Historical Water-Modeling Results of Single-Species VOC-Contaminated Drinking Water at U.S. Marine Corps Base Camp Lejeune, North Carolina

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The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry or the U.S. Department of Health and Human Services

Background

U.S. Marine Corps Base Camp Lejeune North Carolina

- Location
  - Coastal Plain of North Carolina, Onslow County
  - SE of Jacksonville, 70 miles NW of Wilmington
- Area
  - ~ 164 square miles (42,500 ha)
  - Located along coastal North Carolina
- Population:
  - 100,000 active duty and dependents
- Potable water supply
  - 8 water systems
  - 180 groundwater supply wells

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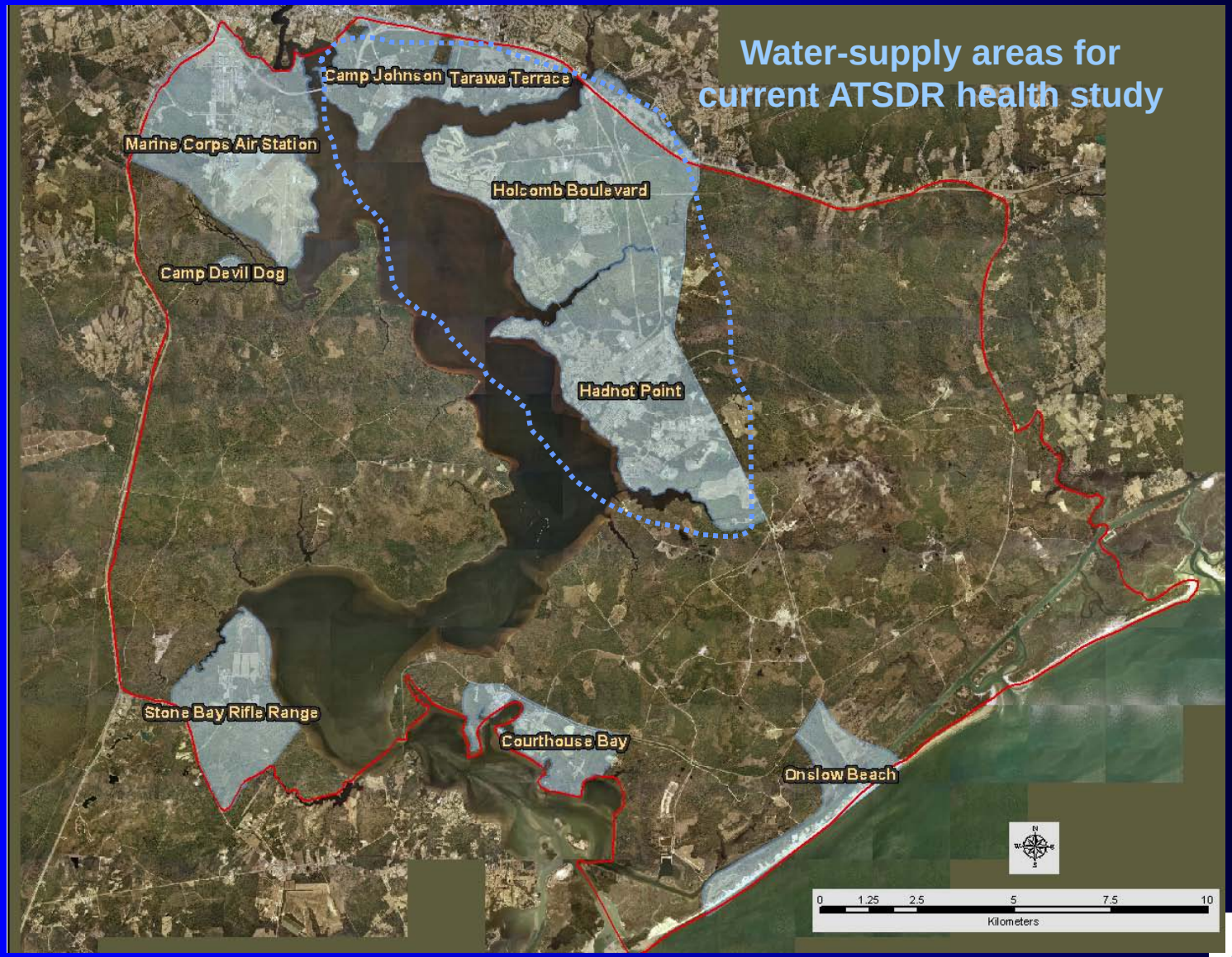
Marine Corps Base Camp Lejeune, NC



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Exposure to volatile organic compounds in drinking water and specific birth defects and childhood cancers (case-control study)

- **Multi-step process**
  - Review scientific literature to identify specific birth defects and childhood cancers associated with drinking water contaminated with chlorinated solvents
  - Conduct telephone survey to ascertain potential cases
  - Obtain medical records to verify diagnoses of reported cases
  - Conduct a case-control study
    - interview parents
    - **obtain estimates of exposure from the water-modeling component**

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Goals and objectives of water-modeling activities supporting current health study

- Arrival dates of contaminants at wells
- Distribution of contaminants by housing location
  - Concentration of finished drinking water at water treatment plant (WTP)
- Monthly mean concentrations
- Reliability of, and confidence in, water-modeling results
  - Range of concentration values for a specified month

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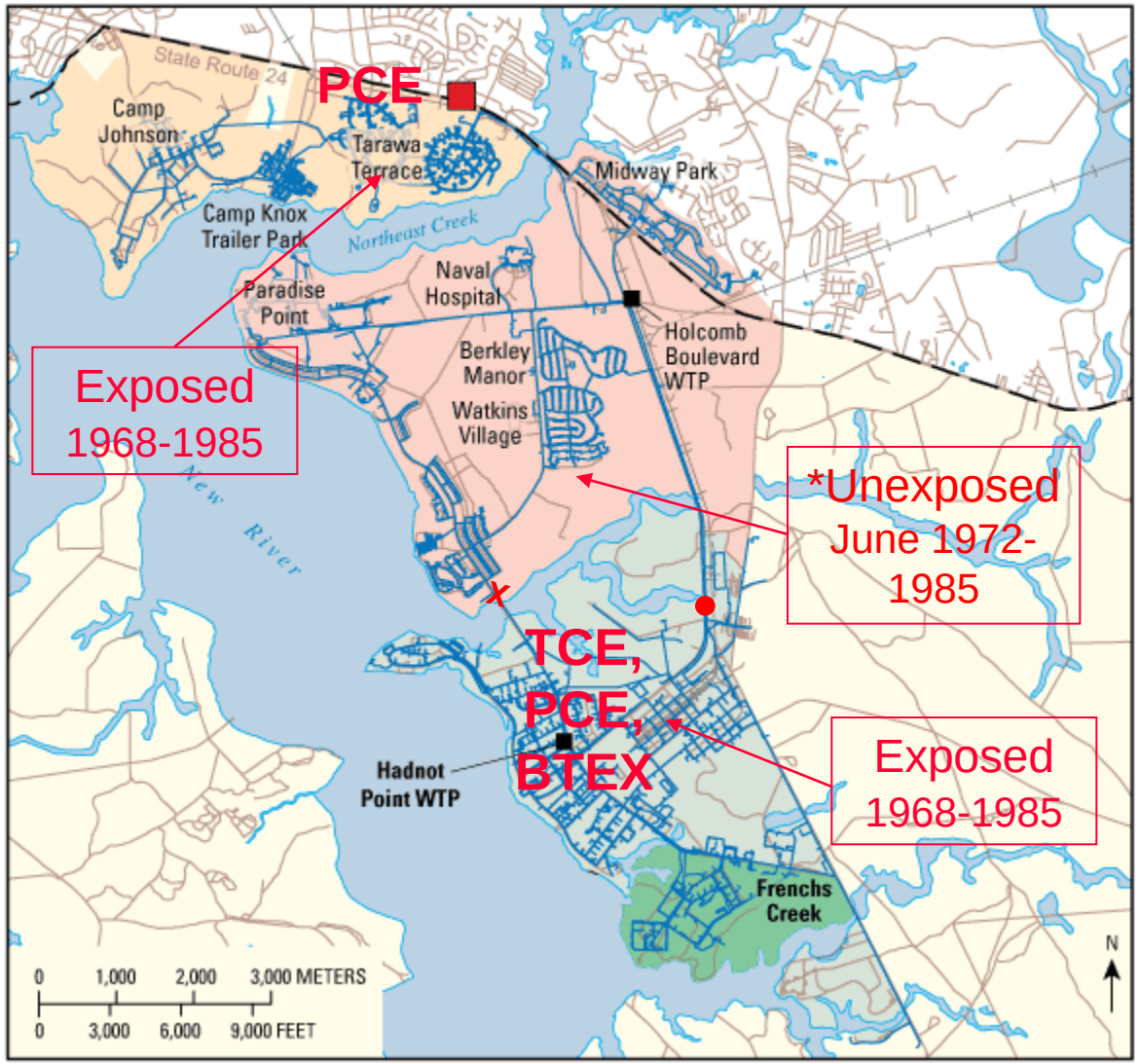
Epidemiological study areas



EXPLANATION

- Camp Lejeune Military Reservation
- Present day (2004) water-distribution system
  - Tarawa Terrace
  - Holcomb Boulevard
  - Hadnot Point
- Water pipeline
- Water-treatment plant (WTP)
- ABC One-Hour Cleaners

*Some intermittent exposure, April-June, 1972-85

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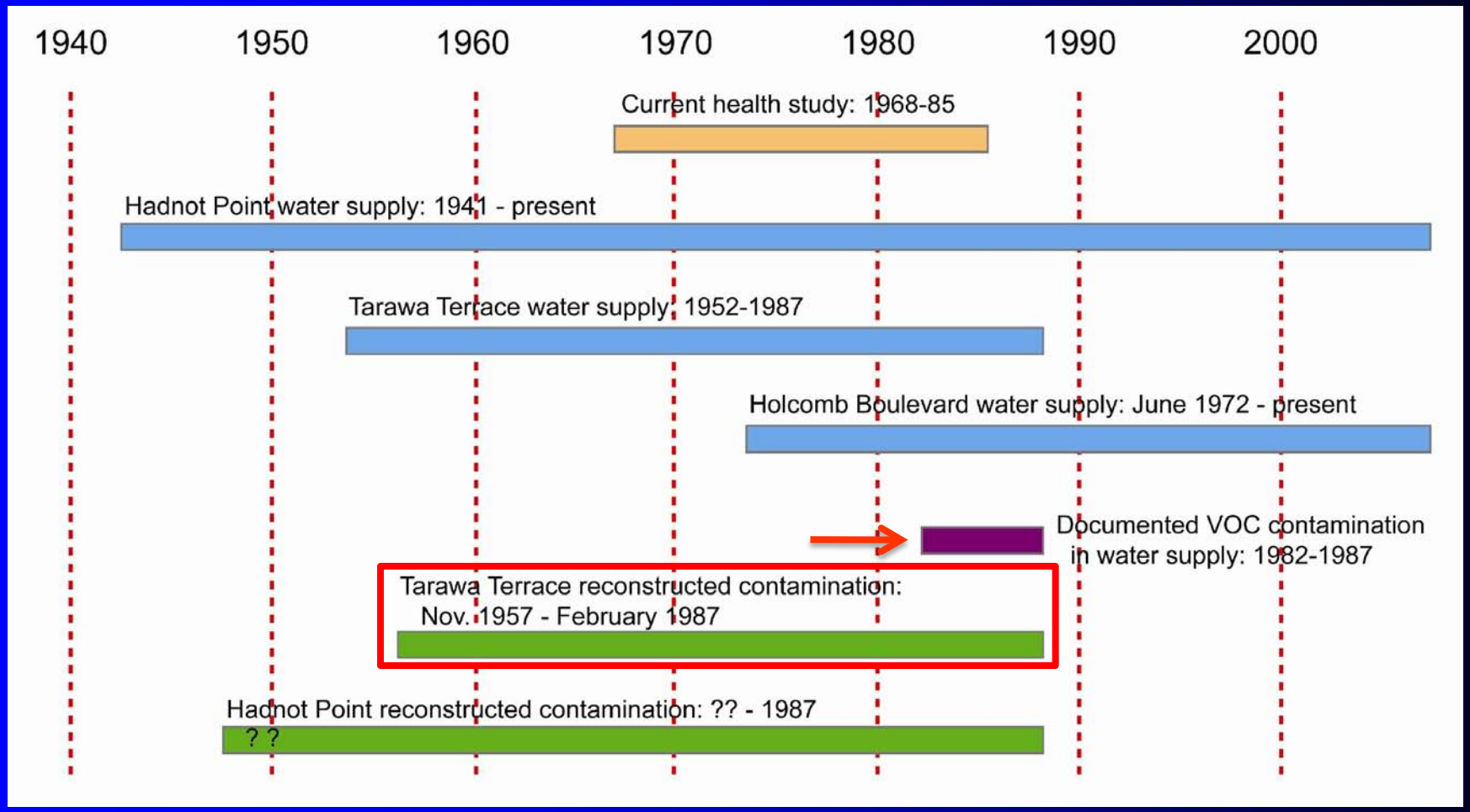
Generalized chronology of events



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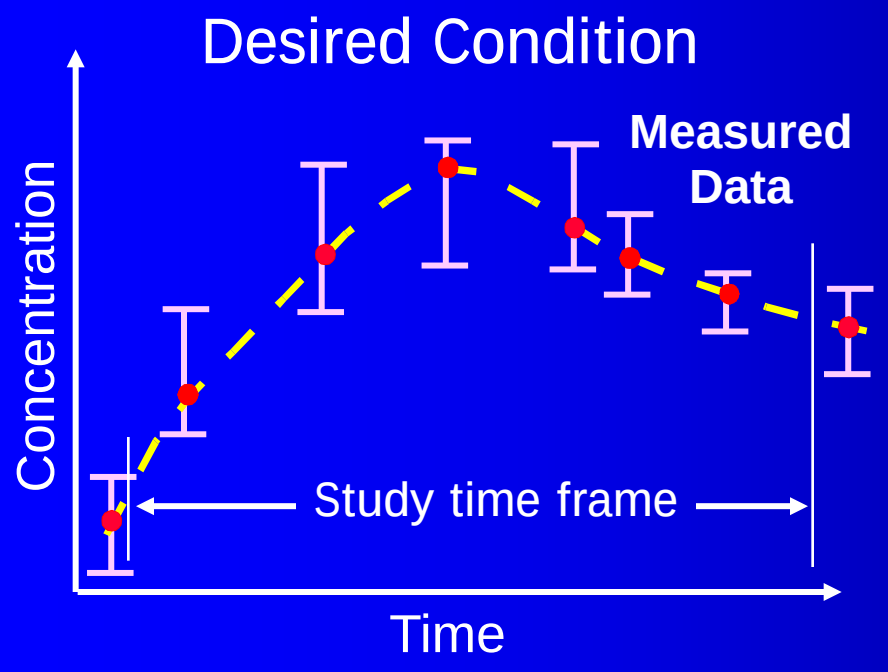
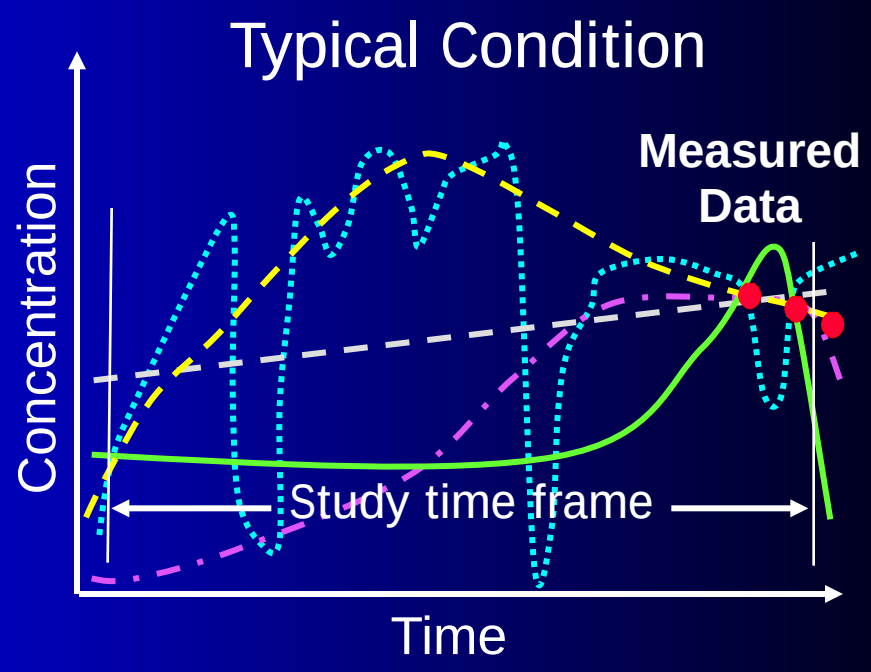
Why use models to estimate exposure scenarios?





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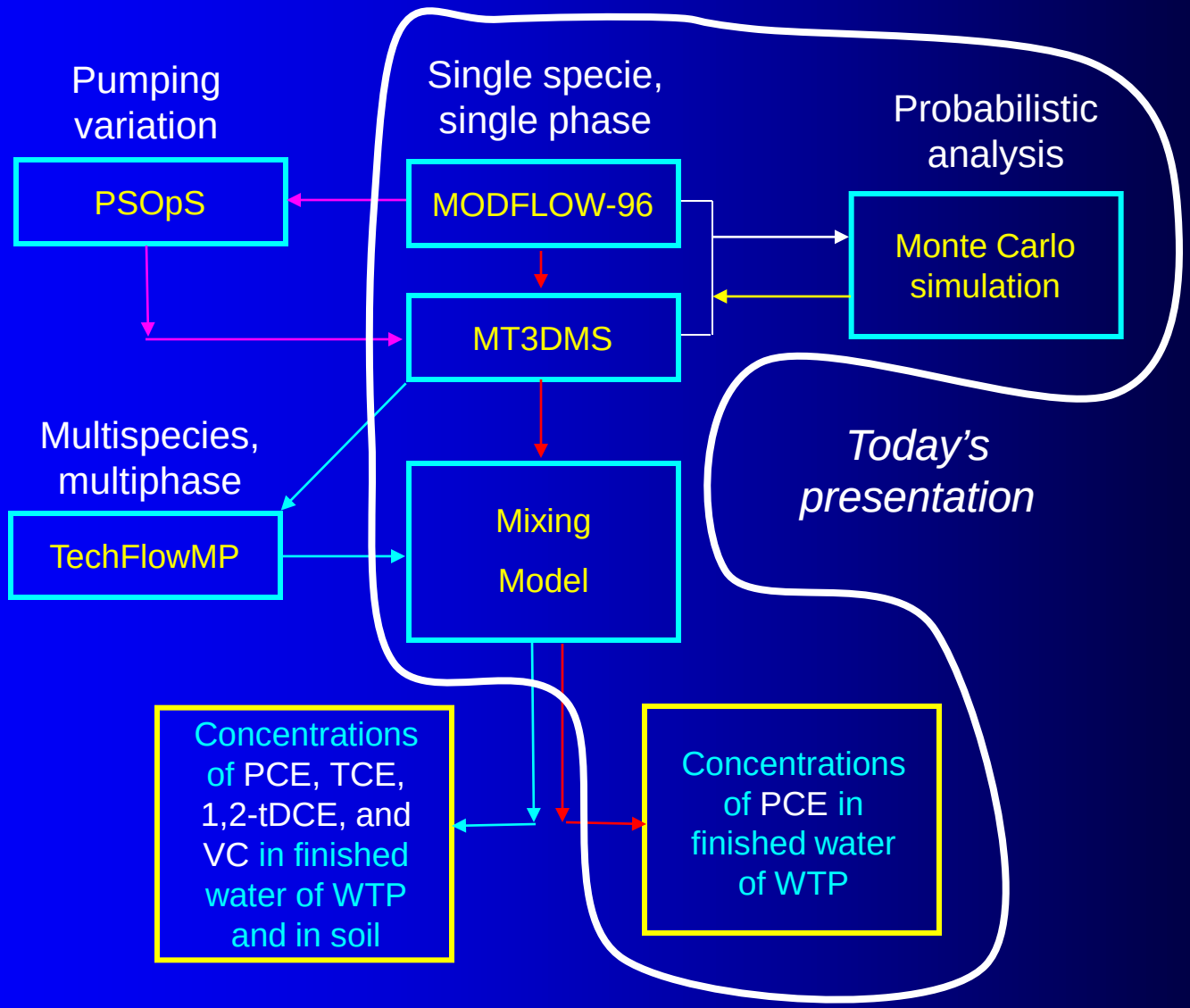
Tarawa Terrace water modeling



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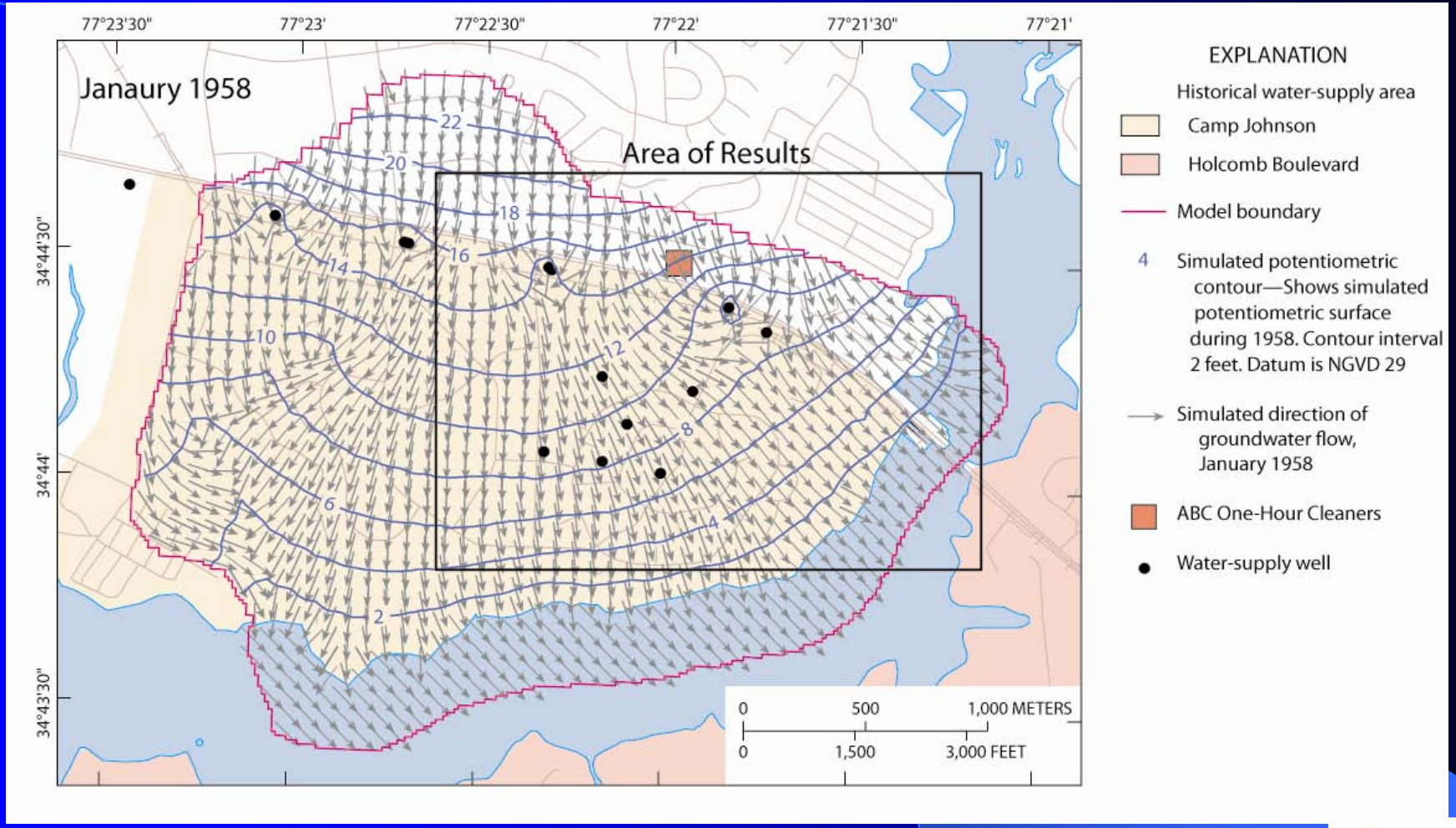
Examples of simulation results: Model layer 1



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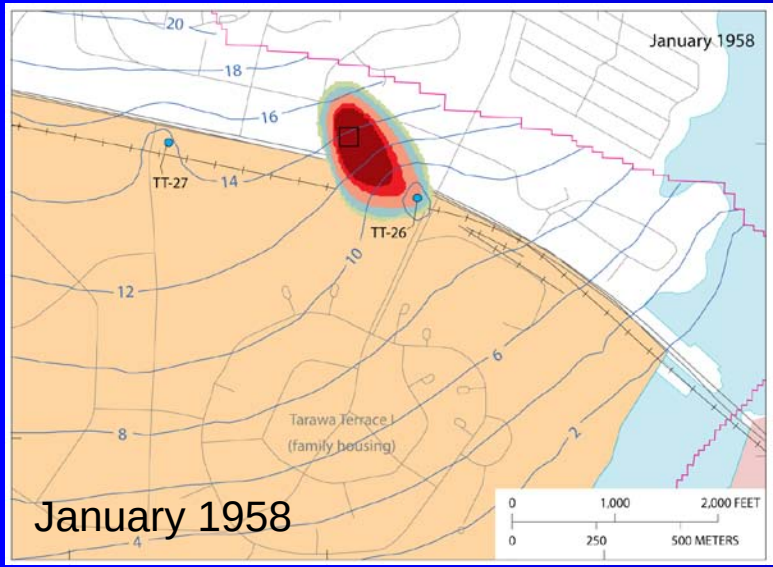
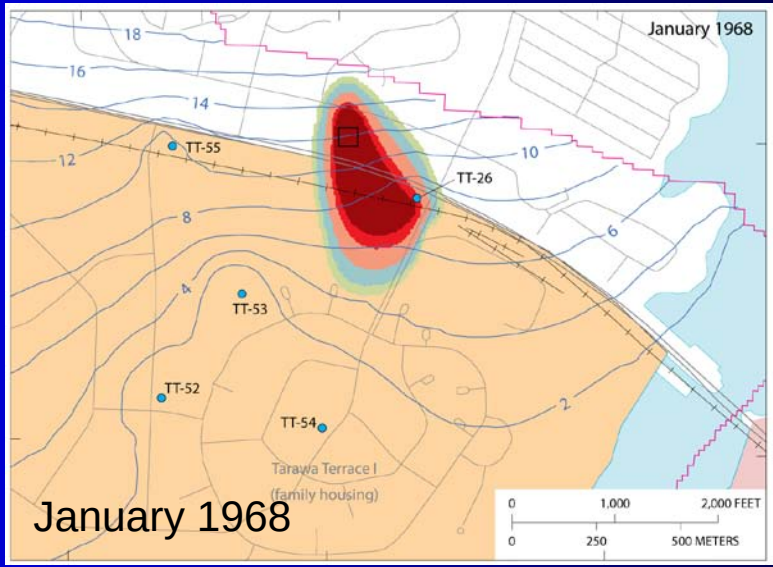
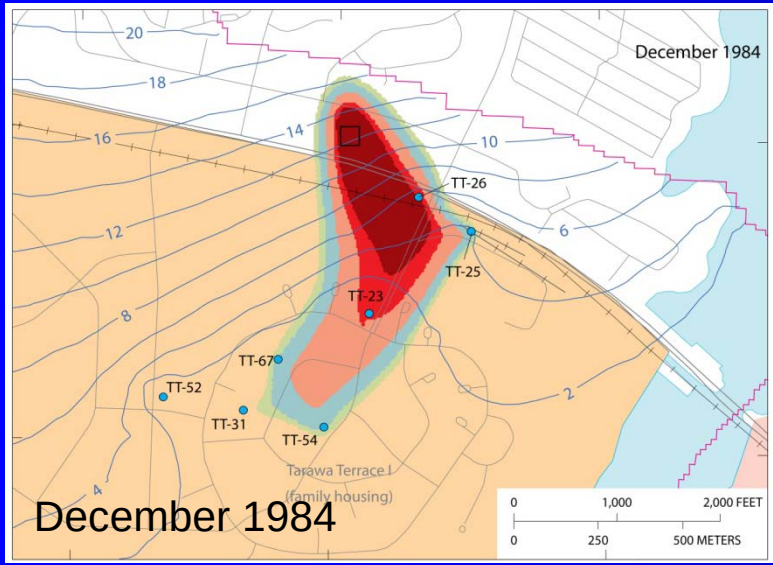
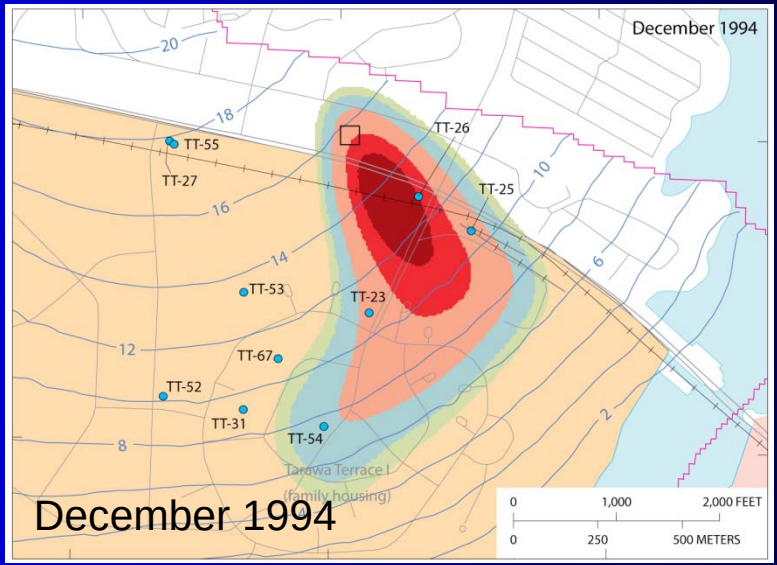
Historical fate and transport of PCE









EXPLANATION

Historical water-supply area

- Tarawa Terrace
- Holcomb Boulevard

Model boundary

Frenchmans Creek

—4— Simulated potentiometric contour—Shows simulated potentiometric surface during January 1958. Contour interval 2 feet. Datum is National Geodetic Vertical Datum of 1929

Simulated direction of groundwater flow, January 1958

ABC One-Hour Cleaners

TT-26 Pumping water-supply well and identification

PCE concentration, in micrograms per liter

- 1 to 5
- Greater than 5 to 50
- Greater than 50 to 500
- Greater than 500 to 1,500
- Greater than 1,500

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Mixing model for Tarawa Terrace water treatment plant

$$Q_T = \sum_{i=1}^{NWP} Q_i$$

$$C_{WTP} = \frac{\sum_{i=1}^{NWP} C_i Q_i}{Q_T}$$

NWP: number of wells pumping for month

Q_i: simulated pumping rate for well i

Q_T: Total simulated pumping rate for month

C_i: simulated concentration for well i

C_{WTP}: concentration in finished water delivered from Tarawa Terrace WTP

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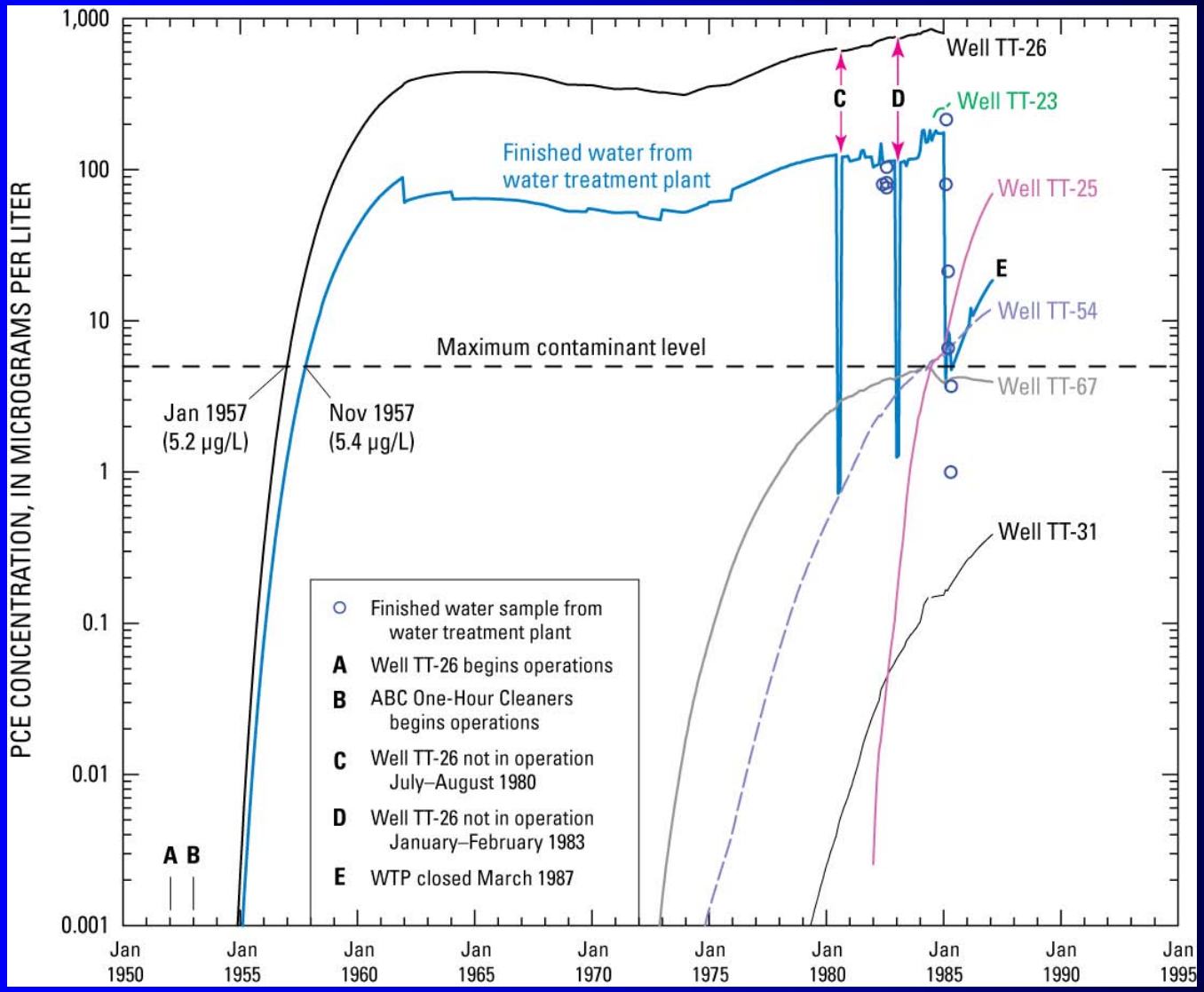
Calibrated results – mean values



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An example: PCE contamination levels (μg/L) by gestational month, Tarawa Terrace

*Child / Time	Child #1	Child #2	Child #3	Child #4	Child #5	Child #6	Child #7	Child #8	Child #9
-3DOC	118	174	108	0	121	0	55	0	0
-2DOC	120	173	109	0	121	0	54	0	93
-1DOC	132	176	110	103	0	0	54	0	94
month1	180	4	111	104	0	0	53	0	95
Month2	183	9	111	105	0	182	0	0	96
Month3	151	8	0	107	0	156	0	82	97

**Water modelers "blinded" to status of child (case or control)*

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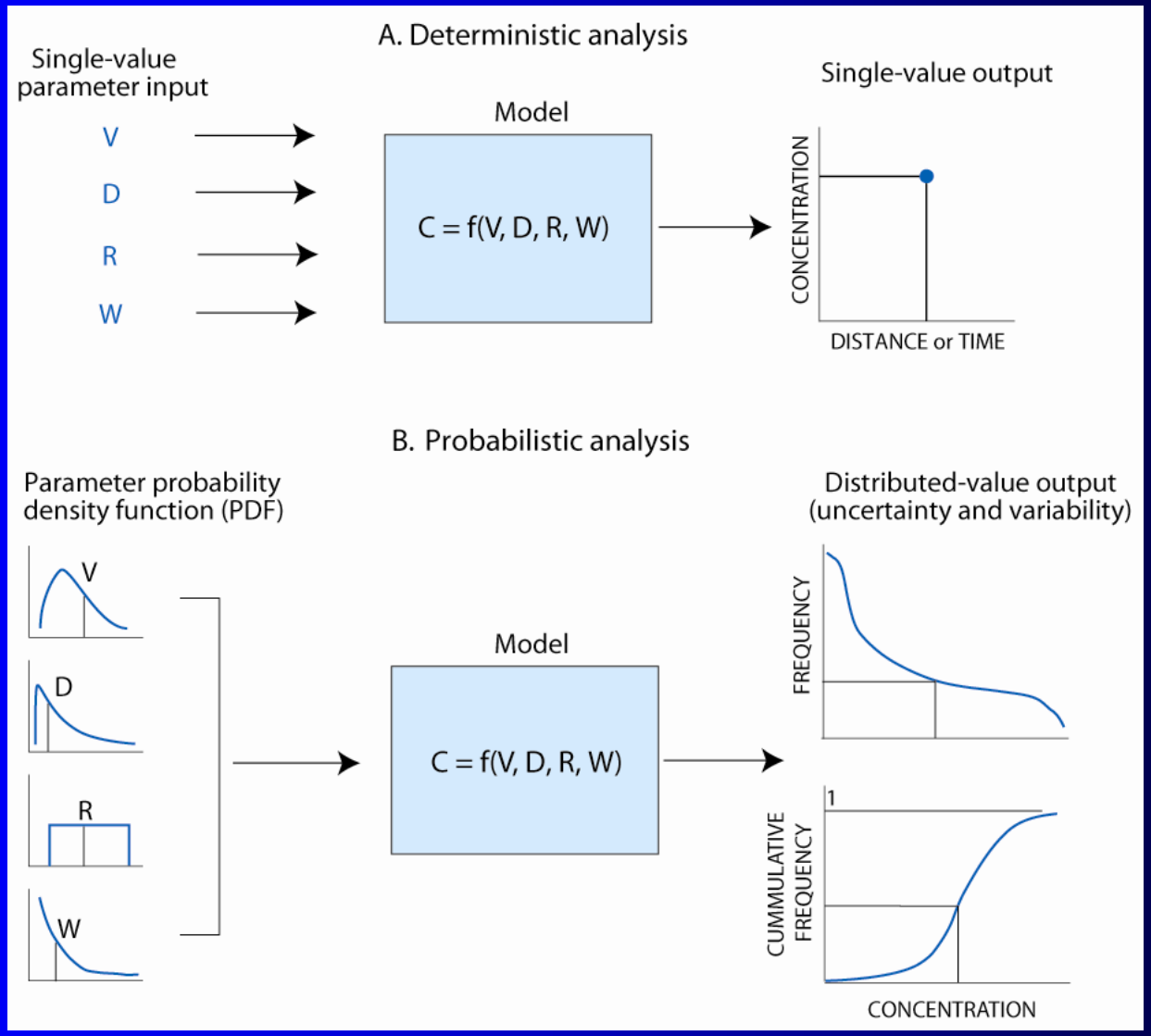
Probabilistic analyses



from Maslia and Aral, 2004

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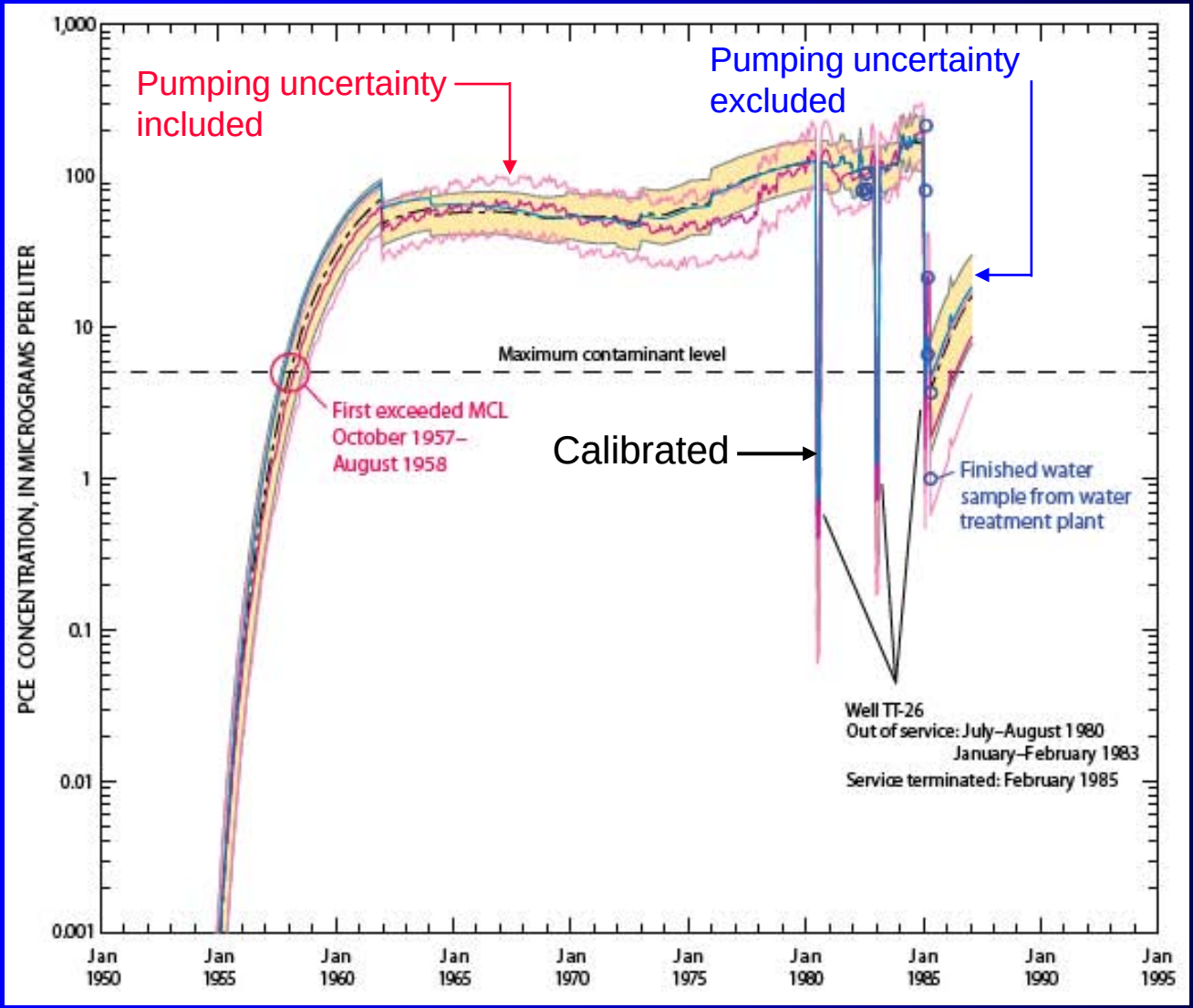
Probabilistic analysis range of values



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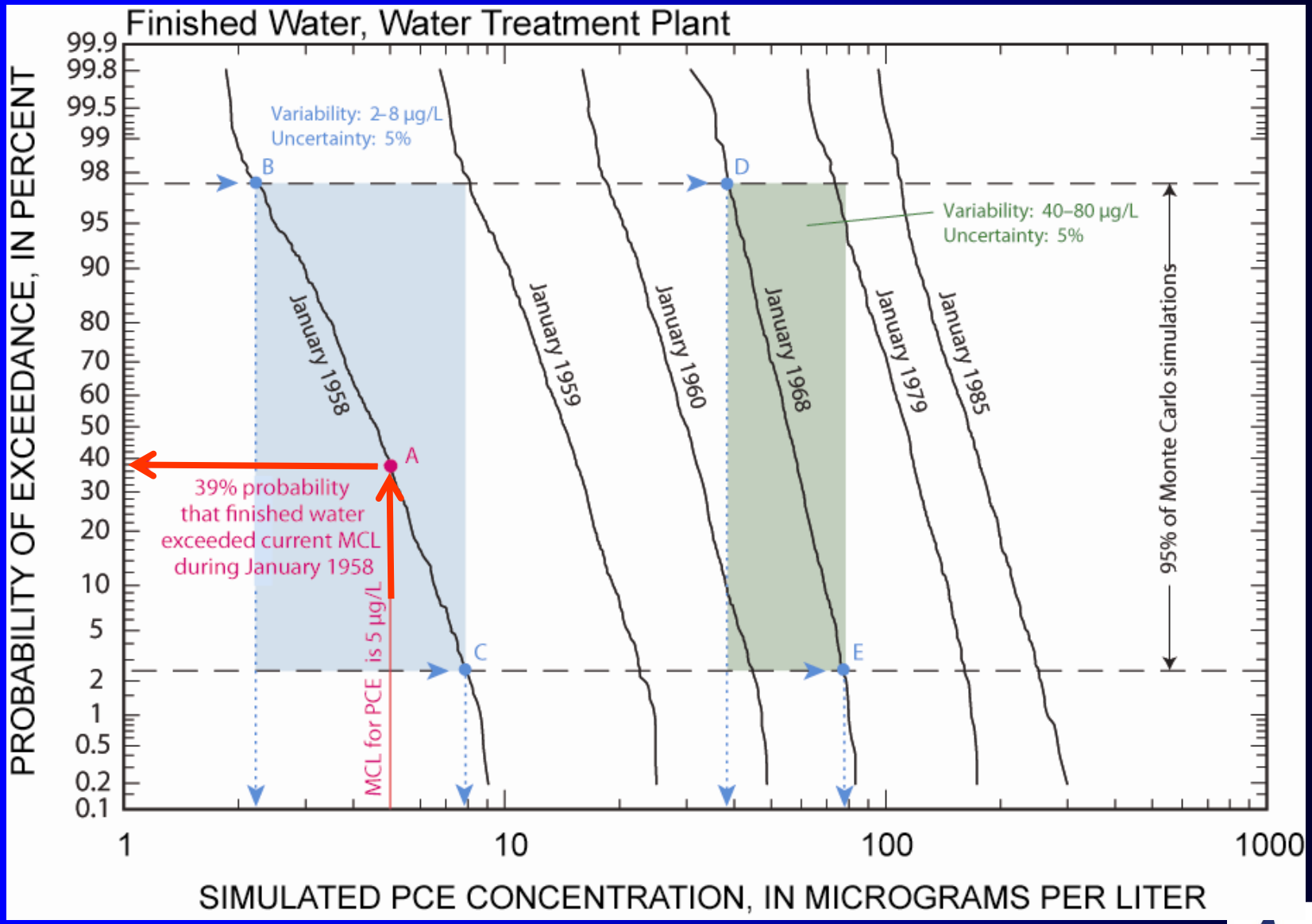
Probability of exceedance: 1958-1985



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Summary of Findings

- PCE concentration exceeded the current MCL of 5 μg/L in finished water at the Tarawa Terrace WTP for 346 months
  - November 1957-February 1987
  - Maximum simulated value:183 μg/L
  - Maximum measured value: 215 μg/L (Feb 1985)

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Tarawa Terrace Modeling Results: The "Big" Picture

- Calibrated and probabilistic models are useful for the epidemiological study
  - Groundwater flow, fate and transport, and mixing
  - Reconstructed monthly concentrations
- Concentrations measured during 1980s are representative of high concentrations experienced over many years
  - No indications that finished water had higher concentrations
- Conclusions would not be possible without using groundwater modeling

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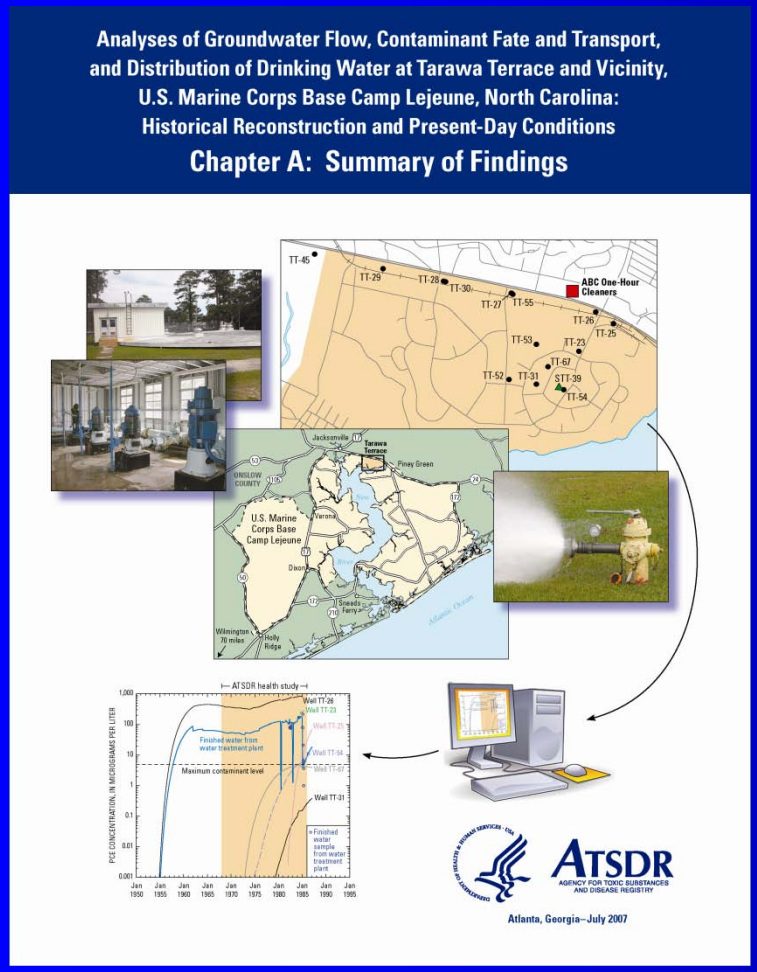
Published Tarawa Terrace results

ATSDR Reports (A-I)



Journal Article

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ORIGINAL PAPER

Reconstructing Historical Exposures to Volatile Organic Compound-Contaminated Drinking Water at a U.S. Military Base

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Abstract Two of three water-distribution systems that have historically supplied drinking water to family housing at U.S. Marine Corps Base Camp Lejeune, North Carolina, were contaminated with volatile organic compounds (VOCs). Scientific data relating to the harmful effects of VOCs on a child or fetus are limited. Therefore, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) is conducting an epidemiological study to evaluate potential associations between in utero and infant (up to 1 year of age) exposures to VOCs in contaminated drinking water at Camp Lejeune and specific birth defects and childhood cancers. The study includes births that occurred during the period 1968–1985 to women who were pregnant while they resided in family housing at Camp Lejeune. To support the epidemiological study, water-modeling techniques are being used to reconstruct historical conditions of groundwater flow, contaminant fate and transport, and the distribution of drinking water contaminated with VOCs. Results for this phase of the study indicate that PCE concentrations in drinking water, delivered to the Tarawa Terrace housing area, exceeded the current maximum contaminant level for PCE of 5 micrograms per liter (μg/L) for 346 months—November 1957–February 1987; the maximum simulated PCE concentration in Tarawa Terrace drinking water was 183 μg/L during March 1984 compared to a measured concentration of 215 μg/L during February 1985.

Keywords Contaminated drinking water · Exposure · Volatile organic compound (VOC) · PCE · TCE · Historical reconstruction · Epidemiological study · Camp Lejeune · North Carolina · USA

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry or the U.S. Department of Health and Human Services.
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Introduction

Three water-distribution systems have historically supplied drinking water to family housing at U.S. Marine Corps Base Camp Lejeune—Tarawa Terrace, Holcomb Boulevard, and Hadnot Point (Fig. 1). Two of the water-distribution systems were contaminated with volatile organic compounds (VOCs). Tarawa Terrace was contaminated mostly with tetrachloroethylene (PCE) and Hadnot Point was contaminated mostly with trichloroethylene (TCE). Therefore, 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 whether in utero and infant (up to 1 year of age) exposures to drinking water contaminated with VOCs at Camp Lejeune were associated with specific birth defects and

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http://www.atsdr.cdc.gov/sites/lejeune/watermodeling.html

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Thank You!

For questions or additional information, you can contact:

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