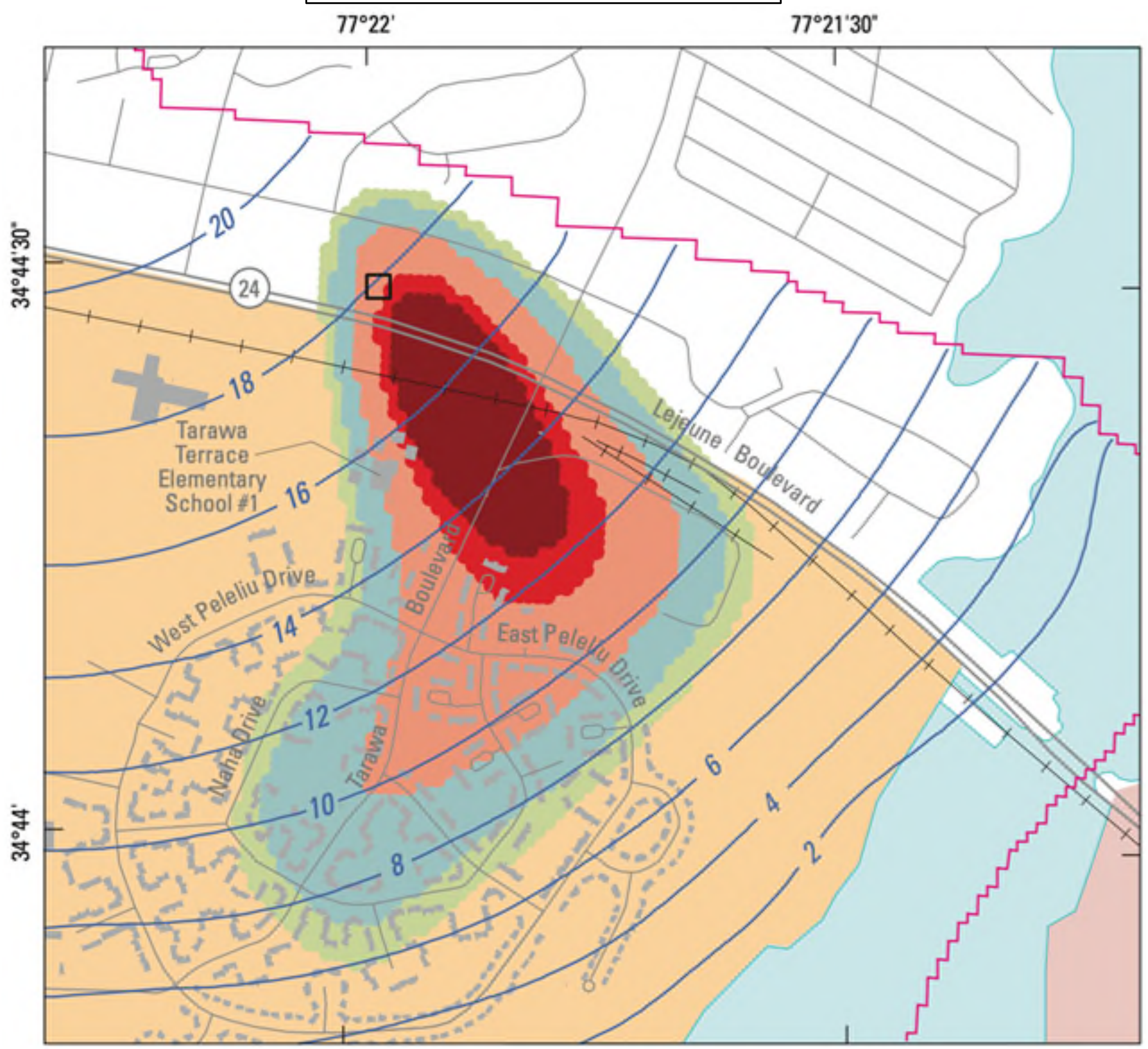
Date	Monitoring Well	PCE Observed Concentration (µg/L)	PCE Simulated Concentration (µg/L)	Error	Absolute Error
3/1/2003	S8	<DL	6.85	6.85	6.85
3/1/2004	S8	<DL	4.54	4.54	4.54
3/1/2005	S8	<DL	3.2	3.2	3.2
3/1/2006	S8	<DL	2.16	2.16	2.16
2/1/2007	S8	<DL	1.46	1.46	1.46
3/1/2008	S8	<DL	1.01	1.01	1.01
6/1/1997	S9	<DL	57.92	57.92	57.92
2/1/2000	S9	<DL	73.25	73.25	73.25
5/1/2002	S9	<DL	35.02	35.02	35.02
8/1/2002	S9	<DL	31.03	31.03	31.03
11/1/2002	S9	<DL	27.5	27.5	27.5
3/1/2003	S9	<DL	23.55	23.55	23.55
3/1/2004	S9	<DL	15.17	15.17	15.17
3/1/2005	S9	<DL	11.39	11.39	11.39
3/1/2006	S9	<DL	7.41	7.41	7.41
2/1/2007	S9	<DL	4.68	4.68	4.68
3/1/2008	S9	<DL	3.25	3.25	3.25
6/1/1997	S10	<DL	505.27	505.27	505.27
2/1/2000	S10	<DL	503.55	503.55	503.55
1/1/2002	S10	<DL	484.38	484.38	484.38
5/1/2002	S10	<DL	477.98	477.98	477.98
8/1/2002	S10	<DL	473.09	473.09	473.09
11/1/2002	S10	0.16	468.13	467.97	467.97
3/1/2003	S10	<DL	461.09	461.09	461.09
3/1/2004	S10	<DL	438.9	438.9	438.9
3/1/2005	S10	<DL	418.76	418.76	418.76
3/1/2006	S10	<DL	390.31	390.31	390.31
2/1/2007	S10	0.74	360.66	359.92	359.92
3/1/2008	S10	<DL	330.09	330.09	330.09
6/1/1997	S11	<DL	<DL	0	0
2/1/2000	S11	<DL	<DL	0	0
3/1/2005	S14	<DL	10.43	10.43	10.43
3/1/2006	S14	<DL	8.57	8.57	8.57
2/1/2007	S14	0.47	6.94	6.47	6.47
3/1/2008	S14	<DL	5.34	5.34	5.34

Notes:
<DL = sample result reported below the detection limit
PCE = tetrachloroethylene

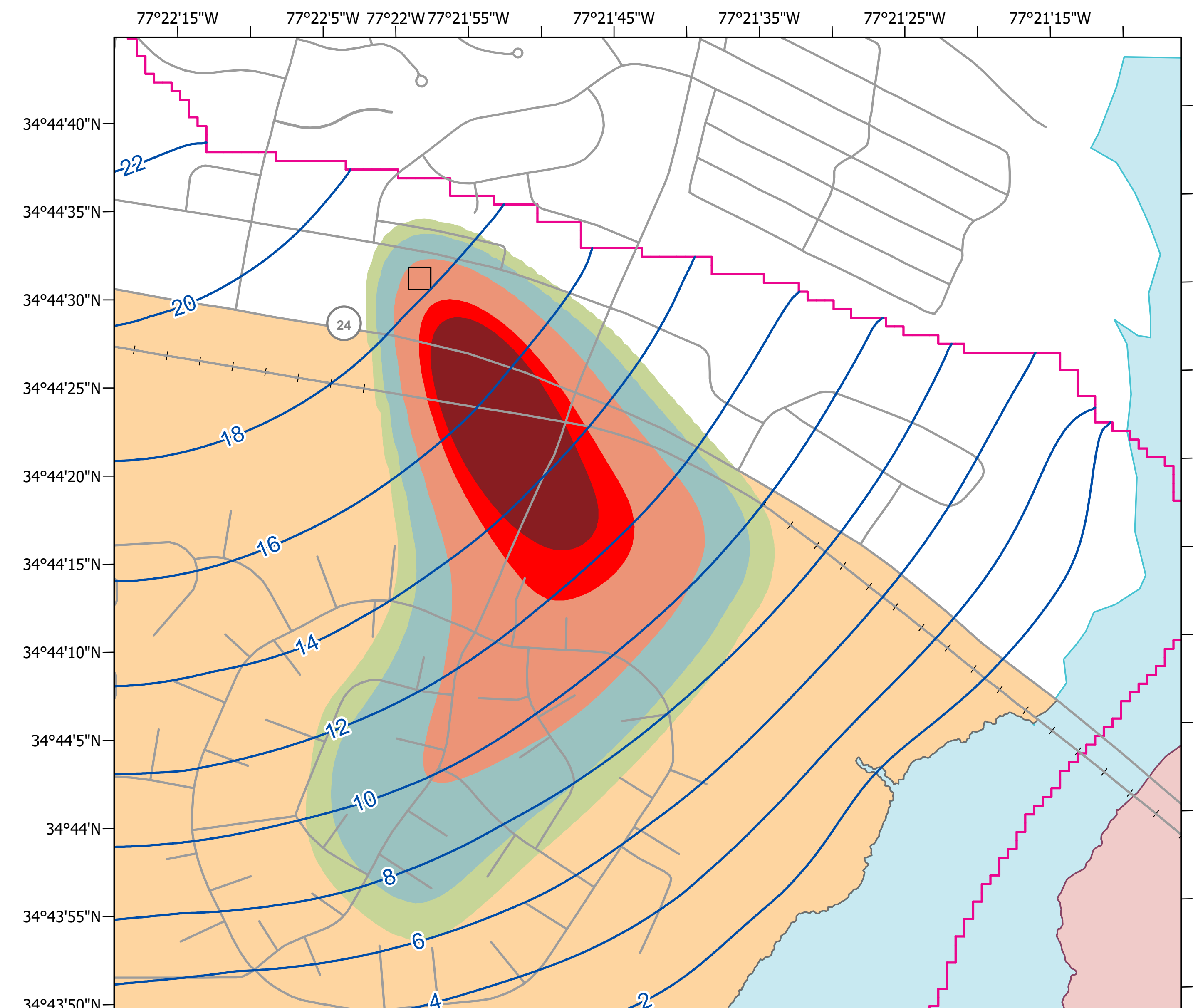
Table A2. Mean Error and Mean Absolute Error for Monitoring Wells (Compare to Table 6 in Post-Audit Report)

Monitoring Well	Model Layer	Mean Error	Mean Absolute Error	Mean Absolute Error Category
C1	3	0	0	0-200
C2	3	519	519	500-2000
C3	3	98	124.5	0-200
C4	5	1.7	1.7	0-200
C5	3	897.6	897.6	500-2000
C9	3	-5.9	6	0-200
C10	5	80.4	80.4	0-200
C12	3	178	178	0-200
C13	3	-555	563.7	500-2000
C14	3	-882.6	882.6	500-2000
C15-D	3	-1.1	1.1	0-200
C15-S	3	-3.1	3.1	0-200
C16	3	0.9	0.9	0-200
C17-D	3	-0.2	0.4	0-200
C17-S	3	-0.5	0.5	0-200
C18	3	56.9	56.9	0-200
FWC-11	3	693.6	693.6	500-2000
FWS-12	1	218.1	218.1	200-500
FWS-13	1	745.7	745.7	500-2000
RWC-1	3	251.9	252.6	200-500
RWC-2	3	-1816.4	1816.4	500-2000
RWS-1A	1	207	207	200-500
RWS-2A	1	301	301	200-500
RWS-3A	1	-83.3	136.4	0-200
RWS-4A	1	-1645.3	1771.3	500-2000
S1	1	-0.5	0.5	0-200
S2	1	-73.8	111.6	0-200
S3	1	356.5	358.6	200-500
S4	1	45.3	45.3	0-200
S5	1	527.7	527.7	500-2000
S6	1	5	5	0-200
S7	1	25.4	25.4	0-200
S8	1	8.7	8.7	0-200
S9	1	26.4	26.4	0-200
S10	1	442.6	442.6	200-500
S11	1	0	0	0-200
S14	1	7.7	7.7	0-200

ATSDR Model PCE Contours (µg/L)



Updated Model PCE Contours (µg/L)



Historical Water Supply Area
- Holcomb Boulevard
- Tarawa Terrace
- Simulated Potentiometric Contour (ft)
- Model Boundary
- ABC One-Hour Cleaner

PCE Concentration (µg/L)
- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,000
- Greater than 1,000 to 5,000

0 1,000 2,000
Feet

N

Notes:
PCE concentrations for model layer 1 are shown for both the ATSDR Model and the Updated Model.
- ATSDR Model PCE Contours were simulated in the original MT3DMS model and copied directly over from Figure F23 (Faye et al. 2007).
- Updated Model PCE Contours were simulated in MT3DMS and exported from GMS software.
- A visual comparison suggests that the updated model is accurately representing the results from the ATSDR model.

ATSDR = Agency for Toxic Substances and Disease Registry
GMS = Groundwater Modeling System
PCE = tetrachloroethylene

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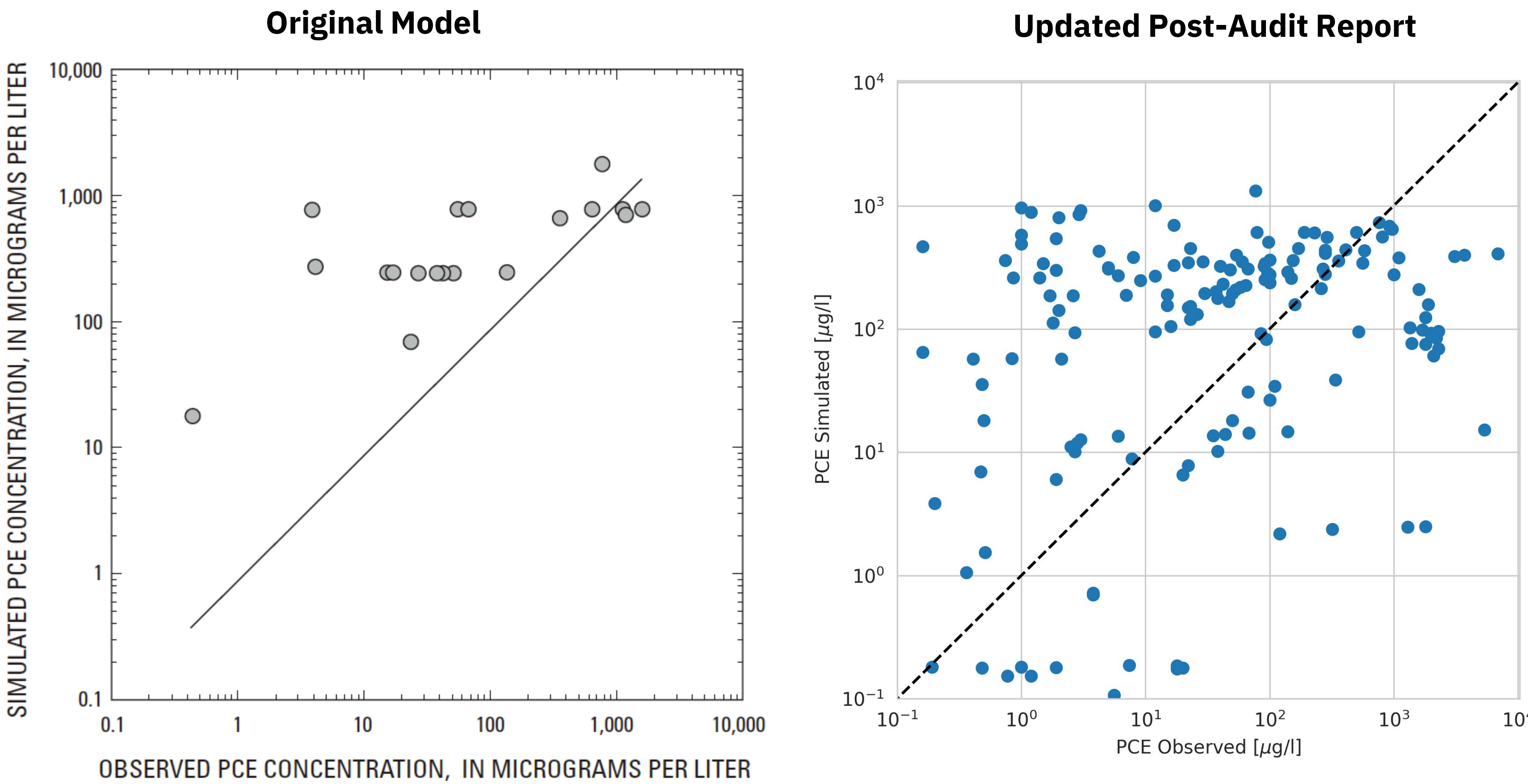
Figure A1.
Comparison of Original Model-Simulated PCE Concentrations (Compare to Figure 2 in Post-Audit Report) to Updated Model-Simulated PCE Concentrations
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A



Notes:
The Original Model results are from (Maslia et al. 2007).
The Post-Audit results were shown in Figure 5 of Jones and Davis (2024).

PCE = tetrachloroethylene

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Figure A2.
Simulated vs. Observed PCE Concentrations
(Compare to Figure 6 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A

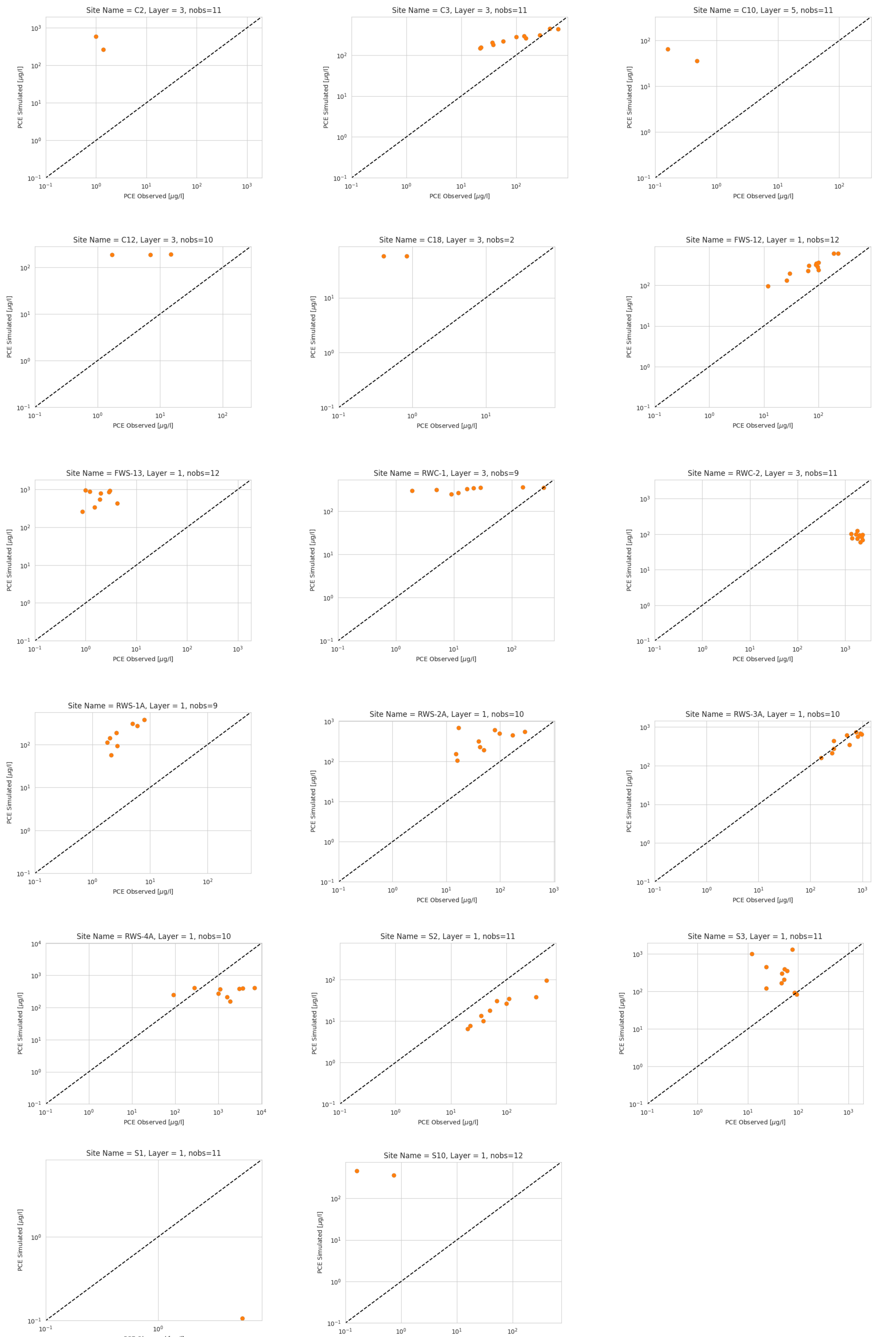

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Figure A3.
Simulated vs. Observed PCE Concentrations
(Compare to Figure 7 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A

integral

Figure A4.
Time Series Plots of Simulated and Observed PCE Concentrations (Compare to Figure 8 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A

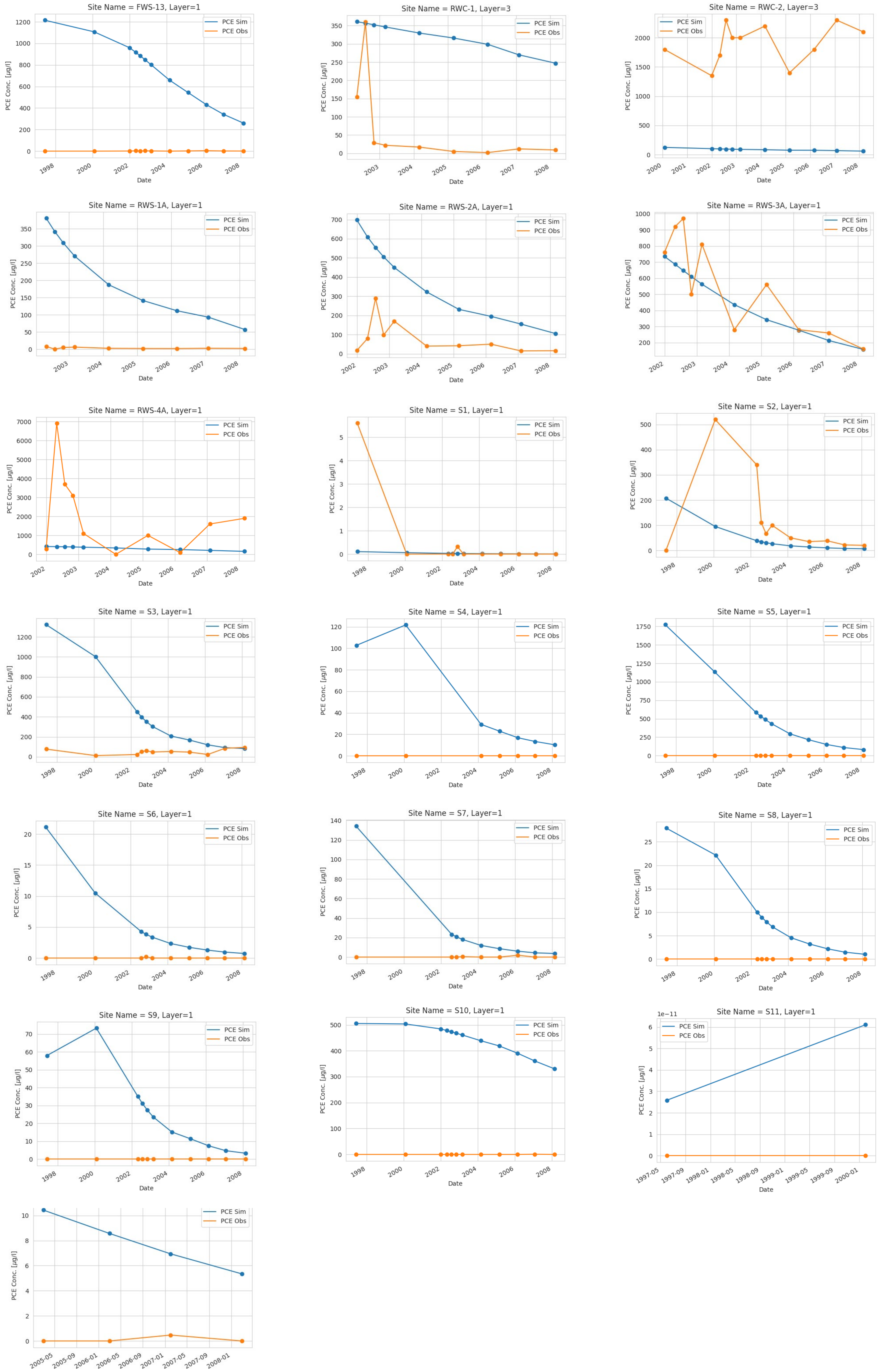

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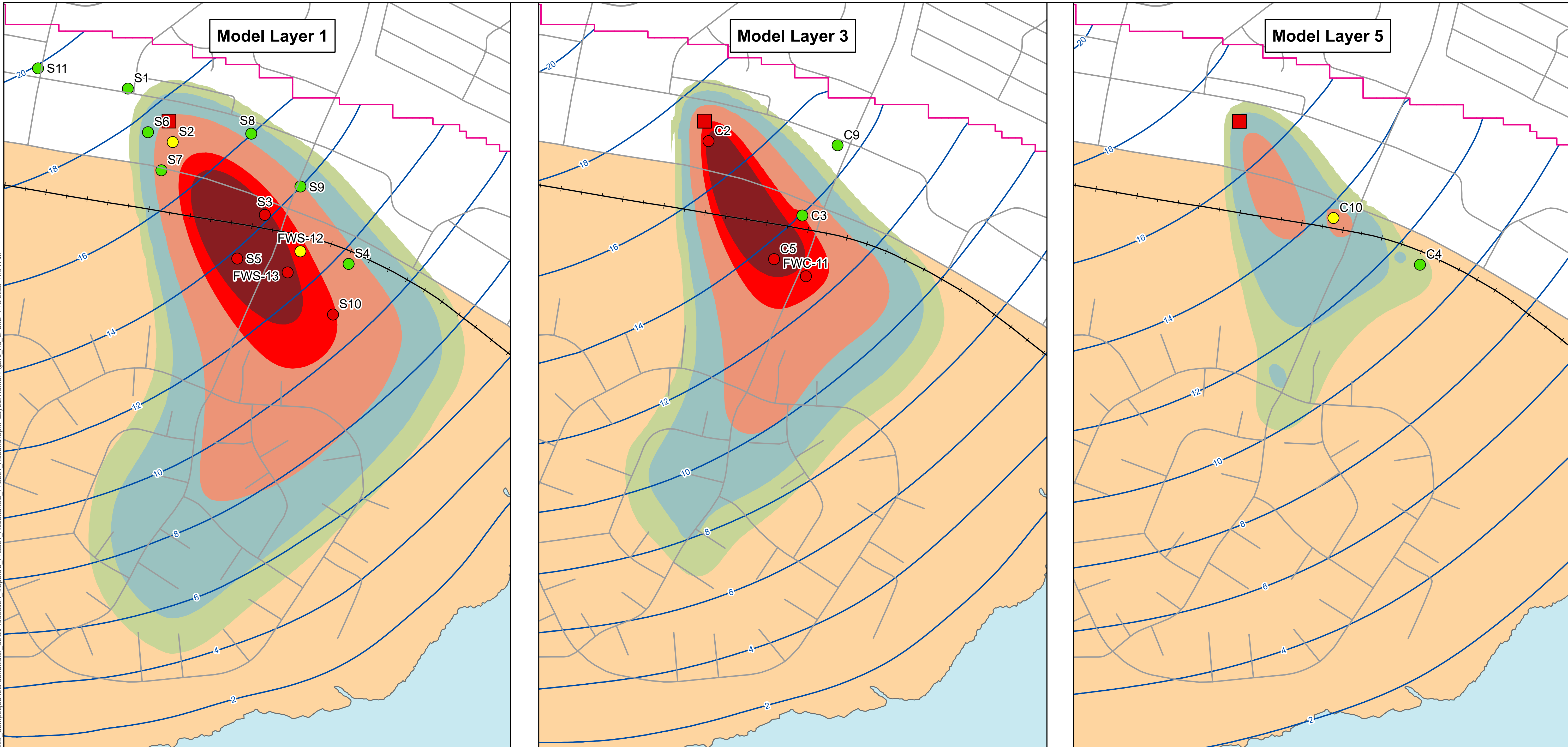
Figure A4.
Time Series Plots of Simulated and Observed PCE Concentrations (Compare to Figure 8 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A



■ ABC One-Hour Cleaner
Simulated Potentiometric Contour (ft)
Model Boundary
Road

0 375 750
Feet

N

Absolute Error for PCE (µg/L)
- 0 - 200
- 200 - 500
- 500 - 2,000
- Greater than 2,000

PCE Concentration (µg/L)
- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,000
- Greater than 1,000 to 5,000

Historical Water Supply Area
- Holcomb Boulevard
- Tarawa Terrace

Notes:
PCE = tetrachloroethylene

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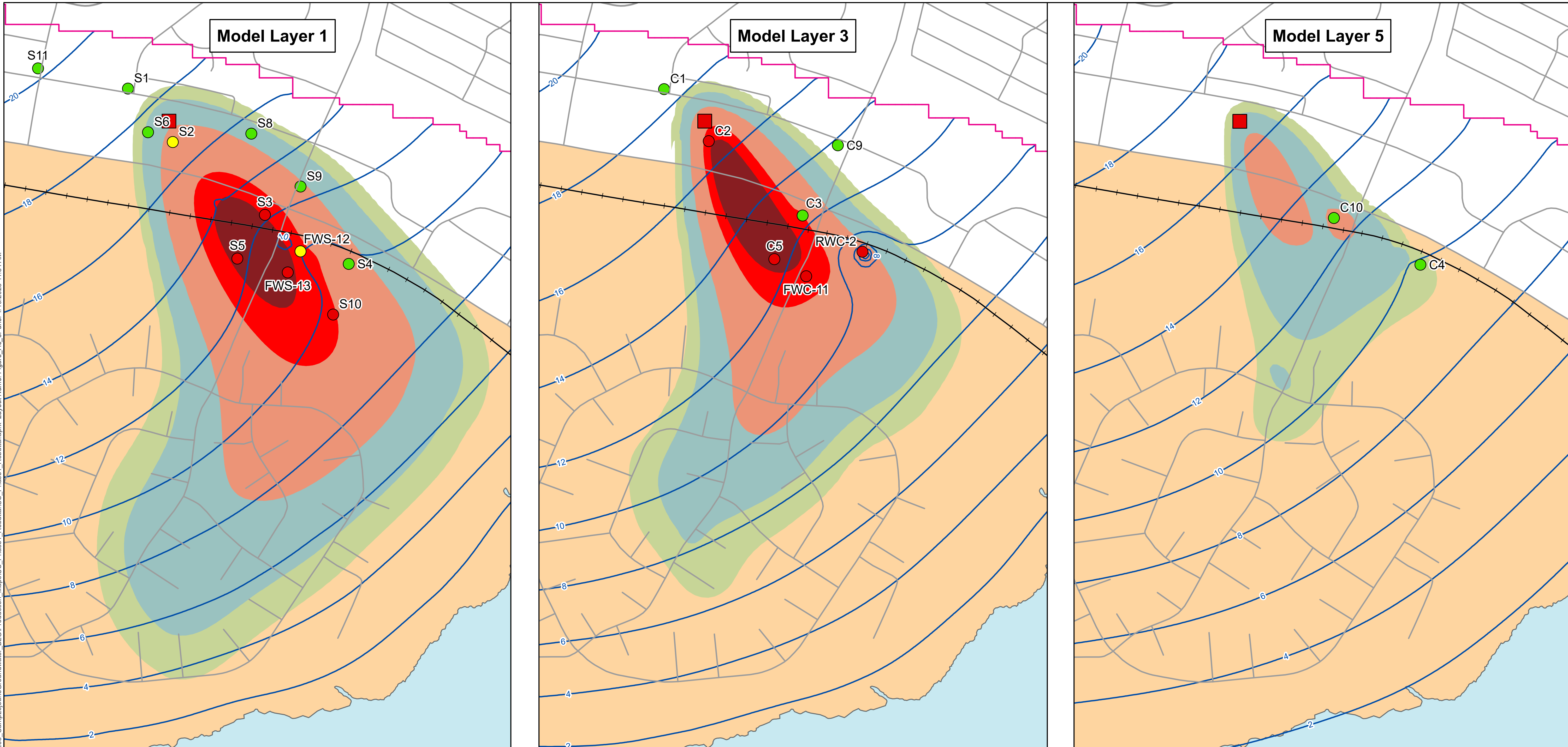
Figure A5.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, June 1997
(Compare to Figure 9 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and
Transport Model Post-Audit
Appendix A



ABC One-Hour Cleaner
Simulated Potentiometric Contour (ft)
Model Boundary
Railroad

Absolute Error for PCE (µg/L)
- 0 - 200
- 200 - 500
- 500 - 2,000
- Greater than 2,000

PCE Concentration (µg/L)
- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,000
- Greater than 1,000 to 5,000

Historical Water Supply Area
- Holcomb Boulevard
- Tarawa Terrace

Notes:
PCE = tetrachloroethylene

0 375 750
Feet

N

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Figure A6.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, February 2000
(Compare to Figure 10 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and
Transport Model Post-Audit
Appendix A

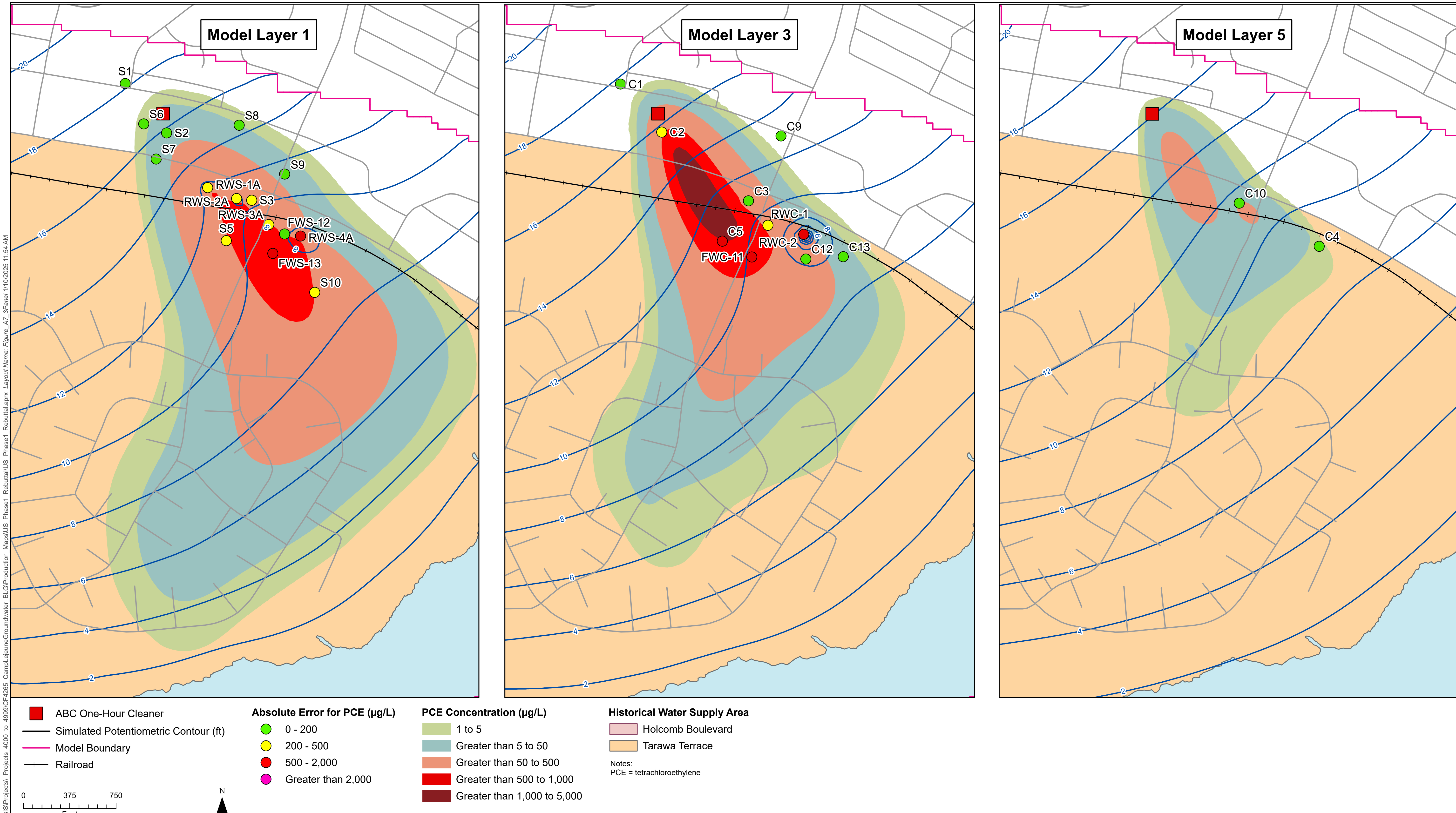

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Figure A7.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2003
(Compare to Figure 11 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and
Transport Model Post-Audit
Appendix A

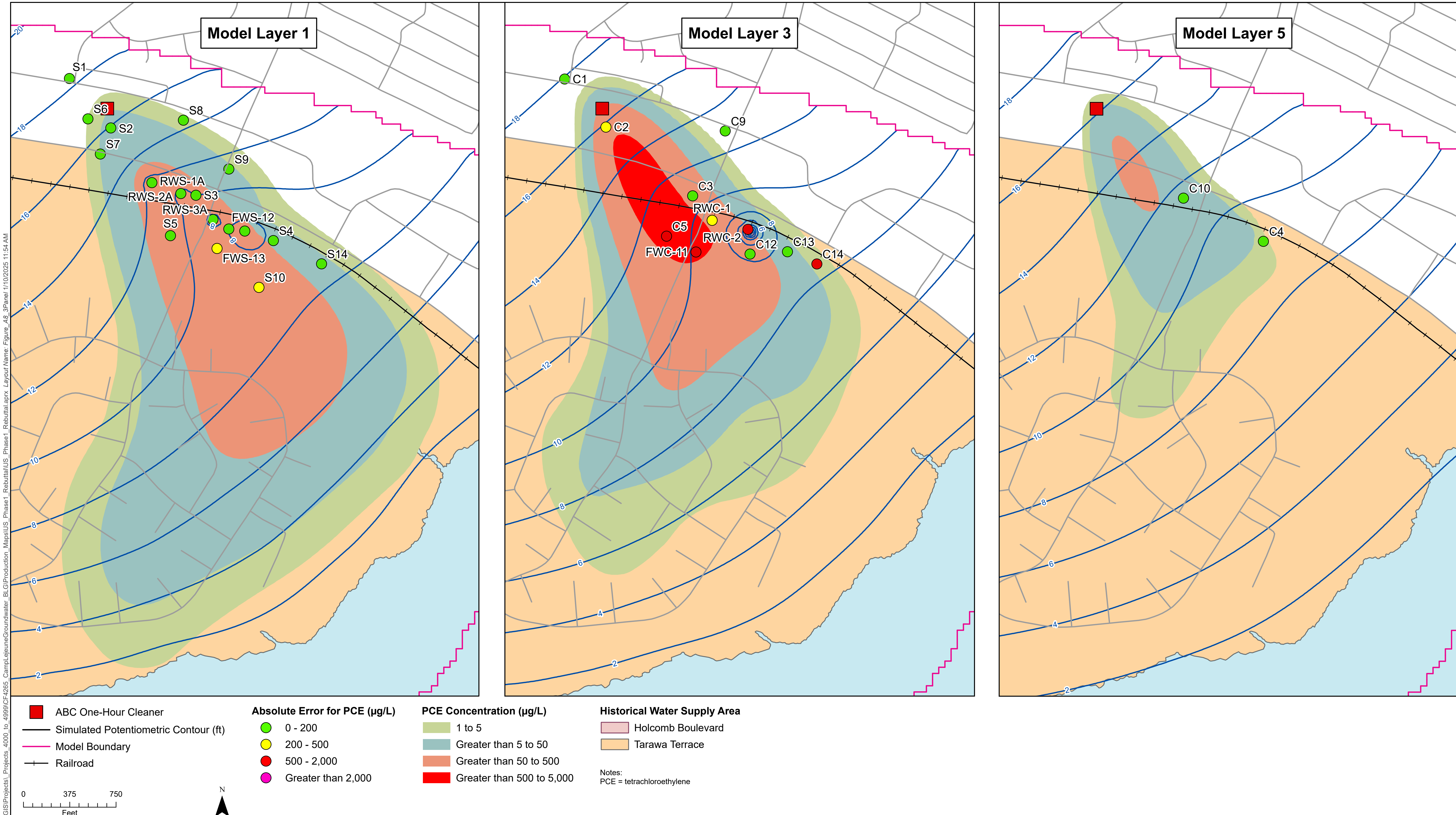

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Figure A8.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2006
(Compare to Figure 12 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and
Transport Model Post-Audit
Appendix A

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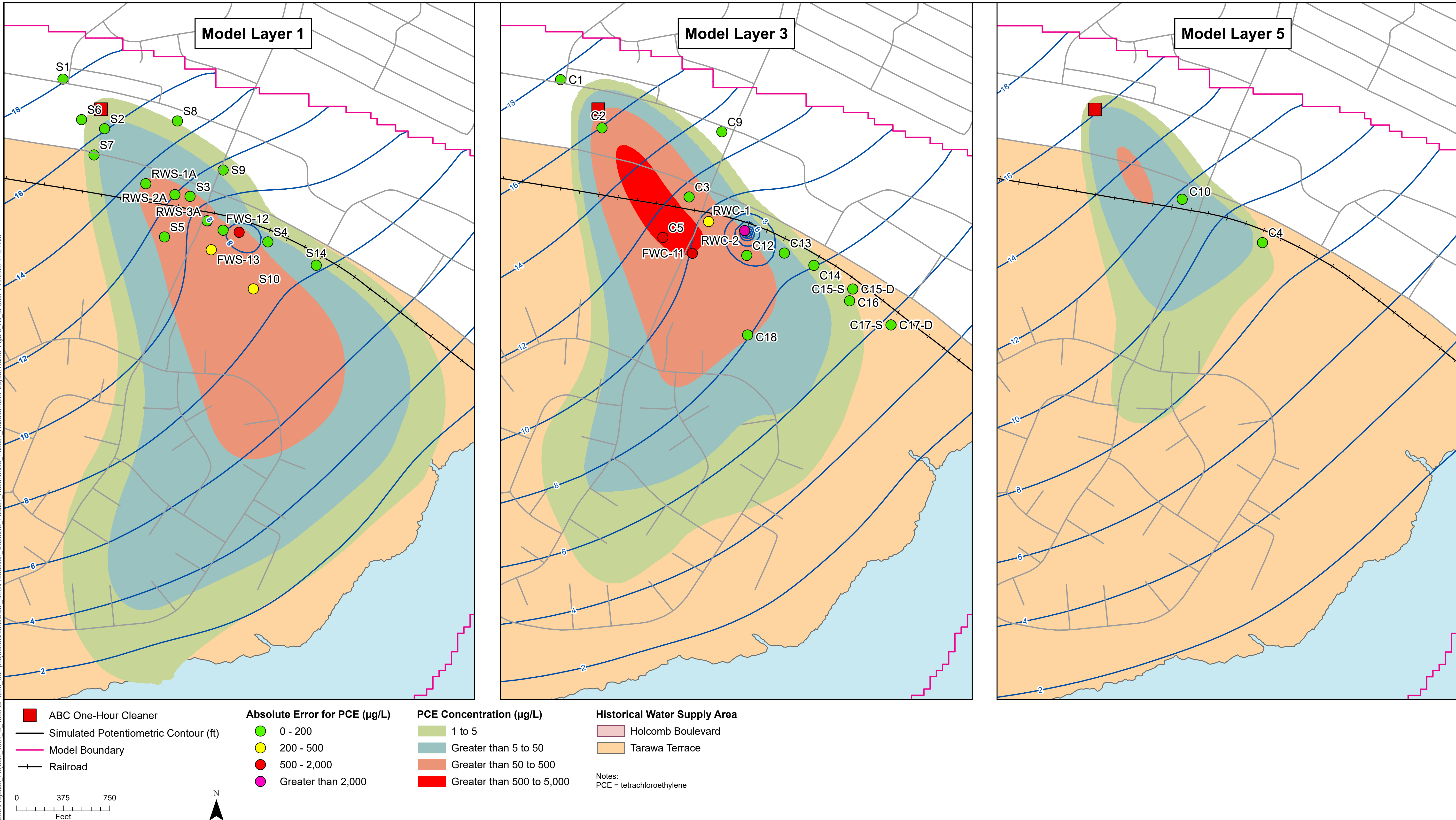

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Figure A9.
Simulated PCE Concentration for Three Model Layers
Compared to Measured Values, March 2008
(Compare to Figure 13 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and
Transport Model Post-Audit
Appendix A

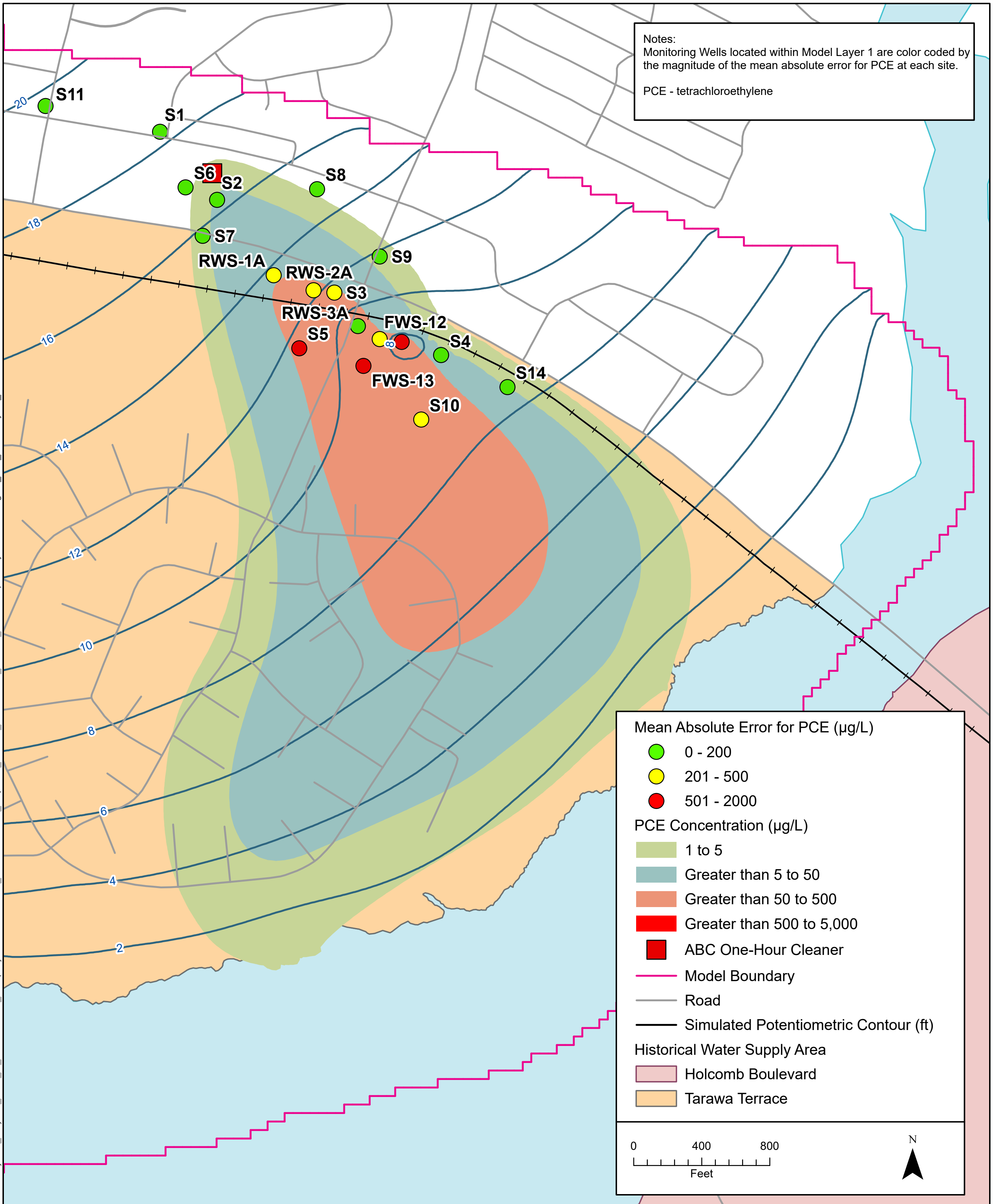

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Figure A10.
Simulated PCE Plume for December 2008 for Model Layer 1
(Compare to Figure 14 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A

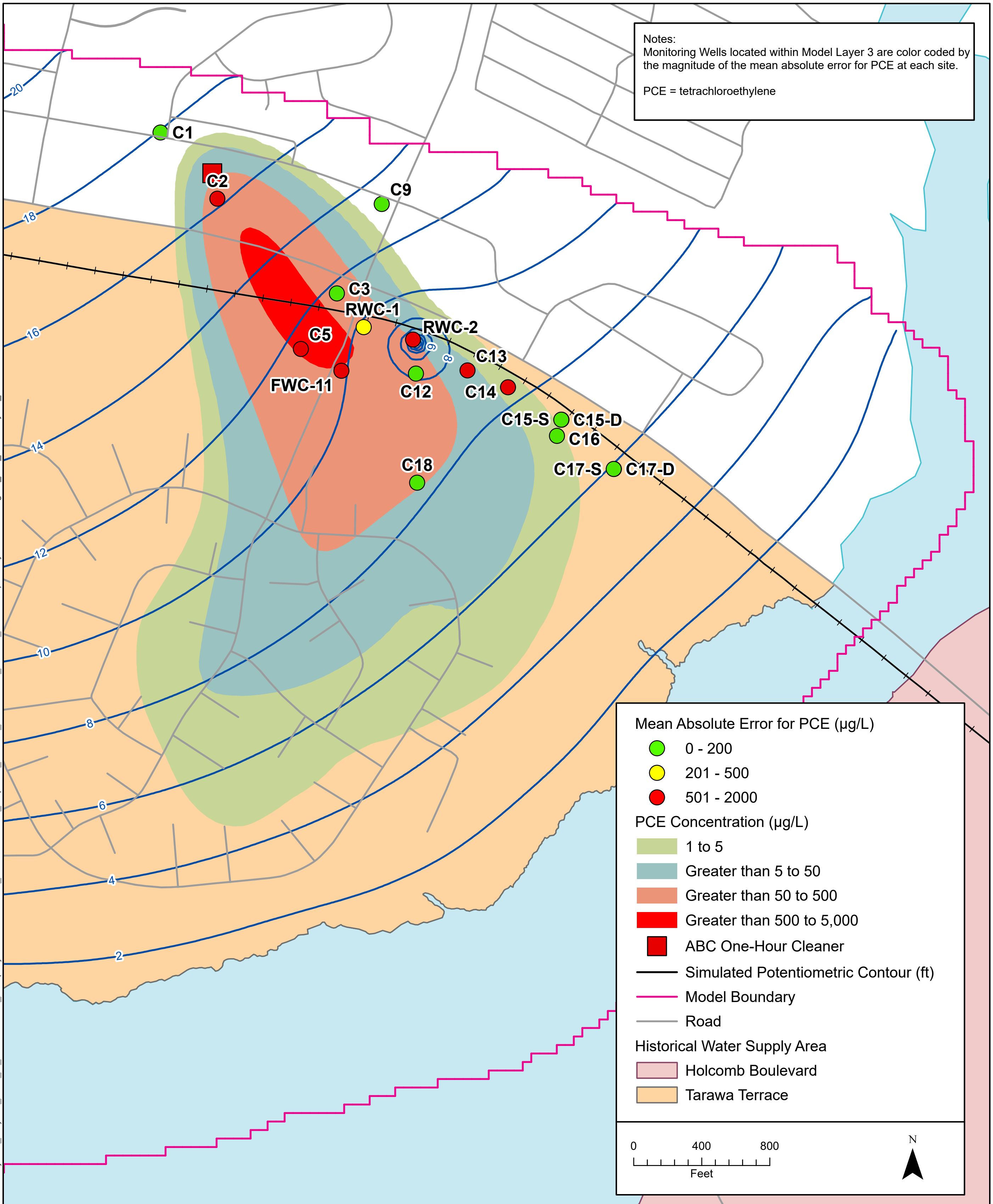

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Figure A11.
Simulated PCE Plume for December 2008 for Model Layer 3
(Compare to Figure 15 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A

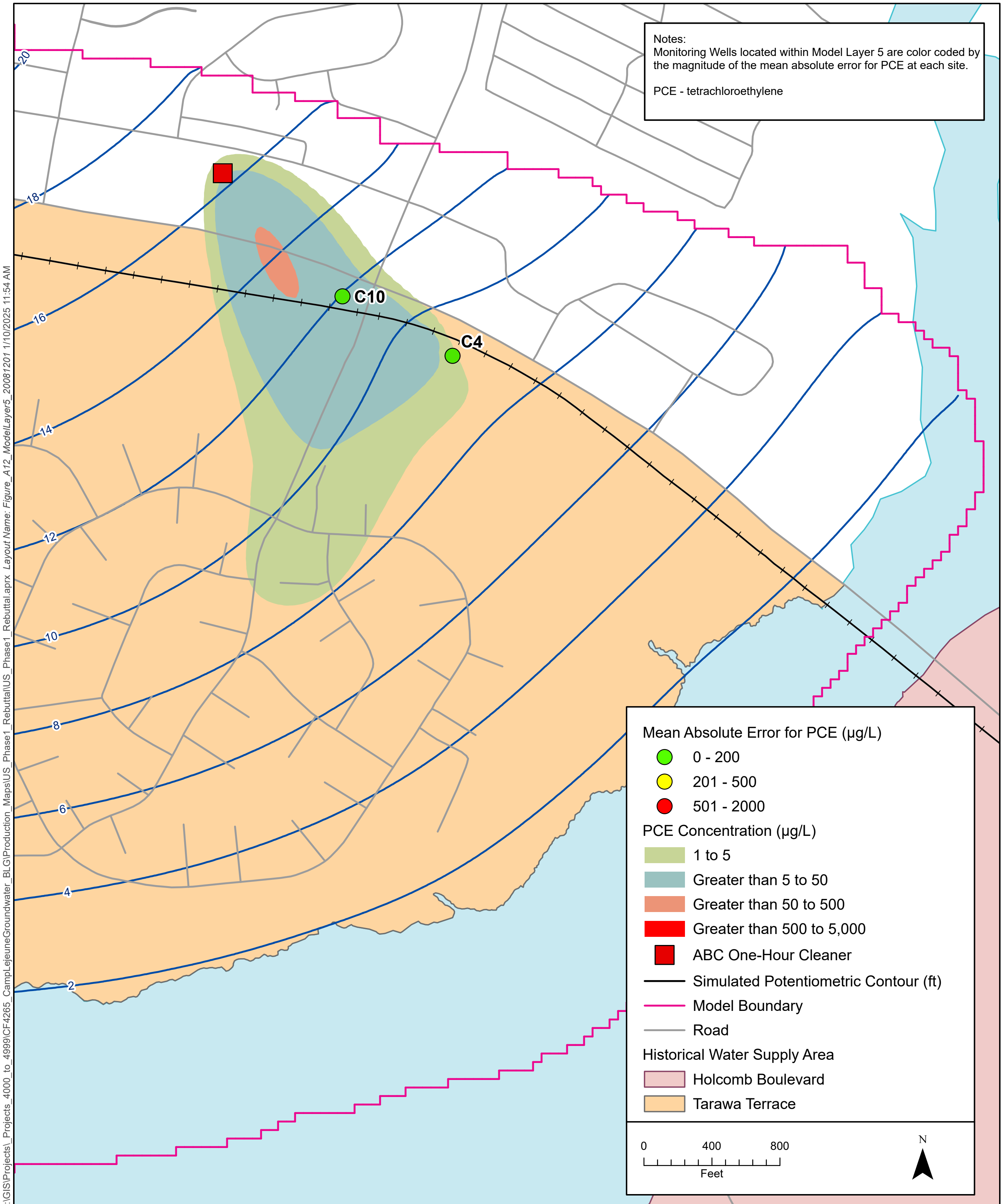

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Figure A12.
Simulated PCE Plume for December 2008 for Model Layer 5 (Compare to Figure 16 in Post-Audit Report)
Rebuttal Report Regarding Tarawa Terrace Flow and Transport Model Post-Audit
Appendix A