NAVFAC
Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

2025 RITS

REMEDIATION INNOVATIVE TECHNOLOGY SEMINAR

Student Handbook
Summer 2025

Day One

- Strategies to Address Per- and Polyfluoroalkyl Substances (PFAS) in Private Drinking Water Wells near Naval Installations
- Contextualizing PFAS Detections: Background and Forensics
- Remediation of PFAS-Impacted Solids

Day Two

- Optimization Tools and Strategies Implemented at Sites with Long-Term Remediation Systems
- Managing Lead-Impacted Sites under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Preliminary Assessment and Site Inspection (PA/SI) Process for Sites with General Radioactive Materials (G-RAM)

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Presentations

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Agenda

RITS Day 1 Presentations

(Times subject to change)

0800 – 0830	**Welcome & Introduction**
0830 – 1015	**Strategies to Address PFAS in Private Drinking Water Wells near Naval Installations** As the Navy continues PFAS investigations and identifies installations where PFAS may have migrated toward private drinking water wells, mitigation of exposure to PFAS in private drinking water continues to be a priority. This presentation will describe the history of the Navy's private drinking water well sampling of PFAS to mitigate exposure, steps to address PFAS in private drinking water wells, and technology alternatives for enduring solutions in accordance with DoD policy. DoD and Navy policies and guidance will also be reviewed. A case study will be presented to illustrate interim actions and approaches to address PFAS in private drinking water wells near Naval installations. **SPEAKER: Paul Landin (NAVFAC LANT)**
1015 – 1030	**Break**
1030 – 1130	**Contextualizing PFAS Detections: Background and Forensics** Current research indicates background sources of PFAS can sometimes exceed regulatory standards, meaning that it may not be feasible to find or delineate a plume boundary, where a remedial action would be implemented, when the entire site (due to background) is above regulatory standards. Therefore, when conducting PFAS investigations it is critical to appropriately assess PFAS background concentrations. Forensic methods based on the understanding of how environmental conditions affect PFAS patterns along routes of migration can be used to identify source areas and assess site-specific background levels. This presentation will highlight how to: 1) identify key factors for assessing PFAS background, 2) select appropriate background reference areas, 3) use forensics methods to contextualize PFAS detections from source areas versus background levels, and 4) summarize key knowledge to support development of more robust PFAS conceptual site models to support decision-making. **SPEAKER: Jeff Gamlin (GSI Environmental)**
1130 – 1300	**Lunch**
1300 – 1415	**Contextualizing PFAS Detections: Background and Forensics, Continued** **SPEAKER: Jeff Gamlin (GSI Environmental)**
1415 – 1430	**Break**
1430 – 1630	**Remediation of PFAS-Impacted Solids** Addressing PFAS-impacted solids has become a pressing challenge in the overall management of impacted sites throughout the Navy. This presentation will provide an overview of remedial technologies for PFAS-impacted solids, specifically ex situ and in situ treatment technologies for PFAS-impacted soils as currently available and under development. Initial results will be discussed from the Environmental Security Technology Certification Program - Defense Innovation Unit (ESTCP-DIU) comparative technology demonstration project hosted at Joint Base Elmendorf-Richardson in Anchorage, Alaska. **SPEAKERS: Jovan Popovic (NAVFAC EXWC) and John Kornuc (NAVFAC EXWC)**
1630	**Adjourn**

Agenda

RITS Day 2 Presentations

(Times subject to change)

0800 – 0815	**Welcome & Introduction**
0815 – 1000	**Optimization Tools and Strategies Implemented at Sites with Long-Term Remediation Systems** Challenges can arise over the course of operating long-term remediation systems, including, but not limited to, pump-and-treat, soil vapor extraction, and multi-phase extraction systems, which can incur significant expenses during operation, maintenance, and monitoring activities. This presentation will discuss the basis and timing for considering a range of tools and strategies to support system optimization throughout the cleanup process. The presentation will then feature case studies from four Navy sites to highlight when optimization efforts were implemented to support a transition from the long-term remediation system to alternative active remedies, natural attenuation, or other stakeholder-agreed strategies to reduce remedial timeframes and/or life cycle costs, while remaining protective. **SPEAKER: Mike Perlmutter (Jacobs)**
1000 – 1015	**Break**
1015 – 1200	**Managing Lead-Impacted Sites under CERCLA** In January 2024, the United States Environmental Protection Agency (EPA) updated the long-awaited soil lead guidance for CERCLA sites and Resource Conservation and Recovery Act (RCRA) corrective action facilities. This update affects several sites in the DON Environmental Restoration Program (ERP). This presentation will discuss the update to the EPA lead soil Regional Screening Level (RSL) and how lead should be assessed during the human health risk assessment process. The integral role of blood lead levels in assessing risk and the use of the Integrated Exposure Uptake Biokinetic (IEUBK) model for developing preliminary remediation goals will also be presented. Case studies will be discussed to highlight the updated EPA lead soil RSL. **SPEAKER: Christopher Saranko (Geosyntec Consultants)**
1200 – 1330	**Lunch**
1330 – 1530	**PA/SI Process for Sites with G-RAM** A framework has been recently developed which provides a standardized approach in conducting a PA/SI for sites with a known presence or potential presence of G-RAM. This presentation will provide an overview of this framework for G-RAM-impacted sites and highlight key differences from other impacted sites addressed under CERCLA. The approach is consistent with the requirements of the United States Nuclear Regulatory Commission (NRC), EPA, DON, and other appropriate state and local regulations, while focusing on the DON's ERP goals. The framework is also consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the Radiological Site Management Toolkit for Navy Installations for surveying and sampling at radiological sites. **SPEAKER: Rion Marcinko (Jacobs)**
1530	**Adjourn**

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Acronyms

µg/dL	microgram(s) per deciliter
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
µg/m^3	microgram(s) per cubic meter
σ	standard deviation
AALM	All-Ages Lead Model
ABL	Allegany Ballistics Laboratory
ACCLPP	Advisory Committee on Childhood Lead Poisoning and Prevention
ADEC	Alaska Department of Environmental Conservation
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AFB	Air Force Base
AFFF	Aqueous Film Forming Foam
ALM	Adult Lead Methodology
AM	Action Memorandum
AOC	area of concern
AOI	area of interest
ARAR	applicable or relevant and appropriate requirement
ARG	active remediation goal
AROD	administrative record of decision
AS	air sparging
AST	aboveground storage tank
bgs	below ground surface
BLL	blood lead level
BPSOU	Butte Priority Soils Operable Unit
BRA	Background Reference Area
BRAC	Base Realignment and Closure
BS	Bachelor of Science
BSVM	Backyard Area soil vapor monitoring probe
CAA	Clean Air Act
CAC	colloidal activated carbon
CAO	corrective action objective
CDC	Center for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHG	certified hydrogeologist
CHP	Certified Health Physicist
CI	confidence interval
CLEAN	Comprehensive Long-term Environmental Action—Navy
CN+S	cyanide and sulfide
Co	cobalt
CO_2	carbon dioxide
COC	chemical of concern

Acronyms

COPC	chemical of potential concern
CPSC	Consumer Product Safety Commission
CS	cesium
CSF	cancer slope factor
CSM	conceptual site model
CTO	contract task order
CVOC	chlorinated volatile organic compound
DABT	Diplomate, American Board of Toxicology
DCE	dichloroethylene
DEC	Department of Environmental Conservation
DERP	Defense Environmental Restoration Program
DLA	Defense Logistics Agency
DNR	Department of Natural Resources
DOC	dissolved organic carbon
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
dpm	disintegrations per minute
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DU	depleted uranium
DWS	domestic water supply
ELAP	Environmental Laboratory Accreditation Program
EPA	United States Environmental Protection Agency
EPM	Environmental Protection Manager
ER, N	Environmental Restoration, Navy
ERD	enhanced reductive dechlorination
ERP	Environmental Restoration Program
ESD	explanation of significant differences
ESTCP	Environmental Security Technology Certification Program
EXWC	Engineering and Expeditionary Warfare Center
FDA	Food and Drug Administration
Fe	iron
FEC	Facilities Engineering Command
FFTA	former fire training area
FS	feasibility study
FSS	final status survey
ft	foot or feet
ft bgs	feet below ground surface
FY	fiscal year
G-RAM	general radioactive material
GAC	granular activated carbon

Acronyms

GC	gas chromatography
GPS	Global Positioning System
GW	groundwater
GWS	Gamma Walkover Survey
H	hydrogen
haz.	hazardous
HF	hydrofluoric acid
HFPO-DA	hexafluoropropylene oxide dimer acid
HHRA	human health risk assessment
HQ	hazard quotient
HRA	Historical Radiological Assessment
HRSC	high-resolution site characterization
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IL	Investigation Level
inject.	injection
IR	installation restoration
IRP	Installation Restoration Program
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ITRC	Interstate Technology & Regulatory Council
IX	ion exchange
J	estimated value
JB	Joint Base
JP-5	jet fuel
JBPHH	Joint Base Pearl Harbor-Hickam
JRB	Joint Reserve Base
K	permeability
K_{oc}	organic carbon partition coefficient
kW	kilowatt
LANT	Naval Facilities Engineering Systems Command Atlantic
lb	pound(s)
LBP	lead-based paint
LC-MS/MS	liquid chromatography tandem mass spectrometer
LCC	life cycle costs
LEAF	Leaching Environmental Assessment Framework
LNAPL	light nonaqueous-phase liquid
LTM	long-term monitoring
LUC	land use control
MAROS	Monitoring and Remediation Optimization System
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual

Acronyms

MBT	molecular biological tool
MCAS	Marine Corps Air Stations
MCL	maximum contaminant level
MCOLF	Marine Corps Outlying Landing Field
MDC	minimum detectable concentration
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mi	mile(s)
Mn	manganese
MNA	monitored natural attenuation
MS	mass spectrometry
MTG	migration to groundwater
N/A	not applicable
NAAQS	National Ambient Air Quality Standards
NAB	Naval Amphibious Base
NaI	sodium iodide detector
NALF	Naval Auxiliary Landing Field
NAPL	nonaqueous phase liquid
NAPR	Naval Activity Puerto Rico
NARM	Naturally Occurring and Accelerator-Produced Radioactive Material
NARL	Naval Arctic Research Laboratory
NAS	Naval Air Station
NASJRB	Naval Air Station Joint Reserve Base
NAVFAC	Naval Facilities Engineering Systems Command
NAVSTA	Naval Station
Navy	Department of the Navy
NAWC	Naval Air Warfare Center
NAWS	Naval Air Weapons Station
NB	Naval Base
NCBC	Naval Construction Battalion Center
NCDEQ	North Carolina Department of Environmental Quality
NCGWQS	North Carolina Groundwater Quality Standards
ND	nondetect
NERP	Navy Environmental Restoration Program
NFA	no further action
ng/kg	nanogram(s) per kilogram
ng/L	nanogram(s) per liter
NIST	National Institute of Standards and Technology
NJDEP	New Jersey Department of Environmental Protection
NOLF	Naval Outlying Landing Field
NORM	Naturally Occurring Radioactive material
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NRMP	Naval Radioactive Materials Permit Program

Acronyms

NRL-CBD	Naval Research Laboratory – Chesapeake Bay Detachment
NS	Naval Ship
NSA	Naval Support Action
NSWC	Naval Surface Warfare Center
NSZD	natural source zone depletion
NTP	National Toxicology Program
NTCRA	Non-Time-Critical Removal Action
NWIRP	Naval Weapons Industrial Reserve Plant
NWS	Naval Weapons Station

O&M	operations and maintenance
OBDW	off-base drinking water
ODASN-EMR	Office of the Deputy Assistant Secretary of Defense for Environmental Management and Restoration
OLEM	Office of Land and Emergency Management
OLF	outlying landing field
OOM	order(s) of magnitude
OSC	On-Scene Coordinator
OSD	Office of the Secretary of Defense
OSWER	Office of Solid Waste and Emergency Response
OTM	Other Test Method
OU	operable unit

P&T	(groundwater) pump and treat
PA	preliminary assessment
PAC	powdered activated carbon
Pb	lead
PbB	blood lead level
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
pCi/g	picocurie(s) per gram
PE	professional engineer
PFAA	perfluoroalkyl acid
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFCA	perfluoroalkyl carboxylic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctansulfonic acid
PG	professional geologist
PhD	Doctor of Philosophy
PI	principal investigator
PIC	product of incomplete combustion
PID	product of incomplete destruction
Pm	promethium
PM	project manager

Acronyms

POC	point of contact
POET	point-of-entry treatment
POU	point-of-use
ppm	parts per million
ppt	part(s) per trillion
PRG	preliminary remediation goal
PSL	Project Screening Level
PVC	polyvinyl chloride

Ra	radium
RA	remedial action
RA-O	remedial action optimization
RAO	remedial action objective
RASO	Radiological Affairs Support Office
RBSC	risk-based screening concentration
RC	response complete
RCRA	Resource Conservation and Recovery Act
RD	remedial design
regen.	regeneration
RfD	reference dose
RI	remedial investigation
RITS	Remediation Innovative Technology Seminar
RO	reverse osmosis
ROD	record of decision
ROPC	radionuclide of potential concern
RPM	remedial project manager
RSL	regional screening level

SAP	sampling and analysis plan
SC	site closeout
SERDP	Strategic Environmental Research and Development Program
SI	site inspection
SOM	soil organic material
Sr	strontium
SSL	soil screening level
SVE	soil vapor extraction
SVM	soil vapor monitoring probe
SVMC	soil vapor migration control
SVOC	semivolatile organic compound
SW	surface water
SWMU	solid waste management unit

T&D	transport and disposal
TA^2	Transition Assessment Teaching Assistant
TCE	trichloroethene
TCH	thermal conduction heating
TCRA	Time-Critical Removal Action

Acronyms

TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TFR	total fluids recovery
Th	thorium
THQ	target hazard quotient
TI	thallium
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TR	target risk
TRL	technology readiness level
TRV	toxicity reference value
TSVM	temporary soil vapor monitoring probe
TWFF	Tow Way Field Farm
U	uranium
UCL	upper confidence limit
UCMR5	Unregulated Contaminant Monitoring Rule 5
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UST	underground storage tank
UTL	upper tolerance limit
UV	ultraviolet
UU/UE	unlimited use/unrestricted exposure
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound
XRF	x-ray fluorescence
yd^3	cubic yard(s)
ZnS	zinc sulfide

Glossary

Aqueous Film Forming Foam (AFFF): A fire suppressant used to extinguish flammable liquid fires, such as fuel fires. Often used in shipboard and shore facility fire suppression systems, fire-fighting vehicles, and at fire-training facilities.

Area of Interest (AOI): Area that cannot be classified as impacted or non-impacted based on existing information.

Asymptotic: A mathematical curve that approaches a single value but never reaches it. In the context of environmental cleanup, asymptotic concentrations indicate the active remedy has reached a limit for efficiently treating a contaminant and other management or technologic strategies should be considered.

Background: Substances or locations that are not influenced by releases from a site and are usually described as naturally occurring or anthropogenic.

Background concentration: The concentration of a substance that is naturally occurring or resulting from human/anthropogenic impacts unrelated to the discharge of pollutants or hazardous substances at a site.

Background Reference Area: An area with similar physical, chemical, geological, radiological, and biological characteristics as the area to be surveyed that has not been potentially contaminated by area activities. Readings are taken in this area to use for comparison with readings taken during radiological surveys.

Baseline ecological risk assessment (BERA): A refined iteration of a screening ecological risk assessment (SERA) that reflects more realistic assumptions and more accurate risk estimates.

Bioaccumulation: Net accumulation of a contaminant in the tissue of an organism.

Bioavailability: The amount of a substance present in a form that organisms can take up or adsorb.

Chemical(s) of concern (COCs): Specific chemicals that are identified for evaluation in the site assessment process.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A United States federal law, also known as Superfund, aimed at cleaning up sites contaminated with hazardous substances and pollutants. CERCLA is codified in 42 United States Code (USC) Chapter 103. CERCLA changed in 1986 with the Superfund Amendments and Reauthorization Act (SARA) to specifically include provisions for environmental restoration at DoD sites.

Conceptual site model (CSM): A written, illustrative, or graphic framework for understanding the key processes and mechanisms controlling the nature, extent, fate and transport of chemicals of concern from the source, through the pathway, to the receptor at a site. It should outline the potential exposure pathways and receptors for consideration in a risk assessment, provide a road map to which pathways require quantified assessment, and reflect the best interpretation of available information at any point in time.

Glossary

Confining layer: A geologic unit of impermeable or low-permeability material that restricts the flow of groundwater.

Data gaps: Missing or incomplete data in a dataset that can impact analysis and decision-making processes.

Data Quality Objective (DQO): Statements derived from the DQO process that clarify technical objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decision making about a site.

Decision support tools: Software or systems designed to help in making informed and data-driven decisions, especially in complex scenarios.

Defense Environmental Restoration Program Management Manual (DERP Manual): The DERP Manual, document number 4715.20, outlines the overall policies that all DoD services need to follow when implementing their individual environmental restoration programs. The DERP has a substantially larger scope than CERCLA.

Defensible: In the context of data and analysis, it refers to results or methodologies that are scientifically and logically sound and can withstand scrutiny.

Definitive data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Definitive data is suitable for final decision-making.

Deliverable: A tangible or intangible output produced as a result of a project or process.

Direct-push technology (DPT): A method of drilling, often referred to as DPT, that uses the static weight of the rig combined with a hydraulic hammer to advance tooling or instrumentation through the subsurface.

Disintegrations per minute (dpm): Unit of measure of radioactivity indicating the number of radioactive decays occurring in a radioactive sample over a minute.

Discharge pathways: Routes through which substances are released into the environment, such as emissions to air or discharges to water.

Environmental Laboratory Accreditation Program (ELAP): A nationwide accreditation program that ensures laboratories generate environmental and public health data of known, consistent, and documented quality to meet stakeholder needs through effective program implementation and continuous improvement.

Environmental Protection Manager: The technical lead designated by Radiological Affairs Support Office (RASO) for all radiological issues.

Environmental Restoration, Navy (ER,N): The Department of the Navy (DON) Environmental Restoration Program account funding all Environmental Restoration activities at active bases where contamination is suspected or confirmed within the environment for the Navy and the Marine Corps.

Glossary

Environmental Restoration Program (ERP): The ERP is a DON program to identify, investigate, and clean up former waste disposal sites on military property, and correct other environmental hazards such as detection and disposal of unexploded ordnance. The ERP's objectives are to reduce the risk to human health and the environment from past waste disposal operations and hazardous material spills in a cost-effective manner.

Exposure assessment: Quantifies the amount of a chemical that receptors are exposed to (internal dose or external media concentration).

Exposure point concentration (EPC): A single number representing a concentration of a chemical (in soil, water, etc.).

Feasibility study (FS): A detailed assessment of cleanup options for a contaminated site, determining the most effective, cost-efficient, and feasible remedial alternative.

Final Status Survey: A combination of measurements and sampling to describe the radiological conditions of a site in preparation for release.

Five-year review (FYR): A periodic assessment of the progress and effectiveness of a remedial action plan or project at contaminated sites.

Gamma Walkover Survey: Process of characterizing the radiological features of a land area by measuring gamma radiation levels with highly sensitive survey equipment. The collected data is then processed to generate detailed contour plots and reports.

General Radioactive Material (G-RAM): A Navy classification for all radioactive materials used by the Navy that are not associated with the Naval Nuclear Propulsion Program or the Naval Nuclear Weapons Program.

GenX: Chemours® trademark name for a synthetic, short-chain organofluorine chemical compound, the ammonium salt of hexafluoropropylene oxide dimer acid (HFPO-DA). It can also be used more informally to refer to the group of related fluorochemicals that are used to produce GenX.

Geologic cross sections: Diagrams showing the features and structures beneath the Earth's surface, presented as a vertical slice through the ground.

Geophysical logs: Records of the physical properties of subsurface formations, obtained through geophysical methods.

Geophysical methods: A variety of tools and techniques for characterizing subsurface structure, composition, and dynamics. Includes electrical resistivity, seismic, electromagnetic, and gravity methods.

Geospatial: Relating to data that is associated with a specific location on the Earth's surface.

Granular Activated Carbon (GAC): A porous adsorption media with extremely high internal surface area that can efficiently remove a variety of chemicals from air and water. GAC can be manufactured from a variety of raw materials with porous structures.

Glossary

Half-life: Time required for a population of atoms of a given radionuclide to decrease through radioactive decay to exactly one-half of the original number of atoms. Provides a relative measure of the persistence of a radionuclide in a given medium, although actual values can vary greatly depending on site-specific conditions. The greater the half-life, the more persistent a radionuclide is likely to be.

Hazard index (HI): The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, sub-chronic, and shorter-duration exposures.

Hazard quotient (HQ): Numerical ratio that compares the exposure level of a substance to a reference level that is considered safe or harmless. The reference level can be a dose, a concentration, or a toxicity value for a specific type of organism or population. If the hazard quotient is less than 1, no adverse effects are expected from the exposure. If the hazard quotient is greater than 1, adverse effects are possible or likely.

Health-based water concentrations: The numerical value proposed for use by the United States Environmental Protection Agency (EPA) to evaluate exposure to mixtures of chemicals in drinking water. The value represents the concentration at which no health effects are expected to occur. These values are based on the most sensitive known adverse health outcome for a chemical.

High-resolution site characterization (HRSC): Strategies and techniques for scale-appropriate measurement and sample density to define contaminant distributions, and the physical context in which they reside, with greater certainty. The goal of high-resolution site characterization is faster and more effective site cleanup.

Historical Radiological Assessment (HRA): A detailed investigation to collect historical radiological information and data for a particular site and its surroundings where radioactive materials were used, stored, or disposed of.

Human health risk assessment (HHRA): EPA defines a CERCLA human health risk assessment as the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future.

Hydraulic gradient: The slope of the water table or other potentiometric surface, indicating the direction and rate of groundwater flow.

Hydrophilic: Having a tendency to mix with, dissolve in, or be wetted by water. Oil-resistant.

Ion Exchange (IX): The reversible interchange of one charged species of ion for another, typically used for water treatment.

Impacted: Area either known to contain residual radioactive material based on radiological surveys or other documented evidence, or suspected with a high probability of containing residual radioactive material based on historical information.

Innovation: Refers to something that is characterized by originality, creativity, and the introduction of new ideas or methods.

Glossary

Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children: A model developed by the EPA to assess health risks to children from lead sources in air, water, and soil.

Interpolation: A method of using existing data points to estimate values within the range of the known values.

Interpretation: The process of explaining or providing the meaning of something, often used in the context of data analysis.

Iso-concentrations: Contours or lines on a map that connect points with equal concentration of a particular substance, often used in environmental studies.

Land use control(s) (LUCs): Administrative and legal controls, or engineered and physical controls/barriers (e.g., fences and security guards) implemented to minimize the potential for exposure to contamination and/or protect the integrity of a response action. LUCs are typically designed to work by limiting land and/or resource use or by providing information that helps modify or guide human behavior at a site.

Life cycle costs: The total cost of a project or system over its entire lifespan, including investigation, design, construction, operating and maintenance, performance monitoring, and decommissioning costs.

Lithology: The physical characteristics of consolidated or unconsolidated rock units, including texture, composition, and grain size.

Long chain per- and polyfluoroalkyl substances (PFAS): Perfluoroalkyl carboxylic acids (PFCAs) with more than 8 carbons, and perfluorosulfonic acids (PFSAs) with more than 6 carbons.

Low-flow groundwater sampling: A method of extracting groundwater at ambient rates to ensure samples are representative of overall characterization of the groundwater. This method extracts water at a slower rate, usually less than 500 milliliters per minute, leading to decreased purging volumes and less water generated for disposal.

Maximum contaminant level (MCL): The legally enforceable primary standards and treatment techniques that apply to public drinking water systems. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the maximum containment level goal (MCLG) as feasible using the best available analytical and treatment technologies and taking cost into consideration.

Maximum contaminant level goal (MCLG): The non-enforceable health benchmark goal that is set at a level at which no known or anticipated adverse human health effect is expected to occur and which allows an adequate margin of safety.

Minimum Detectable Concentration: The a priori activity level that a specific instrument and technique can be expected to detect 95% of the time. When stating the detection capability of an instrument, this value should be used.

Glossary

Modeling: Creating and using models to simulate and analyze complex systems, such as climate or environmental systems.

Molecular biological tools (MBTs): The collective term for a group of laboratory analyses performed directly on cellular biomolecules, including deoxyribonucleic acid (DNA), ribonucleic acid (RNA), phospholipids, and proteins, that are used to evaluate biodegradation potential or activity at contaminated sites.

Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM): MARSSIM provides a nationally consistent consensus approach prepared by the Nuclear Regulatory Commission, Department of Energy, DoD, and United States EPA for conducting radiation surveys and investigations at potentially impacted areas.

Multivariate analysis (MVA): Methods used to find patterns and correlations with more than two variables at the same time**.**

Multivariate time-series analysis: The analysis of data collected over equally spaced intervals of time, which is used to help determine the factors that influence variables over time.

Naval Installation Restoration Information Solution (NIRIS): NIRIS is a specific system or tool used for managing information at naval installations, specifically involving and including environmental restoration data.

NAVFAC Environmental Restoration and BRAC Website (ERB Website): DON's website for all ER information and links to other agency websites. DON guidance documents, reports on innovative environmental restoration technologies, and interactive training tools are easily accessible. www.navfac.navy.mil/go/erb.

Navy Environmental Restoration Program (NERP) Manual: NERP Manual is a user-friendly policy and guidance document for remedial project managers (RPMs) and other professionals working to support the DON's ERP. The most current version is dated 2018.

Non-Impacted: Area having no reasonable possibility of residual G-RAM contamination resulting from site operations based on historical documents and interviewee information suggesting that G-RAM was used, stored, or disposed in a manner that is likely to have left residual G-RAM contamination warranting further evaluation.

Off-the-shelf: Refers to products, solutions, or software that are ready-made and available for immediate use without the need for customization.

Operation and maintenance (O&M): Combination of system operation, repair, optimization, monitoring, and reporting that are collectively used for the proper functioning of a remedy and to ensure that the remedy remains protective of human health and the environment.

Optimization: Systematic site review at any phase of a cleanup process to identify opportunities to improve remedy protectiveness, effectiveness and cost efficiency, and to facilitate progress toward completion of site work.

Per- and polyfluoroalkyl substances (PFAS): A group of human-made chemicals that have been used in industry and consumer products since the 1940s. They have multiple fluorine atoms attached to an alkyl chain and can repel oil, grease, and water. They are found in many products, such as nonstick cookware, stain-resistant textiles, food packaging, firefighting foams, and medical devices. They are persistent and widespread in the environment and might result in harmful health outcomes, such as cancer, increased cholesterol levels, and immune system effects. Perfluoroalkyl substances have a fully fluorinated carbon backbone with the exception of one functional group. The strong carbon-fluorine bonds of PFAS make some of them resistant to degradation and thus highly persistent in the environment.

Perfluorobutanoic acid (PFBA): A perfluorinated PFAS species with four (4) carbon backbone atoms, ending in a carboxylic acid group.

Perfluorobutanesulfonic acid (PFBS): A perfluorinated PFAS species with four (4) carbon backbone atoms and an attached sulfonate end group.

Perfluorohexanoic acid (PFHxA): A perfluorinated PFAS species with six (6) carbon backbone atoms, ending in a carboxylic acid group.

Perfluorohexanesulfonic acid (PFHxS): A perfluorinated PFAS species with six (6) carbon backbone atoms and an attached sulfonate end group.

Perfluorononanoic acid (PFNA): A perfluorinated PFAS species with nine (9) carbon backbone atoms, ending in a carboxylic acid group.

Perfluorooctanesulfonic acid (PFOS): A perfluorinated PFAS species with eight (8) carbon backbone atoms and an attached sulfonate end group. One of two PFAS species receiving the most regulatory and public attention due to its environmental stability and potential toxicity to humans.

Perfluorooctanoic acid (PFOA): A perfluorinated PFAS species with eight (8) carbon backbone atoms, ending in a carboxylic acid group. The other of two PFAS species receiving the most regulatory and public attention due to its environmental stability and potential toxicity to humans.

Perfluoropentanoic acid (PFPeA): A perfluorinated PFAS species with five (5) carbon backbone atoms, ending in a carboxylic acid group.

Perfluoropropanoic acid (PFPrA): A perfluorinated PFAS species with three (3) carbon backbone atoms, ending in a carboxylic acid group.

PFOA:

Picocurie (pCi): Unit of radioactivity equivalent to 2.22×10^{12} disintegrations per minute.

Precursor: A compound that transforms into a different compound within the environment.

Preliminary assessment (PA): This first phase of a CERCLA site investigation identifies contaminated sites based mostly on the review of the existing information about hazardous waste disposal practices at an installation to determine if a release is known, or suspected, to have occurred at a site.

Glossary

Preliminary remediation goal (PRG): Numeric cleanup level developed prior to the decision document.

Previously Impacted: Area that was impacted, remediated, and surveyed, and adequate documentation exists supporting the area's release for unrestricted use. The area could also be categorized as a non-impacted area but is given this specific designation so the area's historical past in not overlooked.

Project Screening Level: Site-specific concentrations of contaminants that, if exceeded, may indicate a need for further investigation or remediation.

Radiological Affairs Support Program (RASO): A Naval Sea Systems Command Detachment, located in Yorktown, Virginia, that provides technical support to the Navy for management and control of G-RAM.

Radionuclide of Potential Concern: A radioactive isotope that may pose a health risk due to its potential to cause harm through radiation exposure.

Reference dose (RfD): An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a no-observed-adverse-effect level (NOAEL), lowest-observed-adverse-effect level (LOAEL), or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments.

Regression coefficient: A numerical value derived using a statistical technique that relates a dependent variable to an independent variable.

Remedial action objectives: Medium-specific goals that the remedial action is expected to meet to protect human health and the environment and to comply with the Applicable or Relevant and Appropriate Requirements (ARARs) established in the decision document. The remedial action objectives guide the formulation and evaluation of remedial alternatives.

Remedial alternatives: Different strategies or options considered for cleaning up or mitigating environmental contamination.

Remedial design (RD): Phase in CERCLA site cleanup where the technical basis, drawings, and specifications for remedies and technologies are designed.

Remedial investigation (RI): A detailed on-site investigation to fully characterize the nature and extent and fate and transport of the contaminant release to the environment and the potential risks to human health and the environment.

Remedy-in-Place: A non-regulatory milestone that is achieved when the construction of a long-term remedy is complete and the remedy is operating as planned to meet project remedial action objectives in the future, or a short-term remedy has been successfully implemented and the final documentation is being prepared.

Glossary

Residual saturation: Saturation (volume of non-aqueous phase liquid divided by the volume of pore space) at which the non-aqueous phase liquid becomes discontinuous and is immobilized by capillary forces under ambient groundwater flow conditions.

Resource Conservation and Recovery Act (RCRA): RCRA is the public law that creates the framework for the proper management of hazardous and nonhazardous solid waste. The law describes the waste management program mandated by Congress that gave the EPA authority to develop the RCRA Program.

Response Complete (RC): Milestone that is achieved when all cleanup goals specified in the decision document are complete.

Retention: Partitioning of a compound within an environmental compartment (e.g., solid interface, air/water interface, etc.) that results in a reduction of migration.

Reverse Osmosis (RO): Reverse osmosis is a water purification process that uses a semi-permeable membrane to treat water for a wide range of chemicals**.**

Risk assessment: Evaluating potential risks and their consequences, including the likelihood and severity of impacts.

Risk Assessment Guidance for Superfund (RAGS): The RAGS is a series of documents prepared by the EPA to provide guiding principles for performing consistent human health risk assessments to support CERCLA site management decisions.

Risk management: The process of identifying, evaluating, selecting, and implementing actions to reduce risk to human health and to ecosystems. The goal of risk management is to implement scientifically sound, cost-effective, integrated actions that reduce or prevent risks while taking into account social, cultural, ethical, political, and legal considerations.

Screening ecological risk assessment (SERA): A conservative screening assessment intended to eliminate chemicals with no complete exposure pathways, and eliminate chemicals present at “safe” concentrations.

Screening level: Environmental concentration used to determine whether chemicals in the environmental warrant further evaluation. This is not an action level.

Short chain PFAS: PFCAs with fewer than eight (8) carbons, and PFSAs with fewer than six (6) carbons.

Site inspection (SI): The onsite investigation of environmental media to verify potential release(s), initiate the characterization of release(s), and identify potential threats to human health and the environment associated with release(s).

Simulation: Imitating the operation of a real-world process or system over time.

Smoldering: Thermal technology for treating chemicals in solids, where air is forced through the material to be treated to propagate a low-temperature, flameless form of combustion. The reaction travels from an ignition location through impacted solids, destroying most of the chemicals, while a small fraction is recovered as vapors and treated.

Glossary

Soil Washing: Soil washing is a process that uses physical and/or chemical techniques to separate chemicals from soil and sediments.

Solidification/Stabilization: A remedial technology option which blends treatment reagents into impacted material to impart physical and/or chemical changes to reduce the flux of chemicals that leaches from a source to within acceptable parameters set forth in a site-specific remediation goal.

Subtitle C: Establishes a federal program to manage hazardous wastes from cradle to grave. The objective of the Subtitle C Program is to ensure that hazardous waste is handled in a manner that protects human health and the environment. To this end, there are Subtitle C regulations for the generation, transportation and treatment, storage or disposal of hazardous wastes.

Subtitle D: Regulates non-hazardous solid waste landfills, including municipal solid waste landfills and industrial waste landfills. These landfills are subject to federal minimum criteria, although states can implement more stringent requirements.

Target treatment: Specific methods or processes used to address and mitigate environmental issues or contamination.

Thermal Conduction Heating (TCH): Thermal conduction is used to distribute heat throughout an impacted volume of solids (in situ or ex situ), raising the temperature high enough to mobilize and extract the chemicals.

Toxicity reference value (TRV): Also called screening ecotoxicity value (SEV), defines “safe” exposure levels based on dose response and is usually derived from controlled experiments in which a laboratory organism is exposed to several doses of a chemical.

Transformation: The process of a precursor compound transforming to a degradation product in the environment.

Transport and migration pathways: The routes by which contaminants or other materials move through environmental media, such as soil, groundwater, or air.

Vapor intrusion: The migration of vapor-forming compounds from the subsurface to indoor air.

Visualization: The process of representing data graphically to make it easier to understand and interpret.

HANDBOOK CONTENT

Presentations

Strategies to Address Per- and Polyfluoroalkyl Substances (PFAS) in Private Drinking Water Wells near Naval Installations

Contextualizing PFAS Detections: Background and Forensics

Remediation of PFAS-Impacted Solids

Optimization Tools and Strategies Implemented at Sites with Long-Term Remediation Systems

Managing Lead-Impacted Sites under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Preliminary Assessment and Site Inspection (PA/SI) Process for Sites with General Radioactive Materials (G-RAM)

NAVFAC
Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Strategies to Address Per- and Polyfluoroalkyl Substances (PFAS) in Private Drinking Water Wells near Naval Installations

Paul Landin, NAVFAC Atlantic

RITS 2025

Disclaimer

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Information in this presentation is current as of May 30, 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Paul Landin, P.E.
NAVFAC Atlantic

- Supervisory Environmental Engineer (VA)
- Branch Head of Restoration Engineering and Sciences at NAVFAC Atlantic
- SME for off-base drinking water projects
- Workgroups
  - Emerging Contaminants
  - Radiological

Presentation Overview

- Introduction
- Background
- PFAS Policy and Regulation
- History of Navy's Private Drinking Water Well Sampling
- 3 September 2024 DoD Policy Impacts
- 3 September 2024 DoD Policy Response Options
- Planning for Private Drinking Water Well Sampling
- Case Study and Lessons Learned
- Summary and Closing Statements

DoD: Department of Defense

Introduction

- The DON identified PFAS as an emerging contaminant as early as 2014
- The most likely exposure pathway is through groundwater, which could impact on-base and off-base drinking water wells
- Sampling PFAS in private drinking water wells provides the data needed to allow the Navy to take action to eliminate exposure
- Need to identify appropriate solutions to address exposure
  - Follow DoD and Navy policies and guidance
  - Determine whether private drinking water wells may be impacted
  - Evaluate technologies and approaches for enduring solutions

DoN: Department of the Navy

PFAS: per- and polyfluoroalkyl substances

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Background

- EPA
  - What is a health advisory?
    - Issued for chemicals not subject to a National Primary Drinking Water Regulation
    - Identifies concentration at which adverse effects are NOT anticipated to occur
    - Subject to change as science evolves
    - Not legally enforceable
    - Interim or provisional health advisory
      - Developed in response to an urgent situation
      - Considers health-based hazard concentrations
      - Can be updated or removed

EPA: United States Environmental Protection Agency

Background

- EPA
  - What is an MCL?
    - Highest level of a contaminant allowed in drinking water
    - Enforceable drinking water standard
    - Applicable to public water systems

- "The National Primary Drinking Water Regulations (NPDWR) are legally enforceable primary standards and treatment techniques that apply to public water systems. Primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water." (EPA 2025)
- April 24, 2024 - EPA published a final NPDWR establishing nationwide drinking water standards for public drinking water systems for certain PFAS under the Safe Drinking Water Act
- Operators of public drinking water systems regulated by the NPDWR have until April 26, 2029 to meet these standards
- In May 2025, EPA announced plans to adjust some aspects of this rule. If EPA updates the applicable requirements, DoD will update its policy as appropriate

MCL: maximum contaminant level

Background

Timeline of EPA PFAS Advisories and Regulatory Levels

2009 Provisional Health Advisory

- PFOA: **400 ppt**
- PFOS: **200 ppt**

2016 Lifetime Health Advisory

- PFOA: **70 ppt**
- PFOS: **70 ppt**
- PFOA + PFOS: **70 ppt**

2022 Lifetime Health Advisory

Interim
- PFOA: **0.004 ppt**
- PFOS: **0.02 ppt**

Final
- HFPO-DA (GenX): **10 ppt**
- PFBS: **2,000 ppt**

2023 Proposed MCLs

- PFOA: **4.0 ppt**
- PFOS: **4.0 ppt**
- HFPO-DA (GenX): **10 ppt**
- Mixtures with 1 or more of PFHxS, PFNA, HFPO-DA (Gen-X), and PFBS: **Hazard Index of 1**

2024 Final MCLs

- PFOA: **4.0 ppt**
- PFOS: **4.0 ppt**
- PFHxS: **10 ppt**
- PFNA: **10 ppt**
- HFPO-DA (GenX): **10 ppt**
- Mixtures with 2+ of PFHxS, PFNA, HFPO-DA, and PFBS: **Hazard Index of 1**

HFPO-DA: hexafluoropropylene oxide dimer acid
PFBS: perfluorobutane sulfonic acid
PFHxS: perfluorohexane sulfonic acid
PFNA: perfluorononanoic acid
PFOA: perfluorooctanoic acid
PFOS: perfluorooctane sulfonic acid
ppt: part(s) per trillion

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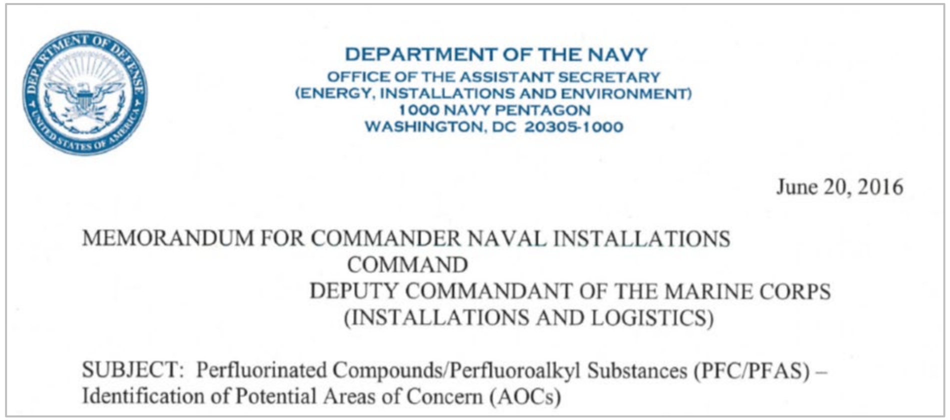
PFAS Policy and Regulation – Navy

- June 20, 2016, policy memorandum (Navy 2016): *Perfluorinated Compounds/Perfluoroalkyl Substances (PFC/PFAS) – Identification of Potential Areas of Concern (AOCs)*
    - Developed process to inventory, validate, and prioritize areas where PFAS were or may have been released
        - Provided preliminary list of installations based on desktop review
        - Directed Navy and U.S. Marine Corps to identify all releases at all installations
    - Does not document or authorize use of 70 ppt



DEPARTMENT OF THE NAVY
OFFICE OF THE ASSISTANT SECRETARY
(ENERGY, INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON, DC 20305-1000

June 20, 2016

MEMORANDUM FOR COMMANDER NAVAL INSTALLATIONS COMMAND
DEPUTY COMMANDANT OF THE MARINE CORPS (INSTALLATIONS AND LOGISTICS)

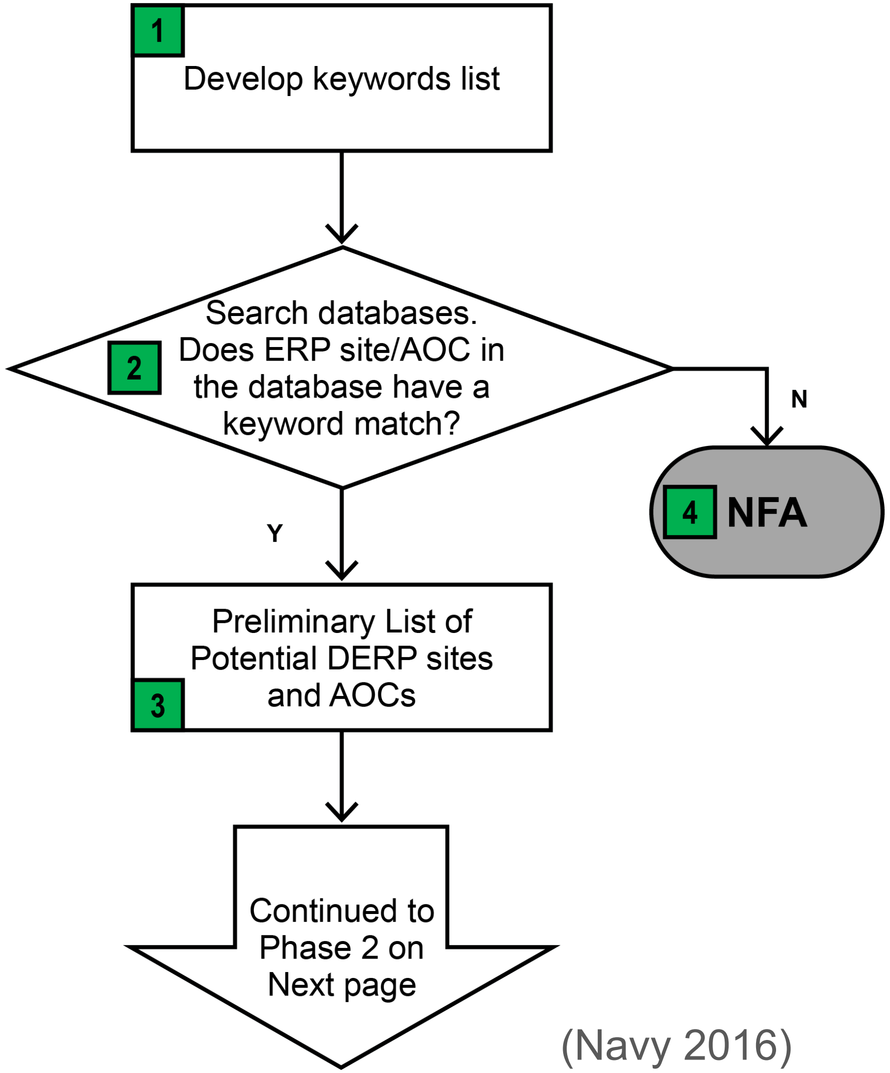
SUBJECT: Perfluorinated Compounds/Perfluoroalkyl Substances (PFC/PFAS) – Identification of Potential Areas of Concern (AOCs)

(Navy 2016)

AOC: area of concern

PFAS Policy and Regulation – Navy

- June 20, 2016, policy memorandum (continued)
  - Enclosures
    - Flowchart outlining process to identify PFAS AOIs
    - Preliminary list of PFAS AOIs per installation (not an inclusive installation/AOI list)
    - List of potential PFAS release mechanisms
  - Flowchart includes steps for evaluation of off-Base drinking water



(Navy 2016)

AOI: area of interest
DERP: Defense Environmental Restoration Program
ERP: Environmental Restoration Program
NFA: No Further Action

PFAS Policy and Regulation – DoD

- December 22, 2021, technical guidance memorandum (DoD 2021): *Department of Defense Guidance on Using State Per- and Polyfluoroalkyl Substances Drinking Water Standards in Comprehensive Environmental Response, Compensation, and Liability Act Removal Actions*
    - Clarifies
        - When a removal action can be conducted for PFAS under CERCLA
        - How promulgated state PFAS standards can be used in removal actions
    - For groundwater used as drinking water, removal actions
        - May be conducted where DoD is responsible for a confirmed release with PFOS/PFOA concentrations above 70 ppt in private drinking water wells
        - May be extended to drinking water wells when site-specific hydrogeological conditions are expected to result in PFOS/PFOA above 70 ppt without a removal action
        - "…once initiation of a removal action is triggered as set out above, and DoD as the lead agency identifies a properly promulgated, consistently implemented State PFAS drinking water standard as an ARAR for the specific removal action, DoD may use the State PFAS drinking water standard when determining the cleanup level to be attained at the completion of the removal action." (DoD 2021)

KEY POINT

3 September 2024 DoD levels now apply.

ARAR: Applicable or Relevant and Appropriate Requirement

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act

PFAS Policy and Regulation – DoD

- 3 September 2024 DoD Policy: *Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances under the Defense Environmental Restoration Program*
  - Authorizes interim actions to address private drinking water wells impacted by PFAS from DoD activities at or above these levels
    - These are not final remedy values, which will consider MCLs and background
  - Focuses on implementing enduring solutions

PFAS	Level
perfluorooctanoic acid (PFOA)	12 ppt
perfluorooctane sulfonic acid (PFOS)	12 ppt
perfluorononanoic acid (PFNA)	30 ppt
perfluorohexane sulfonic acid (PFHxS)	30 ppt
hexafluoropropylene oxide dimer acid (HFPO-DA, or GenX)	30 ppt
hazard index for mixture of at least two of PFHxS, PFNA, HFPO-DA, and perfluorobutane sulfonic acid (PFBS)	3 (no units)

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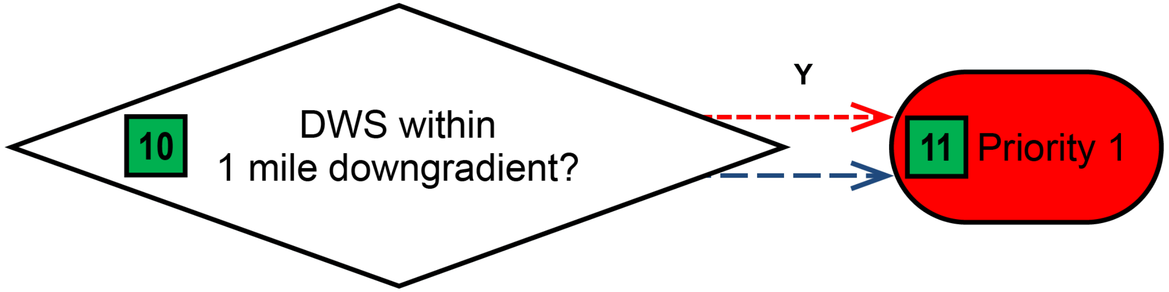
History of Navy’s Private Drinking Water Well Sampling

- 2014: Former NAWC Warminster, Former NAS JRB Willow Grove
- 2015 to 2016: NALF Fentress
- 2015 to 2016: NWS Earle
- 2016: Prioritization



(Navy 2016)

DWS: drinking water system
JRB: Joint Reserve Base
NALF: Naval Auxiliary Landing Field
NAS: Naval Air Station
NAWC: Naval Air Warfare Center
NWS: Naval Weapons Station

History of Navy's Private Drinking Water Well Sampling

Priority 1 Installations

- NRL-CBD (MD)
- NAS Whidbey Island* (WA)
- OLF Coupeville (NAS Whidbey Island)* (WA)
- NARL Barrow* (AK)
- MCOLF Atlantic (MCAS Cherry Point)* (NC)
- NWS Crane (IN)
- Former NWIRP Calverton (NY)
- NWS Earle* (NJ)
- NAS Oceana (VA)
- NALF Fentress (NAS Oceana)* (VA)
- NCBC Gulfport (MS)
- NAS Jacksonville (FL)
- OLF Whitehouse (NAS Jacksonville) (FL)
- NS Mayport (FL)
- NAS Pensacola (FL)
- Saufley Field (NAS Pensacola)* (FL)
- NAS Whiting Field* (FL)
- NAS Meridian (MS)
- Point Mugu (CA)
- NAS Fallon (CA)
- MCLB Barstow* (CA)

***PFOA and/or PFOS above 70 ppt**

MCAS: Marine Corps Air Station
MCOLF: Marine Corps Outlying Landing Field
MCLB: Marine Corps Logistics Base
NRL-CBD: Naval Research Laboratory – Chesapeake Bay Detachment
NARL: Naval Arctic Research Laboratory
NCBC: Naval Construction Battalion Center
NS: Naval Station
NWIRP: Naval Weapons Industrial Reserve Plant
OLF: Outlying Landing Field

History of Navy's Private Drinking Water Well Sampling

- Designation of sampling areas
  - 2016 policy does NOT require analytical data to confirm release to groundwater
  - Conservative approach to account for uncertainty
  - 1 mile downgradient from installation boundary or release area
  - Step out areas
    - Early days: 0.5-mile step out from property with exceedance of 70 ppt
    - More recent: 0.5-mile step out considered along with conceptual site model and drinking water well location information
- With SIs complete and RIs underway, sampling areas may be further refined

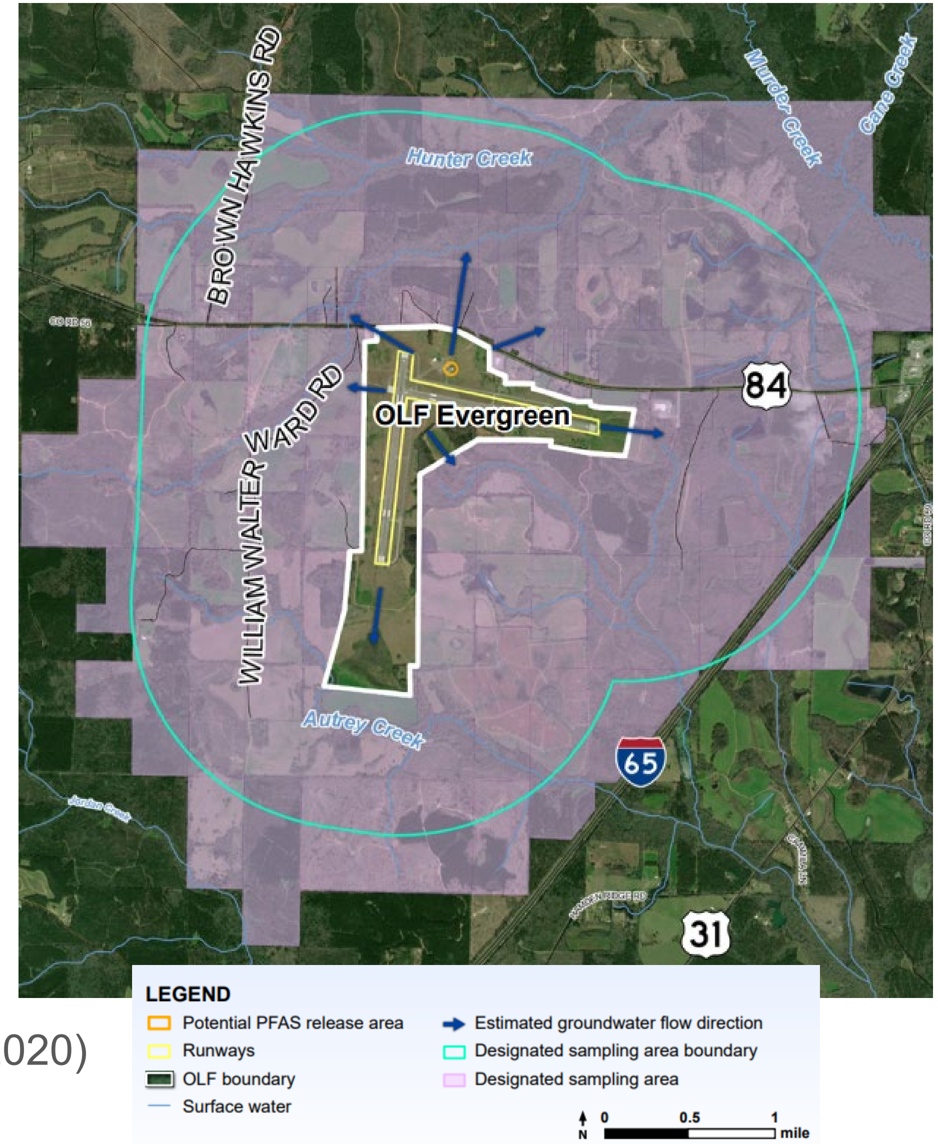
KEY POINT

Evaluation of exposure in private drinking water wells is ongoing.

RI: Remedial Investigation
SI: Site Inspection

Examples of Sampling Areas

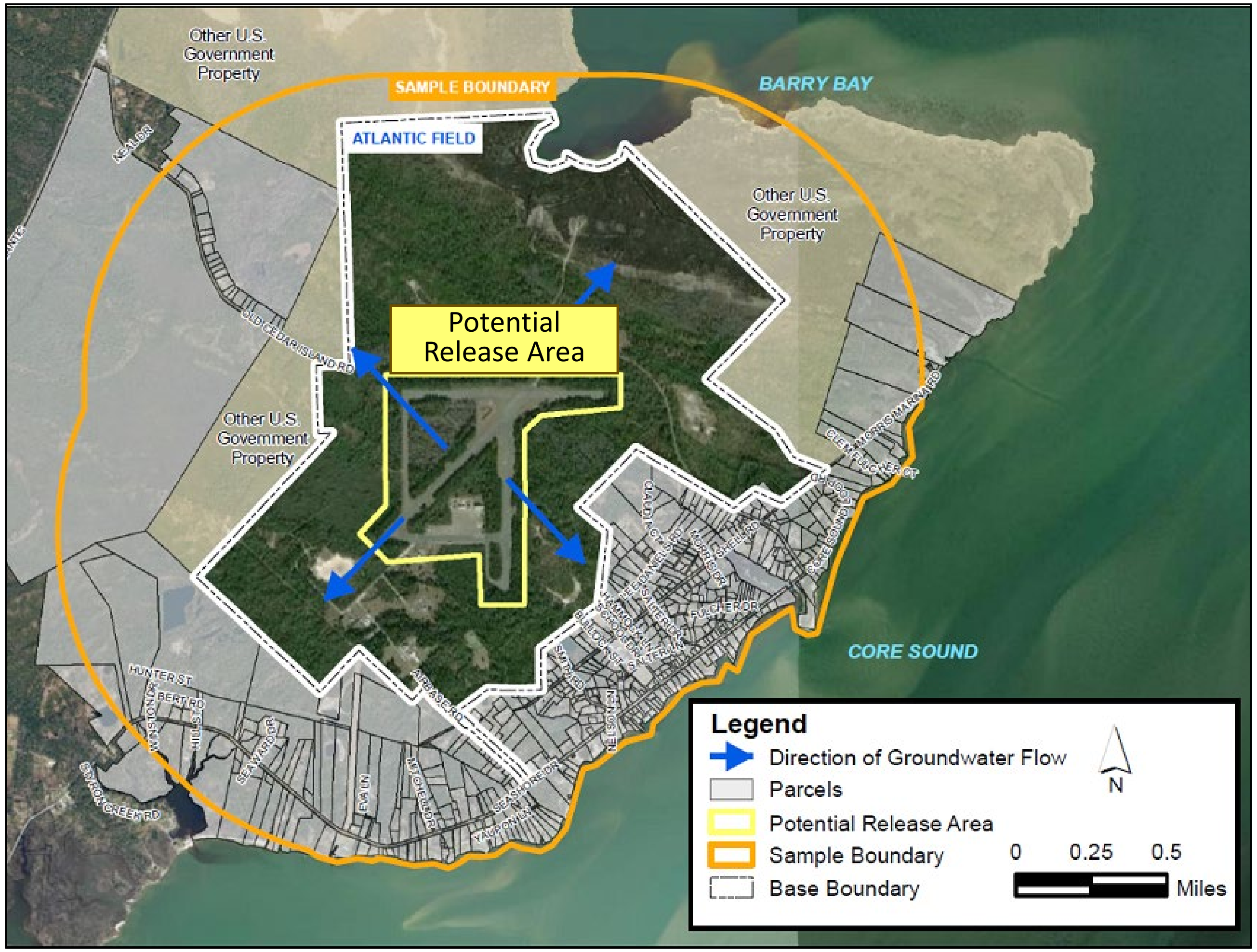
- OLF Evergreen (AL)
  - Suspected PFAS release (crash shack and runways)
  - Groundwater flow assumed to be radial
  - 1 mile from installation boundary



(NAFVAC Atlantic 2020)

Examples of Sampling Areas

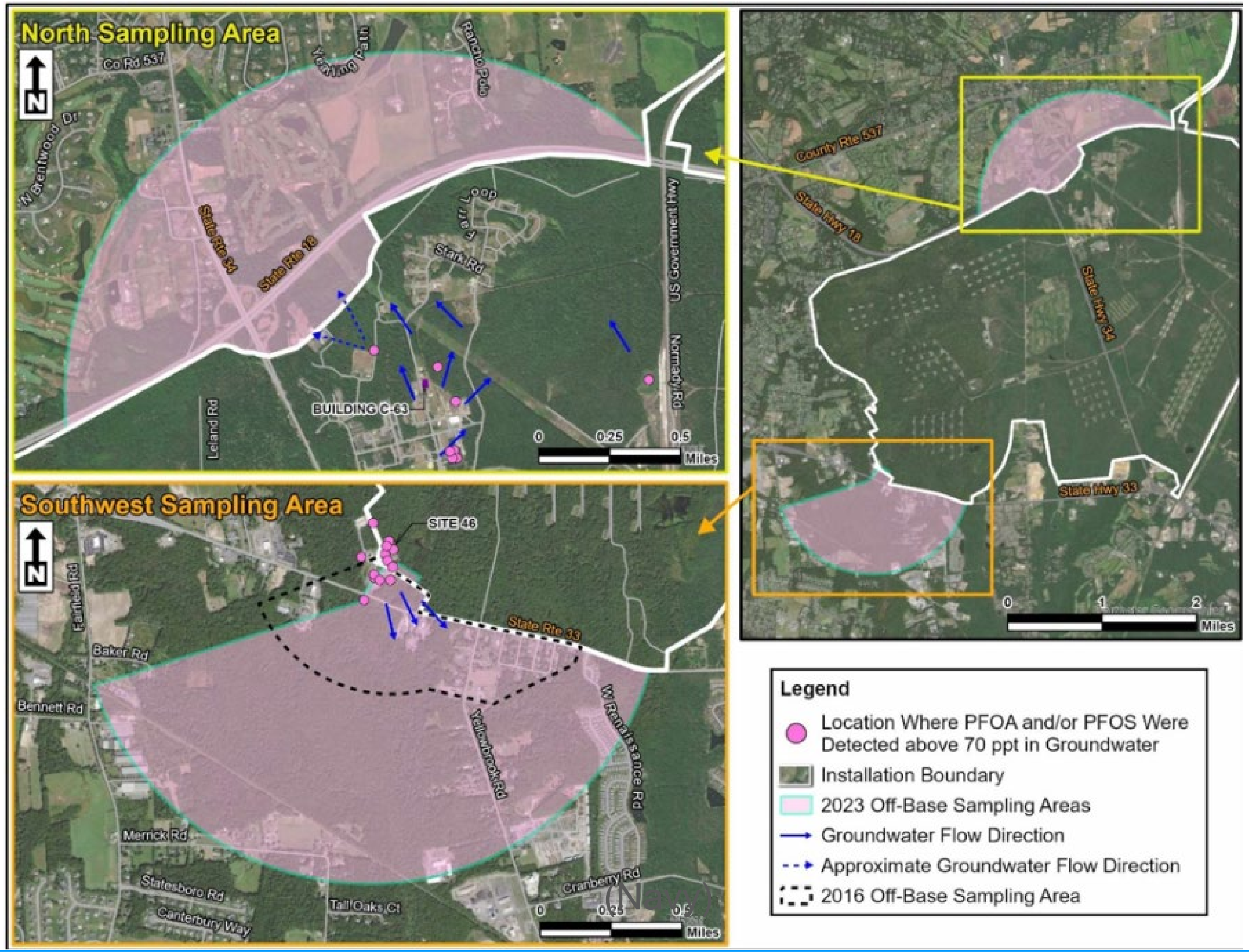
- MCOLF Atlantic (NC)
  - Suspected PFAS release (runways)
  - Groundwater flow assumed to be radial
  - 1 mile from release area (airfield)



(NAVFAC Atlantic 2017)

Examples of Sampling Areas

- NWS Earle (NJ)
  - Site 46, Fire Training School
    - PFOA/PFOS detected in groundwater above 70 ppt
    - Groundwater flow from Site 46 to the southeast
    - 0.5 mile from release area
  - During SI
    - Confirmed additional release areas
    - Refined groundwater flow
    - Additional sampling area identified
    - Area downgradient of Site 46 expanded



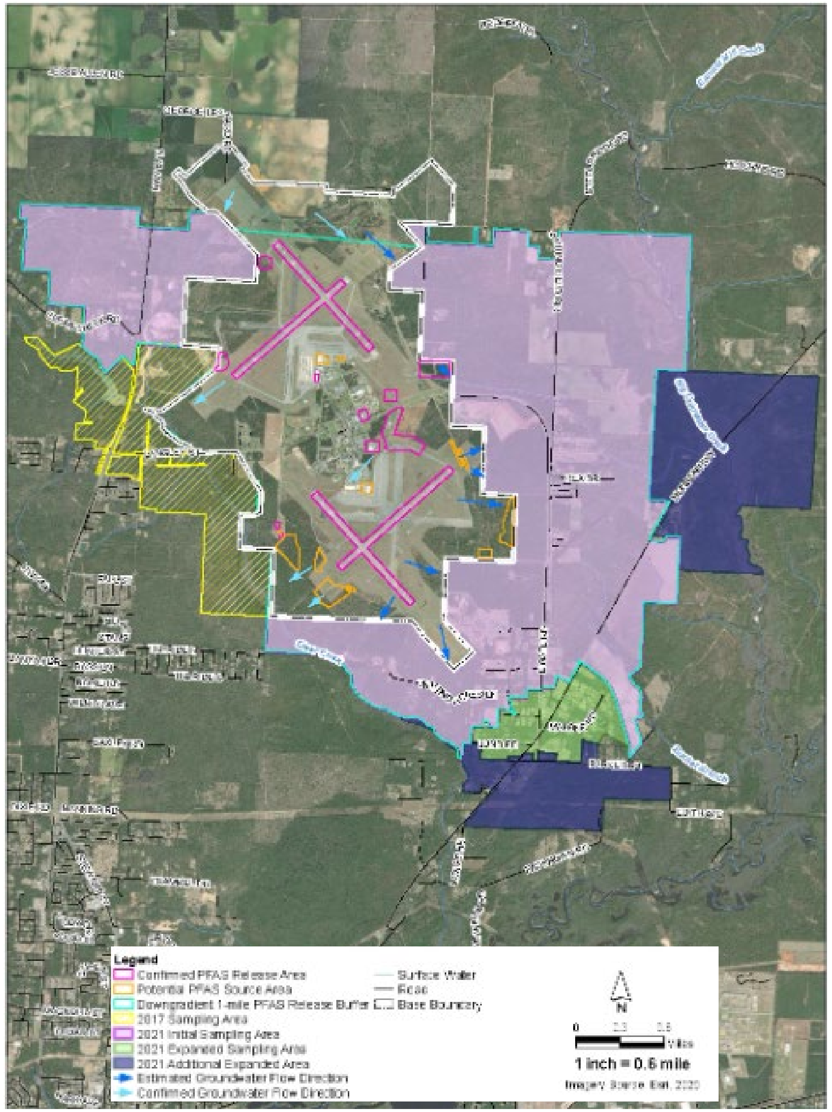
(NAVFAC Mid-Atlantic 2015)

Examples of Sampling Areas

- NAS Whiting Field (FL)
  - Priority 1 sampling area downgradient of Site 18 (Fire Training Area)
  - Additional PFAS release areas identified during PA
  - Additional sampling areas identified
  - Multiple stepout areas due to exceedances in private drinking water wells

KEY POINT

Sampling areas are specific to each installation.

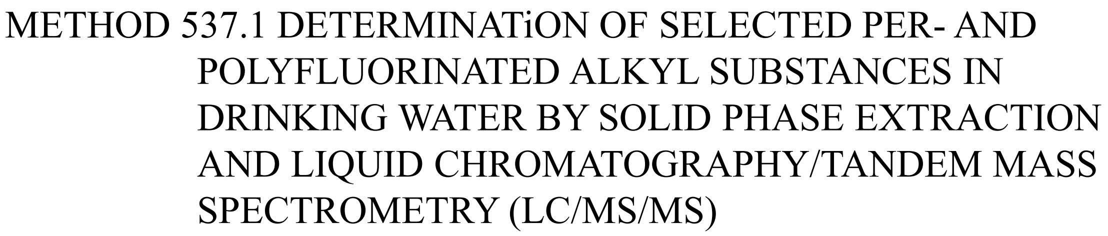


(NAVFAC Atlantic 2017)

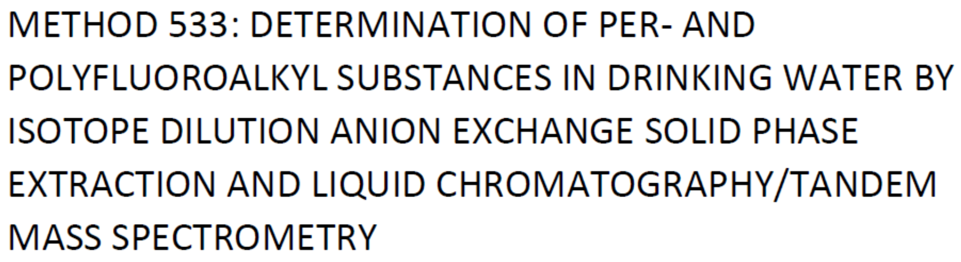
PA: Preliminary Assessment

History of Navy’s Private Drinking Water Well Sampling

- Analytical requirements
  - Early days
    - PFOA, PFOS, PFBS reported
    - High reporting limits
  - Progression of analyte list
    - 537.1 – 14 analytes, then 18
    - 537.1 and 533 – 29 analytes (to align with) UCMR5



METHOD 537.1 DETERMINATiON OF SELECTED PER- AND POLYFLUORINATED ALKYL SUBSTANCES IN DRINKING WATER BY SOLID PHASE EXTRACTION AND LIQUID CHROMATOGRAPHY/TANDEM MASS SPECTROMETRY (LC/MS/MS)



METHOD 533: DETERMINATION OF PER- AND POLYFLUOROALKYL SUBSTANCES IN DRINKING WATER BY ISOTOPE DILUTION ANION EXCHANGE SOLID PHASE EXTRACTION AND LIQUID CHROMATOGRAPHY/TANDEM MASS SPECTROMETRY

(EPA 2020)

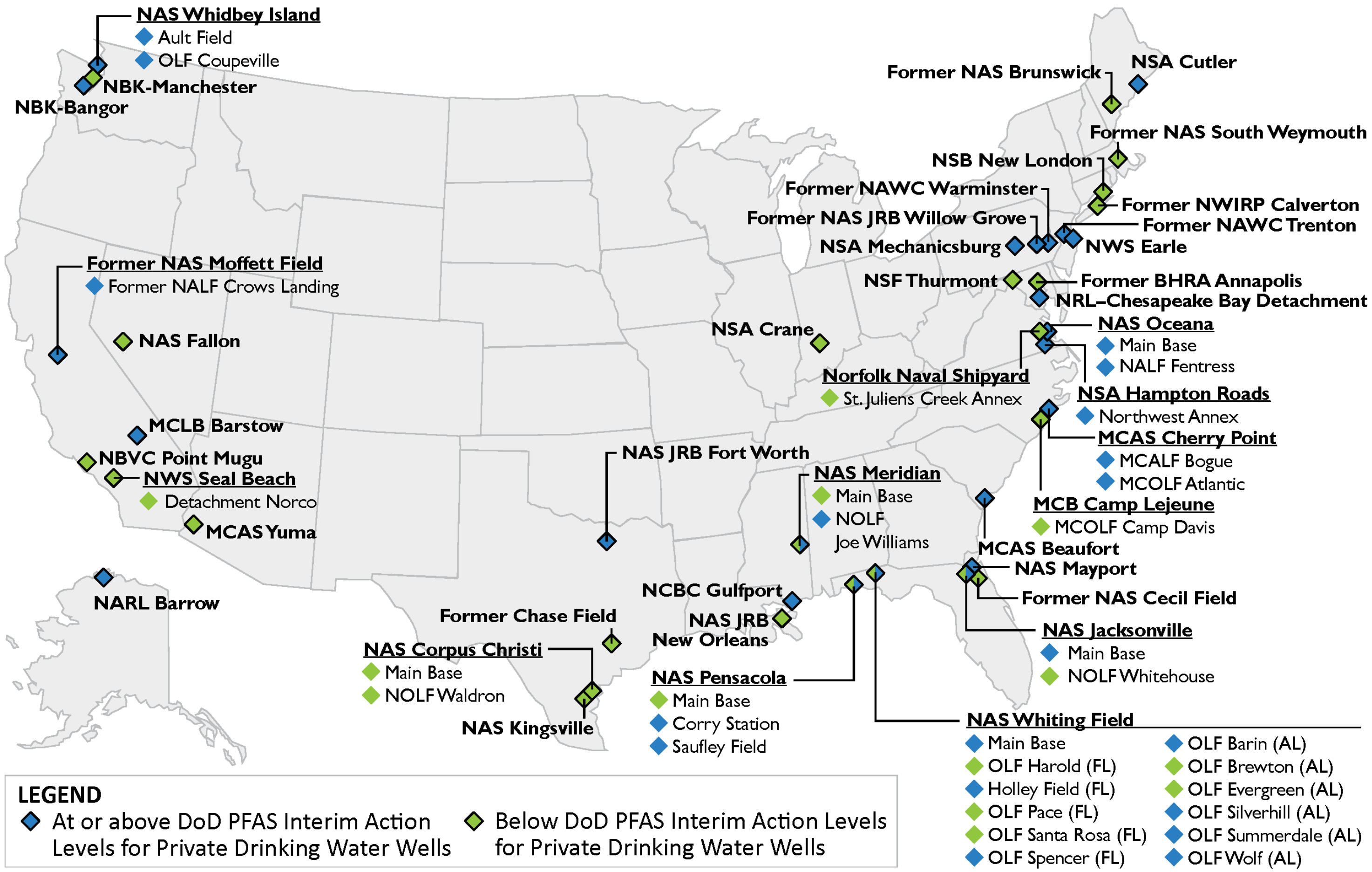
UCMR5 : Unregulated Contaminant Monitoring Rule 5

History of Navy’s Private Drinking Water Well Sampling

- Fall 2016 through Spring 2024
  - More than 60 installations (active and BRAC) with private drinking water well sampling
  - Number of wells sampled per installation ranges from <5 to >500

BRAC: Base Realignment and Closure

Navy Off-Base Private Drinking Water Well Sampling



As of March 21, 2025

Presentation Overview

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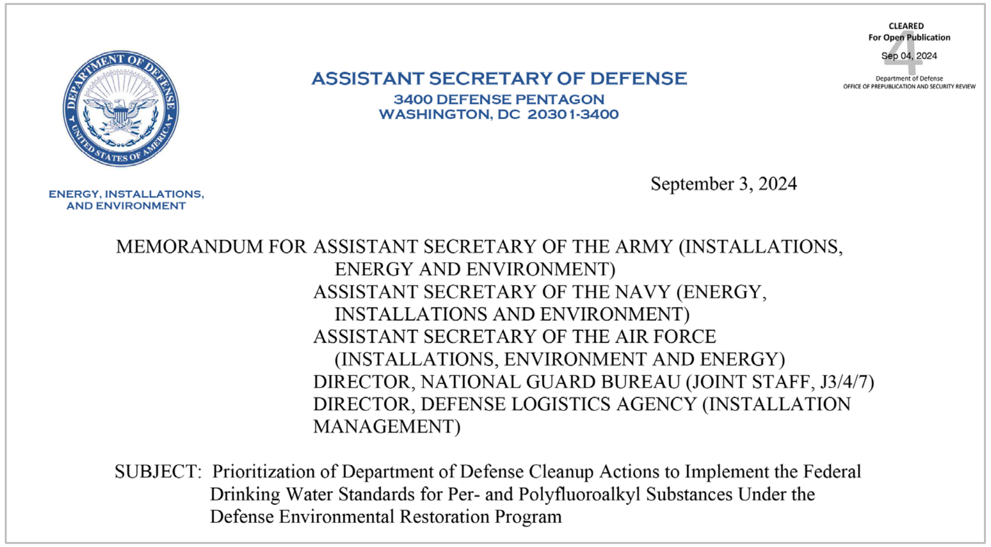
DoD Policy Impacts

- 3 September 2024 DoD Policy: *Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program*
- Summary
    - EPA announced MCLs for several PFAS
        - Effective June 2024
        - Applies to public drinking water systems



CLEARED
For Open Publication
Sep 04, 2024
Department of Defense
OFFICE OF PREPUBLICATION AND SECURITY REVIEW

ASSISTANT SECRETARY OF DEFENSE
3400 DEFENSE PENTAGON
WASHINGTON, DC 20301-3400

ENERGY, INSTALLATIONS,
AND ENVIRONMENT

September 3, 2024

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, NATIONAL GUARD BUREAU (JOINT STAFF, J3/4/7)
DIRECTOR, DEFENSE LOGISTICS AGENCY (INSTALLATION MANAGEMENT)

SUBJECT: Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program

(DoD 2024)

DoD Policy Impacts

- 3 September 2024 DoD Policy Summary
  - Interim Action options in prioritized order
    - At or above DoD PFAS Interim Action Levels for private drinking water wells
      - Connection to public water systems
      - Installation of whole house treatment systems
      - Provision of point of use treatment systems
      - Provision for bottled water
        - Allowed when other options technically infeasible (requires waiver)
        - PFOS/PFOA above 70 ppt (individually or combined)
        - Bottled water already being provided prior to DoD policy and at or above DoD levels
  - Allows for prioritized response for highest levels of PFAS in private drinking water wells
  - Considers ubiquitous nature of PFAS and potential background concentrations
  - DoD Components will address drinking water down to MCLs or background for remedial actions utilizing the CERCLA process

KEY POINT

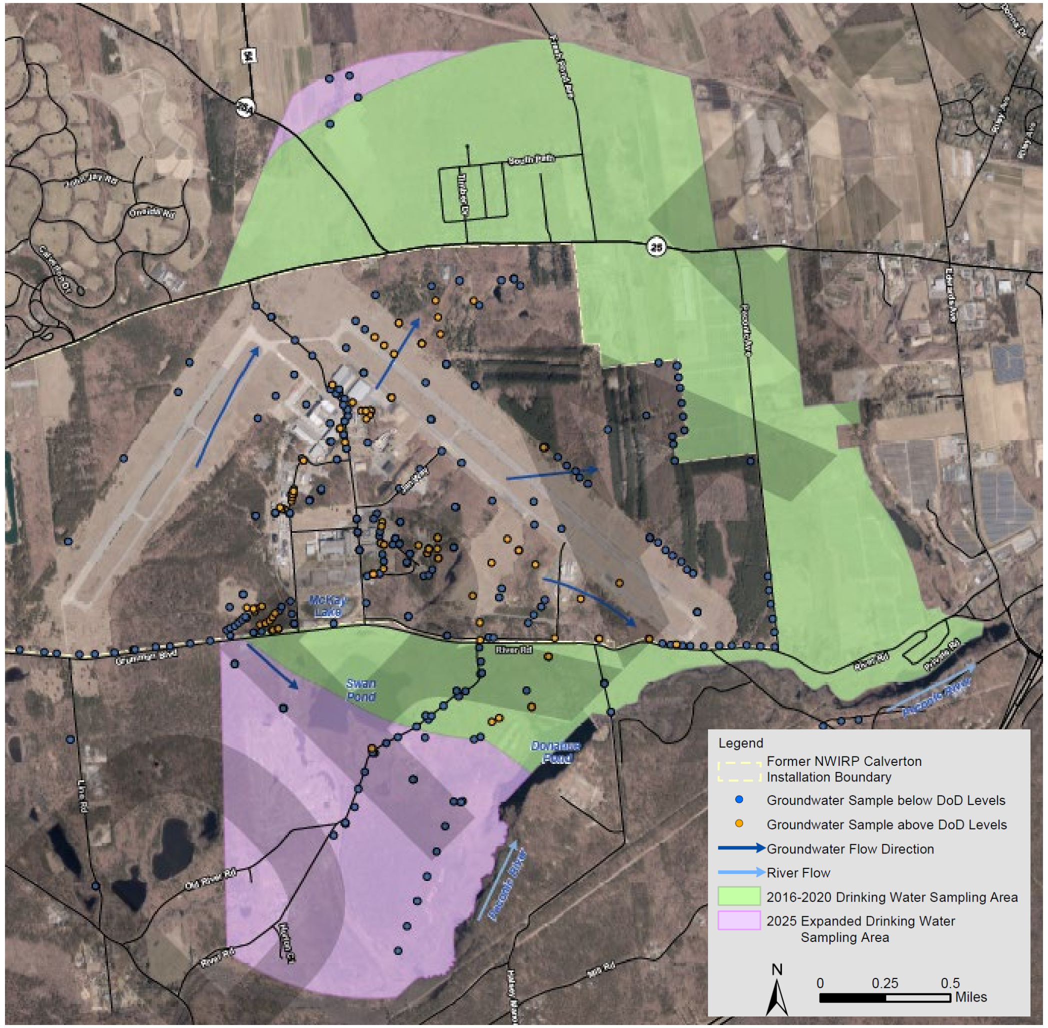
Interim action options are project specific. Identify options early.

DoD Policy Impacts

- Re-evaluation of data
  - On-Base groundwater
  - Private drinking water wells
- Resampling
- Revised (expanded) sampling areas
- Additional interim actions
  - Based on available data
  - Resulting from new sampling or resampling

KEY POINT

Re-evaluation of the sampling area(s) is required as new data is obtained or as the screening values change.



(NAVFAC Mid-Atlantic 2025)

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- History of Navy’s Private Drinking Water Well Sampling
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- 3 September 2024 DoD Policy Response Options
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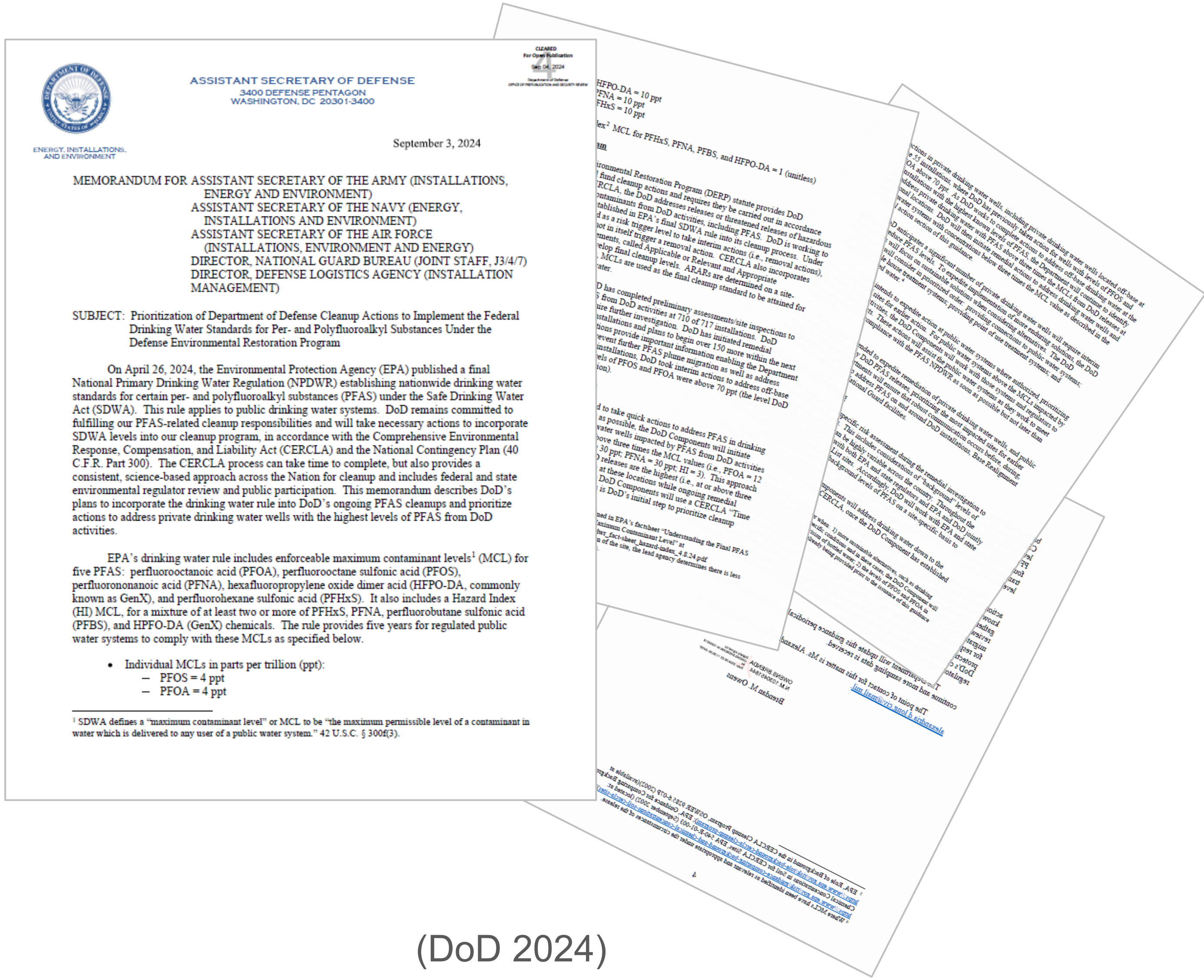
DoD Policy Response Options

- Enduring solutions in prioritization memorandum (DoD 2024)
  - Connection to public water
  - Treatment system installation
    - POET
    - POU
  - New well installation*
  - Bottled water**

*Not listed in policy, still a viable option, especially where there is no public water supply
**Limited applicability
POET: point-of-entry treatment
POU: point-of-use



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Department of Defense
OFFICE OF PREPUBLICATION AND SECURITY REVIEW

ASSISTANT SECRETARY OF DEFENSE
3400 DEFENSE PENTAGON
WASHINGTON, DC 20301-3400

ENERGY, INSTALLATIONS, AND ENVIRONMENT

September 3, 2024

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, NATIONAL GUARD BUREAU (JOINT STAFF, J3/4/7)
DIRECTOR, DEFENSE LOGISTICS AGENCY (INSTALLATION MANAGEMENT)

SUBJECT: Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program

On April 26, 2024, the Environmental Protection Agency (EPA) published a final National Primary Drinking Water Regulation (NPDWR) establishing nationwide drinking water standards for certain per- and polyfluoroalkyl substances (PFAS) under the Safe Drinking Water Act (SDWA). This rule applies to public drinking water systems. DoD remains committed to fulfilling our PFAS-related cleanup responsibilities and will take necessary actions to incorporate SDWA levels into our cleanup program, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (40 C.F.R. Part 300). The CERCLA process can take time to complete, but also provides a consistent, science-based approach across the Nation for cleanup and includes federal and state environmental regulator review and public participation. This memorandum describes DoD's plans to incorporate the drinking water rule into DoD's ongoing PFAS cleanups and prioritize actions to address private drinking water wells with the highest levels of PFAS from DoD activities.

EPA's drinking water rule includes enforceable maximum contaminant levels[1] (MCL) for five PFAS: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX), and perfluorohexane sulfonic acid (PFHxS). It also includes a Hazard Index (HI) MCL, for a mixture of at least two or more of PFHxS, PFNA, perfluorobutane sulfonic acid (PFBS), and HPFO-DA (GenX) chemicals. The rule provides five years for regulated public water systems to comply with these MCLs as specified below.

- Individual MCLs in parts per trillion (ppt):
  - PFOS = 4 ppt
  - PFOA = 4 ppt

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[1] SDWA defines a "maximum contaminant level" or MCL to be "the maximum permissible level of a contaminant in water which is delivered to any user of a public water system." 42 U.S.C. § 300f(3).

(DoD 2024)

Connection to Public Water

- Preferred option as enduring solution where feasible
- Eliminates exposure pathway and long-term liability
- December 2021 technical guidance document can be used to justify connection of other properties
- Timeframe to complete may be a few weeks to many years

(NAVFAC Southeast 2023)

Connection to Public Water

- Cost and time to connect dependent on site conditions
  - Lateral connections from existing lines simplest
  - Larger expansions to unserved areas more complicated
    - May require city council approval
    - Design challenges may arise due to pressure concerns and age of piping
    - Likely require new meter and may require new hydrant(s)
    - Consider potential future requirements when planning large designs to avoid rework
- Property owner will receive water bill from public water purveyor
- Grants may be available to aid with connections

(NAVFAC Southeast 2023)

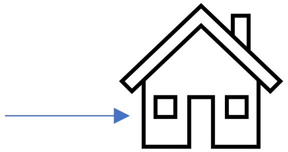
Treatment System Options

POET

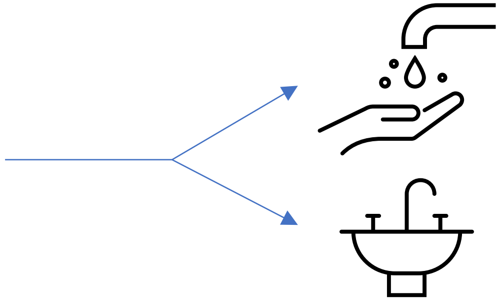
- Treats all water coming from well to building including water for sanitation
- Typically requires a larger area for installation
  - May require a shed
- Can be designed for longer treatment times or less frequent changeout

POU

- Treats water from a single point where water for drinking and cooking is sourced, such as a kitchen sink
- Can usually be installed under sink or on faucet or countertop
- May require validation testing
- Requires periodic filter replacement



Point of Entry



Point of Use

Treatment System Comparison

POET

- May be long-term interim solution until connected to public water
- May be long-term final solution
- May need to consider:
  - Local/regional water quality for additional treatment/polishing
  - Geographically-specific conditions
    - Freeze protection
    - Storm protection
    - Wildlife
- Many U.S. private wells already have treatment systems for pH, iron, arsenic, manganese, etc., and existing systems may be upgraded to treat PFAS if feasible

POU

- May be short-term interim solution until connected to public water or POET system installed
- Not recommended for long-term final solution
- Many commercially available options with varying degrees of removal efficiency
- May be limitations on capacity and/or treatment volume
- Systems should be selected for ease of maintainability by the resident

Treatment Types: Granular Activated Carbon

- System construction with one or more GAC-filled vessels typically in series
- GAC adsorbs PFAS as water flows through vessels
- Not all granular activated carbons are same
  - Coal or coconut sourced
  - Performance may be different for long- and short-chain PFAS
- Typical design for empty bed contact time of 10 minutes
- Include sample ports upstream, between (if more than one), and downstream of vessels
- Sediment filtration and UV disinfection may improve system performance (through pre-treatment of sediment, which can fill pore space in filter media, and through reducing bacterial concerns downstream of filtration)
- Can be reactivated or reused in some cases
- Can be installed as POET or POU
- May be combined with other treatment (e.g., ion exchange resin)

(iStock 2021)

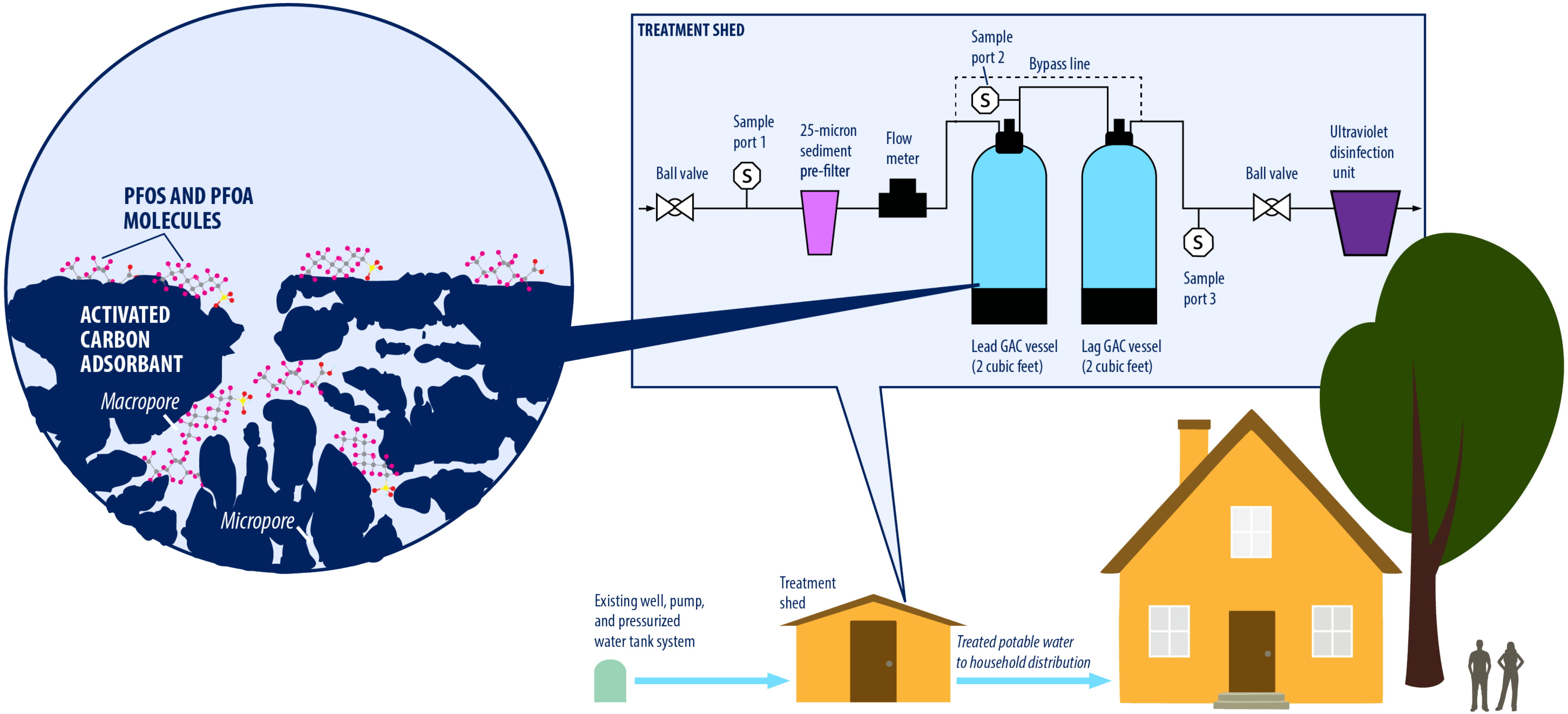
(NAVFAC Mid-Atlantic 2018)

GAC: granular activated carbon

UV: ultraviolet

Treatment Types: Granular Activated Carbon

Example schematic of treatment system using GAC

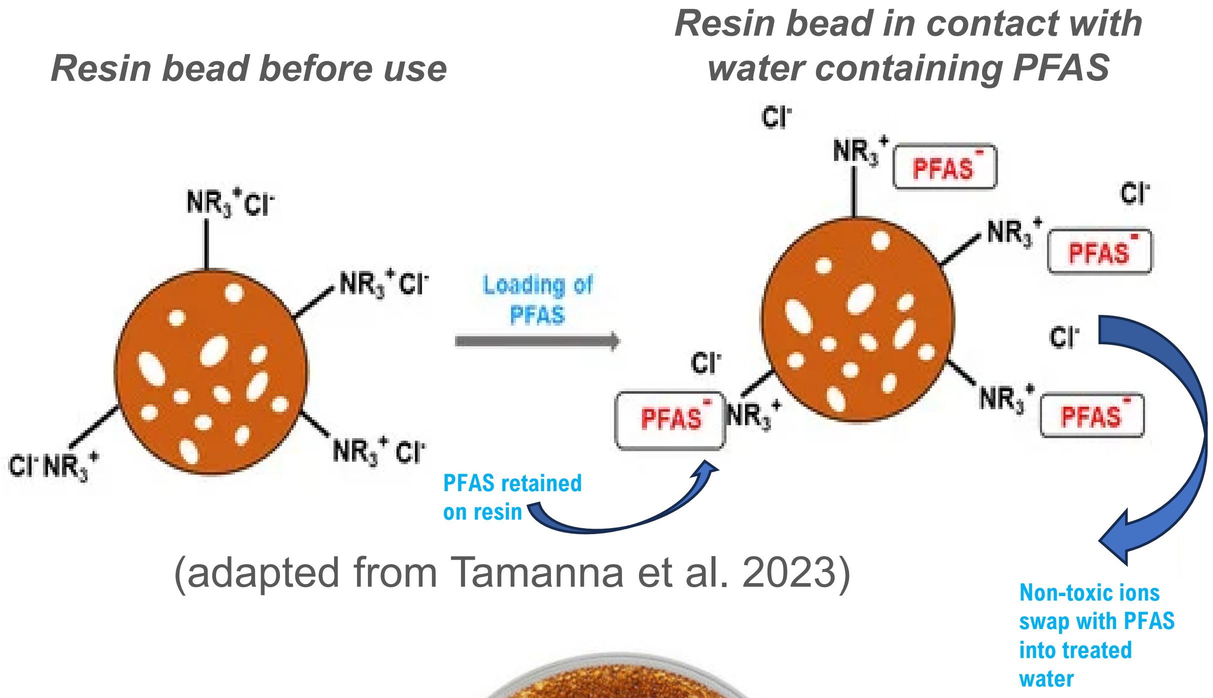


(NAVFAC Mid-Atlantic 2018)

Treatment Types: Ion Exchange

- System construction with two or more resin-filled vessels in series
- Resin has non-toxic ions that are swapped for PFAS as water flows through vessels
- IX resins are chemical or chemical-type specific
  - Numerous options tailored to treat PFAS
- Typical design for empty bed contact time of 3 to 5 minutes
- Include sample ports upstream, between (if more than one vessel), and downstream of vessels
- Sediment filtration and UV disinfection may improve system performance
- Can sometimes be regenerated or reused
- Can be installed as POET or POU
- May be combined with other treatment (e.g., GAC)

IX: ion exchange

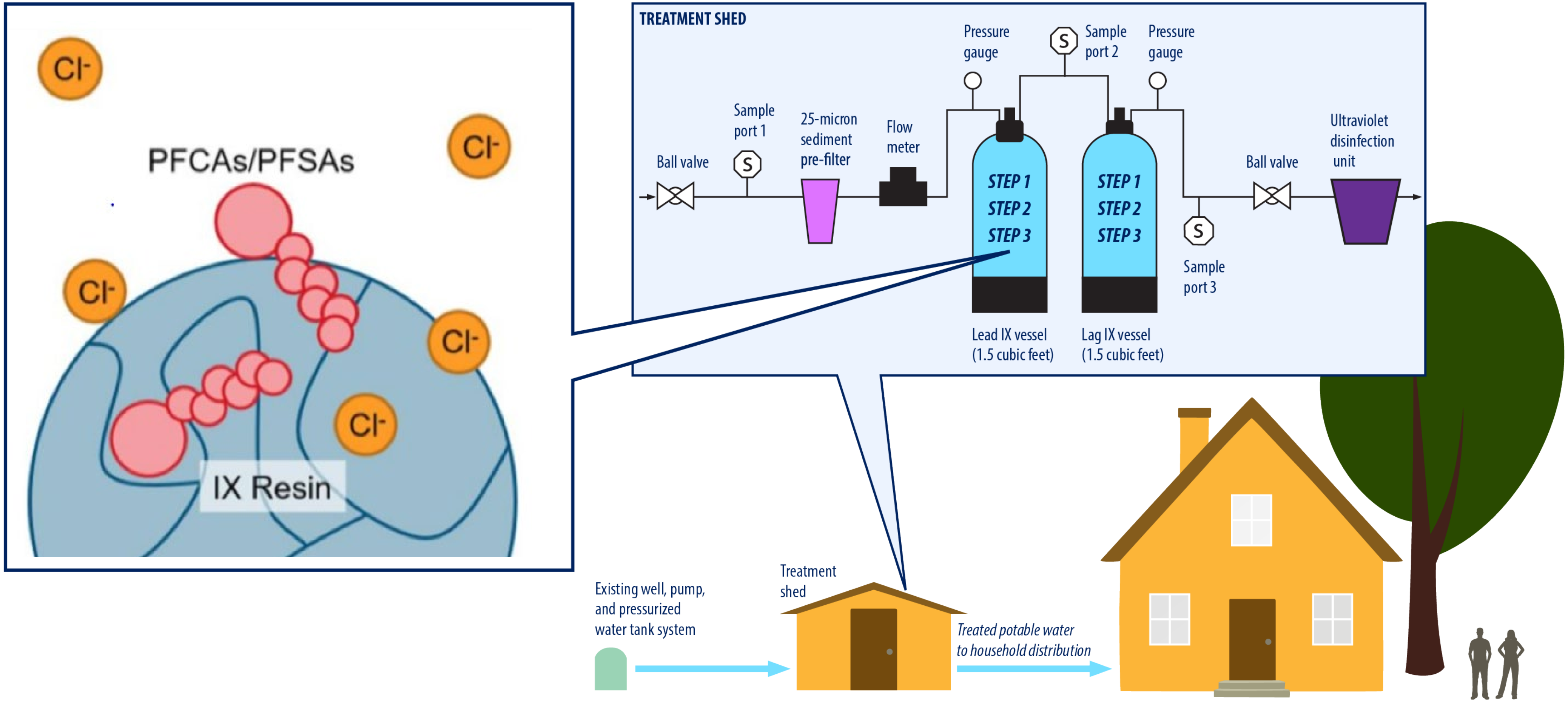


(adapted from Tamanna et al. 2023)

(iStock 2021)

Treatment Types: Ion Exchange

Example schematic of treatment system using ion exchange

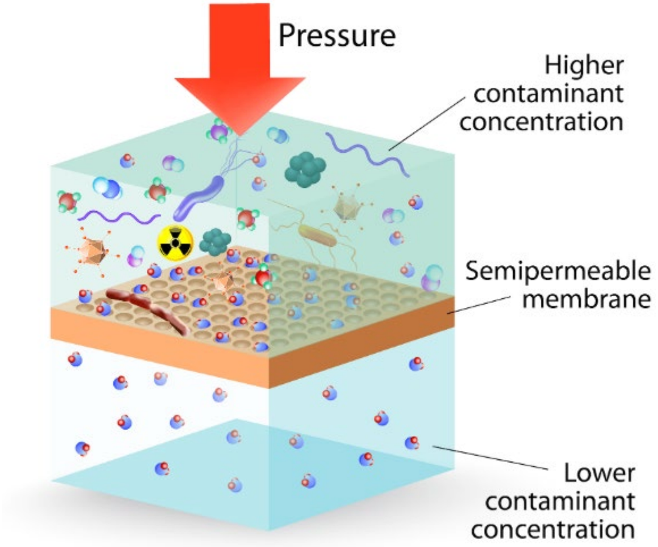


(NAVFAC Mid-Atlantic 2018)

PFCAs: perfluoroalkyl carboxylic acids

Treatment Types: Reverse Osmosis

- System construction with one or more membranes
- Water and small substances (e.g., dissolved gases) can pass through membranes, leaving larger substances like PFAS on upstream side
- Loss of water pressure always occurs across membrane(s)
    - Need for a pressure tank downstream of membranes to maintain water pressure
- Include sample ports upstream and downstream
- Treatment may require remineralization to bring pH to levels suitable for drinking
- Sediment filtration and water softening often needed to prevent membrane damage
- These are included within a self-contained system – all of the above in one unit
- Installed as POU



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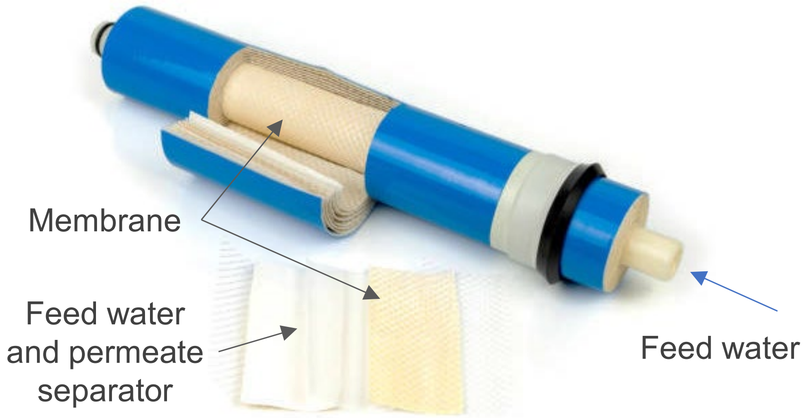


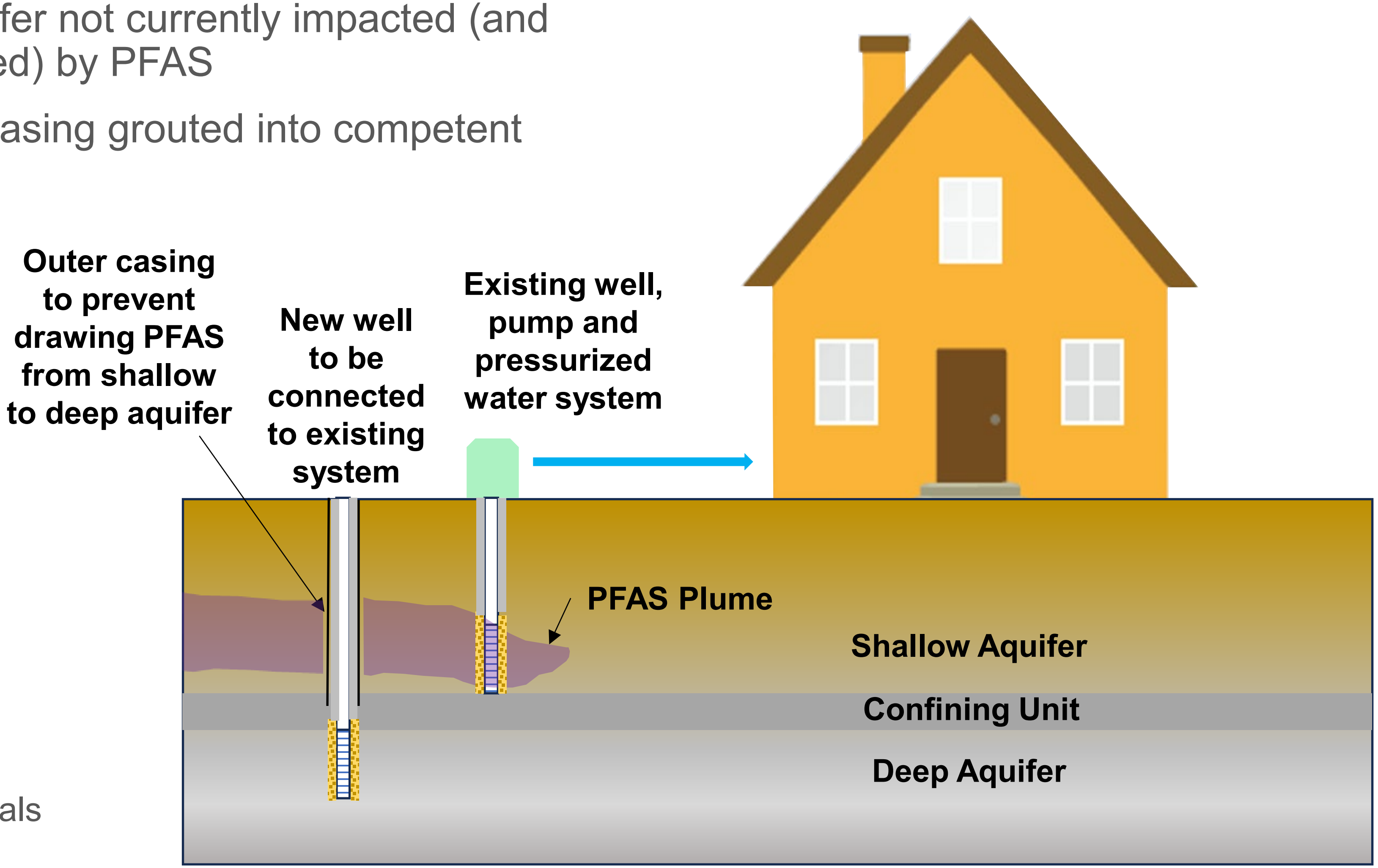
(Modified from iStock 2025)

Other Treatment System Options

- There are other potentially commercially-available options to remove PFAS from drinking water
- Most lack
  - Evidence of ability to meet low ppt levels
  - National Sanitation Foundation certification
- Contact subject matter expert if there is stakeholder interest in implementing other options

Installation of New Well

- Install well in deeper, confined aquifer not currently impacted (and not likely in the future to be impacted) by PFAS
- Must be double-cased, with outer casing grouted into competent confining unit
- Test well prior to use
- Existing well must be removed from use and abandoned
- May not be optimal in all settings due to
  - Lack of continuous, competent confining unit
  - Presence of brackish conditions or other water quality issues at deeper intervals
  - Poor yield at deeper intervals
  - Presence of other non-PFAS chemicals in exceedance of MCLs



(Jacobs)

Bottled Water

- 3 September 2024 DoD MCL Implementation Memo indicates bottled water can only be provided when
  - More sustainable alternatives are technically infeasible
    - Must request a waiver from ODASN-EMR
      - No approved waivers as of February 2025
  - PFOS and PFOS concentrations, individually or combined, are above 70 ppt
  - Bottled water was already being provided and PFAS levels are at or above the DoD levels

(Jacobs)

ODASN-EMR: Office of the Deputy Assistant Secretary of Defense for Environmental Management and Restoration

Comparison of Interim Actions: Advantages

Public Water Connection	GAC	IX	RO	New Well
• Eliminates long-term liability • No long-term maintenance or monitoring requirements • No waste management	• Can be implemented quickly • Reliable treatment method for most PFAS • Relatively inexpensive • Minimal waste management	• Can be implemented quickly • Reliable treatment method for most PFAS • Smaller vessel size than GAC possible • Minimal waste management	• Can be implemented quickly • Extremely reliable for a wide range of PFAS	• Greatly reduces potential for exposure • Minimal maintenance and monitoring needed

Comparison of Interim Actions: Disadvantages

Public Water Connection	GAC	IX	RO	New Well
• Can take time • Potential planning and design challenges • Homeowner may be hesitant to pay water bill	• Larger vessel size than IX needed based on bed contact time • Shorter breakthrough times for some PFAS versus others • Potential microbial growth on filter media • Requires maintenance and performance monitoring (Navy responsibility)	• Shorter breakthrough times for some PFAS versus others • UV disinfection recommended due to potential microbial growth on filter media • Requires maintenance and performance monitoring (Navy responsibility)	• Requires pre-treatment to prevent membrane damage • Requires maintenance and performance monitoring (Navy responsibility)	• Not always possible depending on the site conditions

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Planning for Private Drinking Water Well Sampling

- Identify off-Base sampling area/finalize sampling area figure
- Quantify properties and suspected or confirmed wells within sampling area (include public supply sources such as wells and reservoirs)
- Identify interim action options
- 3 to 4 months before open house
  - Prepare outreach work plan, which provides
    - Overview of the process
    - Task details
    - Project-specific information
    - Templates
  - Start weekly team calls
    - Local team
    - Navy Technical Experts
    - Navy Risk Communication Experts
    - Consultants

Once the need to sample is identified, the planning begins.

Planning for Private Drinking Water Well Sampling

- Engage multi-agency team
  - Health support
  - Regulatory support
- 3 to 4 weeks before Open House
  - Team preparation session
    - Risk communication 101
    - Top line message generation
    - Team understanding of project
    - Individual poster review and message development
    - Station Assignments
    - Mock meeting
  - ODASN-EMR review and Congressional Delegation (CODEL) notification
  - Start notification and outreach
    - All properties in sampling area receive mailings (letters or postcards)
    - Newspaper advertisements
    - Press release
    - Social media
- Host Open House
- Begin private drinking water well sampling

Team Roles

- NAVFAC RPM (typically the lead)
- Consultant
- NAVFAC Atlantic
  - Provides historical context and lessons learned
  - Program consistency
- Navy and Marine Corps Force Health Protection Center (“The Force”)
  - Prepares teams for public engagement by
    - Helping develop project messaging
    - Providing basic risk communication training and tools
  - Provides consistency
- Installation (Commanding Officer, Executive Officer, Environmental, Public Affairs, Community Liaison, Public Works Officer)
  - Part of local community, may be face of the project
- Partner agencies (EPA and state and local environmental/health agencies)
  - Support team as independent agency
  - Answers questions about health, federal and state policies, etc.

RPM: Remedial Project Manager

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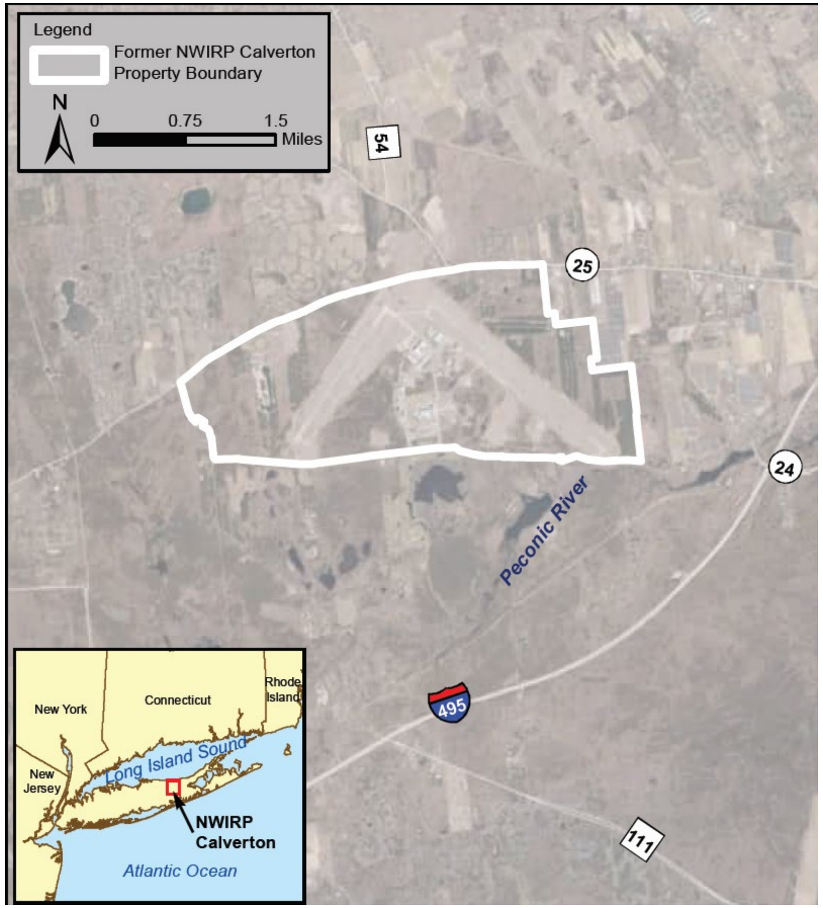
Case Study: Former NWIRP Calverton

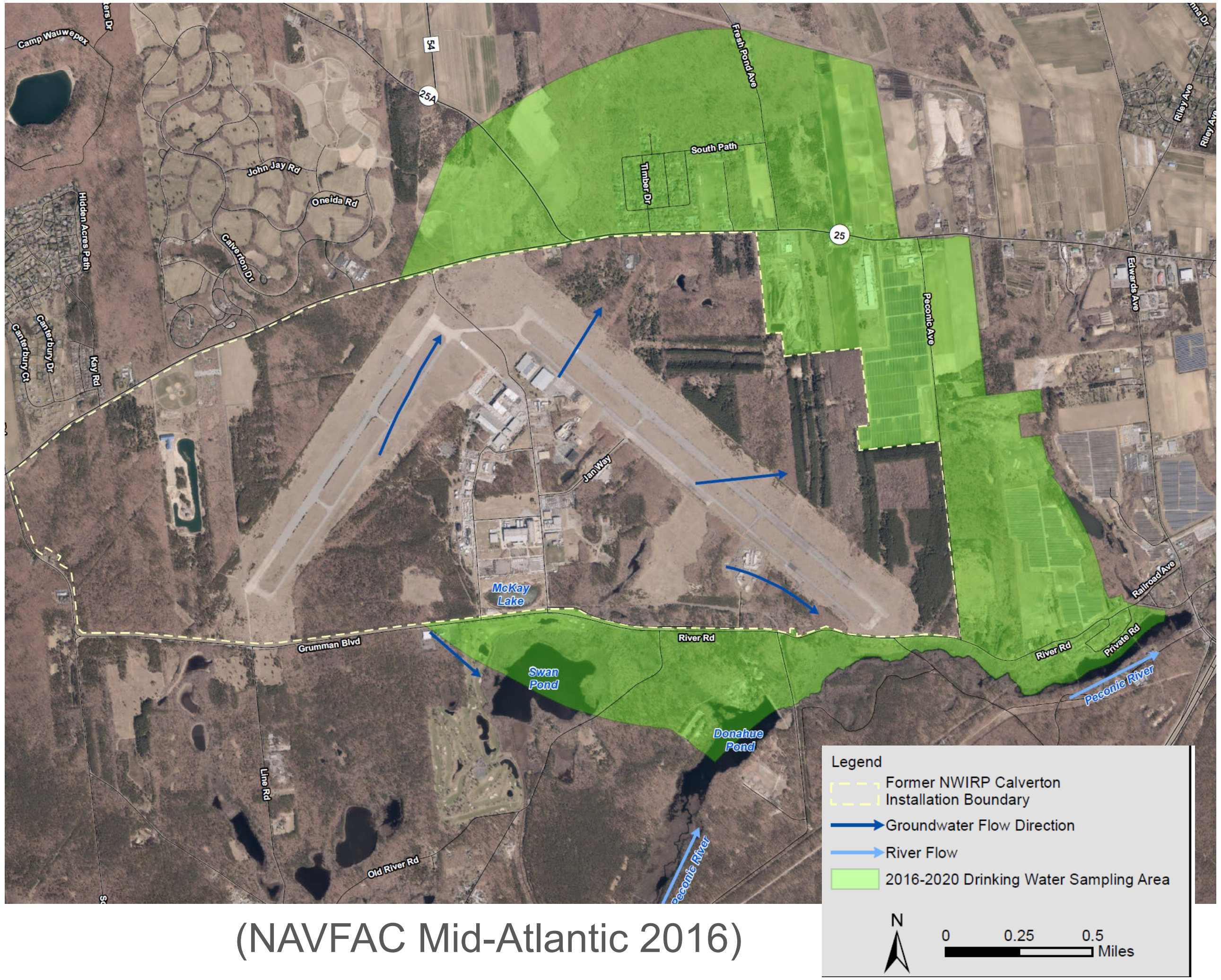
- Former NWIRP Calverton
  - Suffolk County, NY
  - Government-owned, contractor-operated
    - Leased to Northrup Grumman Corporation
    - Aircraft parts manufacturing
  - Non-NPL
  - Most of the property now owned by Town of Riverhead



(NAVFAC Mid-Atlantic 2024)

Case Study: Former NWIRP Calverton

- Identified as a Priority 1 site in 2016
- 54 parcels in sampling area
- 24 suspected/confirmed private drinking water wells
- 16 private drinking water wells sampled
  - No detections of PFOA and/or PFOS above 70 ppt
  - No stepouts
  - Periodic monitoring conducted, no change in results

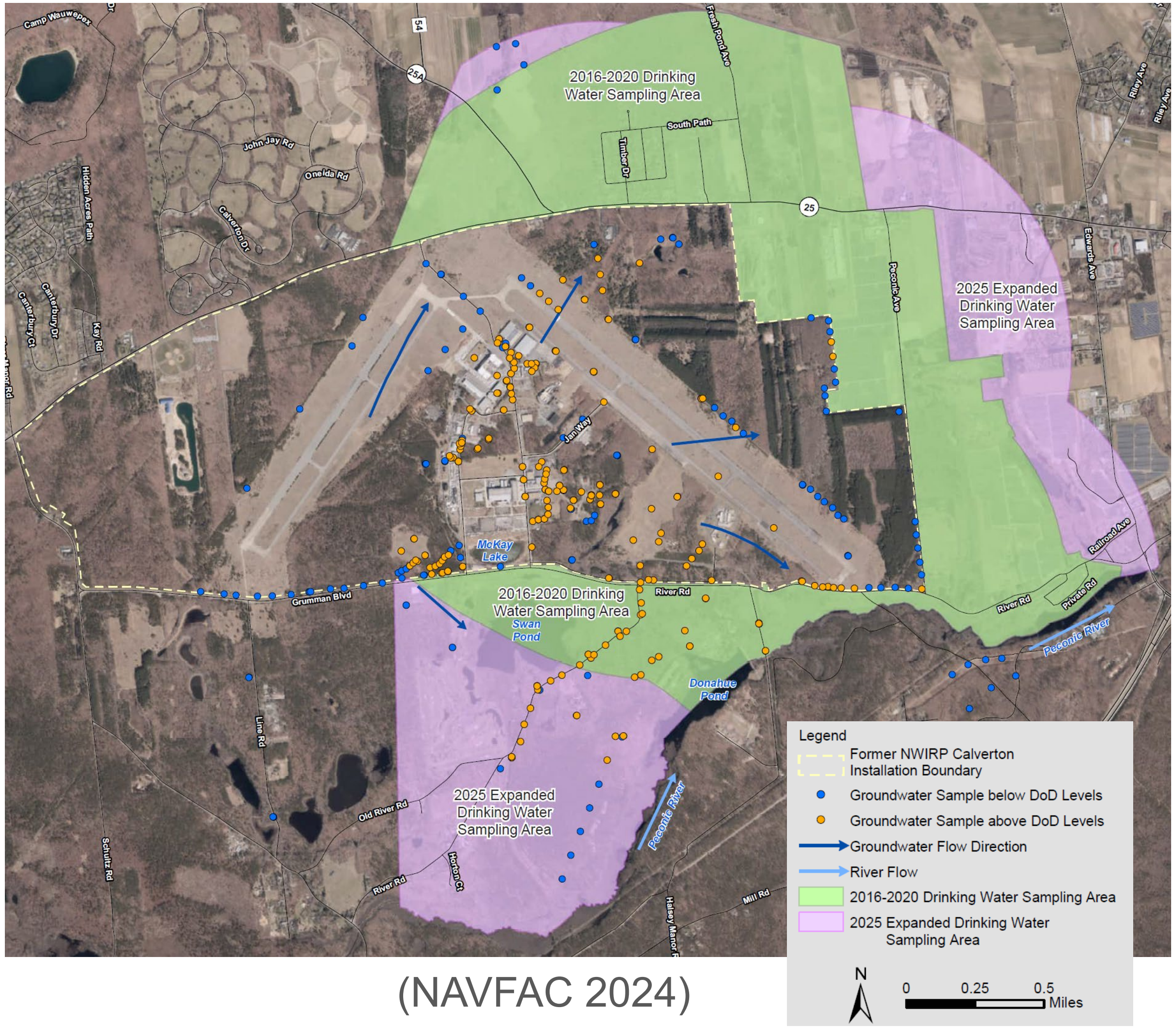


(NAVFAC Mid-Atlantic 2016)

Case Study: Former NWIRP Calverton

- Facility-wide SI completed
- RIs ongoing at multiple sites
- Data from SI and RIs
  - Confirmed PFAS releases
  - Refined understanding of groundwater flow
- Data were reevaluated using DoD PFAS interim action levels for private drinking water wells

Case Study: Former NWIRP Calverton



(NAVFAC 2024)

- Sampling area expanded based on
  - Better understanding of groundwater flow
  - Detections at or above DoD PFAS interim action levels for private drinking water wells
  - Added
    - 120 parcels
    - 40 suspected or confirmed private drinking water wells
- Consultant identified treatment system and bottled water vendor to provide POU systems or bottled water before sampling

Case Study: Former NWIRP Calverton

- Weekly planning meetings began in August 2024
- Preparation Session in December 2024
- Public meeting in January 2025
- Sampling began day after public meeting

(NAVFAC 2025)

Lessons Learned: Planning

- Sampling area figure generation
  - Backbone of project
  - Consider
    - On-Base groundwater data
    - Private drinking water well data (if available)
      - Detection limits
      - Reported analyte list
  - Includes collection of parcel water source data
    - Public water supply
    - Private drinking water well information
      - May not be available
      - NEVER exact
    - Helpful to understand parcel development status
  - Likely to take many iterations to finalize sampling area
  - Work with The Force, NAVFAC Atlantic, RPM, and consultants to refine sampling area
  - Finalize before
    - Kickoff meeting with installation personnel
    - Preparation of any outreach materials

Lessons Learned: Planning

- Open House venues
  - Convenient location, near sampling area if possible
  - Easily accessible
  - Ample parking
  - Other activities may be scheduled for same time
  - Know maximum capacity
  - Security

Lessons Learned: Planning

- Ensure funding is available to start sampling
  - Potential for exposure initially identified in PA
  - If not identified in PA, prioritize drinking water source evaluation
- Include drinking water source evaluation in all documents and record path forward
  - SAPs may require separate objective
  - Private drinking water well sampling must be covered in separate SAP
- Remind consultants of unique requirements for PFAS sampling
- Be prepared for stepout sampling

SAP: Sampling and Analysis Plan

Lessons Learned: Interim Actions

- Connection to public water
  - Engage consultant’s utility engineers for design support
  - Distance to existing water lines and connection size
    - Fire hydrant installation
    - Multiple properties can be connected
    - December 2021 OSD technical guidance
      - Removal actions may be completed if property is hydrologically connected and detections in groundwater or drinking water at or above DoD levels
    - Taking drinking water wells offline may alter local groundwater flow due to changing pumping conditions
  - Administrative requirements
    - Right-of-entry agreements
    - Permitting
    - Easements
    - Account setup

OSD: Office of the Secretary of Defense

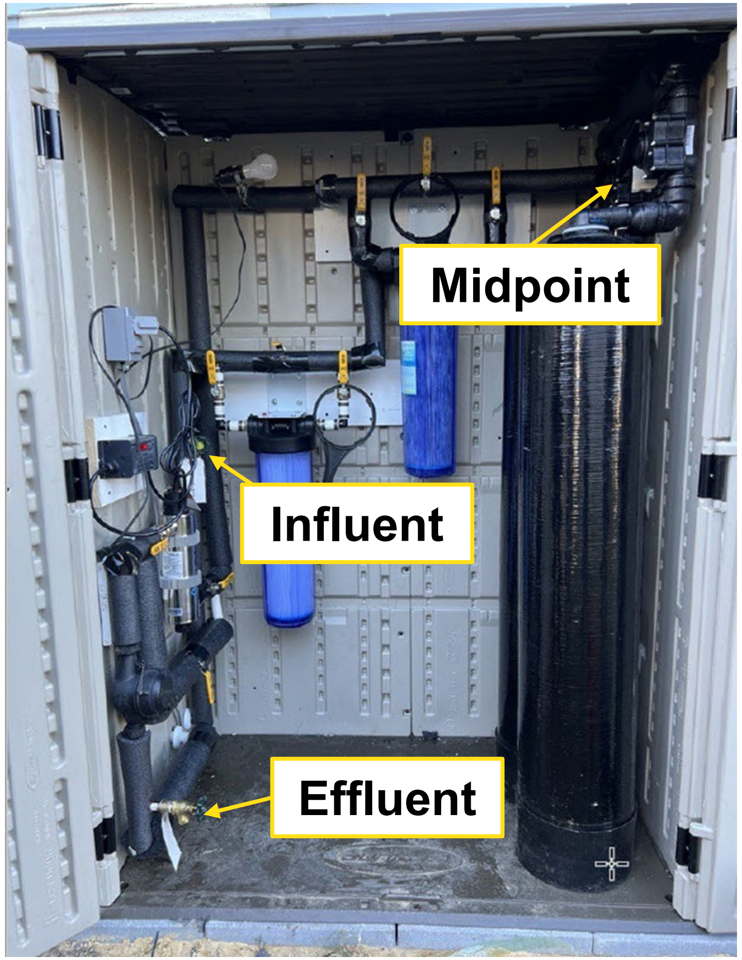
Lessons Learned: Interim Actions

- Connection to public water (continued)
  - Contracting mechanisms for installing water lines
    - Directly with water provider
      - Waterline ownership
      - Navy has little control over schedule, consider funding expiration
    - Navy consultants
      - Ideal for TCRAs, hire a plumber
      - Water line easily accessible, near property
      - Laterals already in place or need to be installed
  - Engage NAVFAC Real Estate and Counsel

TCRA: Time-Critical Removal Action

Lessons Learned: Interim Actions

- POET/POUs
  - May require validation testing
    - SAP required
    - Ensures treatment system is functioning
    - Conducted by consultant
    - Label and document sample ports
    - Once performance monitoring is validated, stop collecting samples
  - Maintenance
    - Should be conducted by treatment system vendor
    - Material changeout
    - Leaks
    - Catastrophic failures
  - Site-specific considerations
    - Space for treatment system
    - Plumbing upgrades
    - Climate
    - Water quality



(NAVFAC Mid-Atlantic 2018)

Lessons Learned: Interim Actions

- Bottled water considerations
  - Number of people in household
  - 5-gallon containers with dispenser
  - Smaller containers, tabletop dispenser
  - Ice
  - Not for pets or farm animals
  - Provide property owner with bottled water vendor and Navy consultant contacts
  - Bottled water vendor must stick with contracted scope
    - No specialty waters
    - No other non-water items

Lessons Learned: Documentation Requirements

- Emergency Removal Action
  - Response within hours or days (immediate)
  - AM
    - Publish notice of availability within 60 days of initiation
    - 30-day comment period

- TCRA
  - Planning is 6 months or less
  - AM
    - Publish notice of availability within 60 days of initiation
    - 30-day comment period

- Non-TCRA
  - Planning period is more than 6 months
  - Engineering Evaluation/Cost Analysis
    - Publish notice of availability
    - 30-day comment period
  - AM once complete

KEY POINT

Documentation is required for action taken. Do not delay completing an AM following completion of removal action to ensure compliance with requirements. Ensure documentation is loaded into NIRIS.

AM: Action Memorandum

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Summary and Closing Statements

- Begin planning early!
- Communicate early and often with surrounding communities
- Important to assemble a knowledgeable team to help manage all aspects of addressing private drinking water

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Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Questions

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Contextualizing PFAS Detections: Background and Forensics

Jeff Gamlin, PG, CHG, GSI Environmental Inc.

RITS 2025

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Information in this presentation is current as of 28 March 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Jeff Gamlin, PG, CHG
Principal Hydrogeologist
GSI Environmental Inc.

CHG: Certified Hydrogeologist
PG: Professional Geologist
PFAS: per- and polyfluoroalkyl substances

EDUCATION

- Master of Science, Hydrogeology, 2002, *University of Nevada, Reno*
- Bachelor of Science, Geology, 1999, *University of California, Santa Barbara*

PROFESSIONAL EXPERIENCE

- ~25 years in the environmental remediation industry
- Has evaluated 70+ PFAS sites around the world
- Organizing Committee Member: PFAS Environmental Professionals Working Group

RECENT PUBLICATIONS

- Gamlin, J., Newell, C., Holton, C., Kulkarni, P., Skaggs, J., Adamson, D., Blotevogel, J., Higgins, C. 2024. “Data Evaluation Framework for Refining PFAS Conceptual Site Models.” *Groundwater Monitoring & Remediation.*
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Presentation Overview

- Part 1: Introduction to the PFAS Analyte List
- Part 2: PFAS Forensics: Fate and Transport Considerations
- Part 3: PFAS Background Definitions
- Part 4: Key Considerations for Assessing Background PFAS
  - Lunch Break
- Part 5: Putting it All Together: Source Areas vs. Background
- Part 6: PFAS Background at Navy Installations
- Wrap-Up

PFAS Have a Lot of Acronyms…

- The next few slides will present a lot of acronyms…
- Don’t worry, this is just for reference, and you do not need to memorize
- We will break the PFAS acronyms into smaller “buckets” to make this easier to understand

(Image from Microsoft Office)

Introduction to the PFAS Analyte List

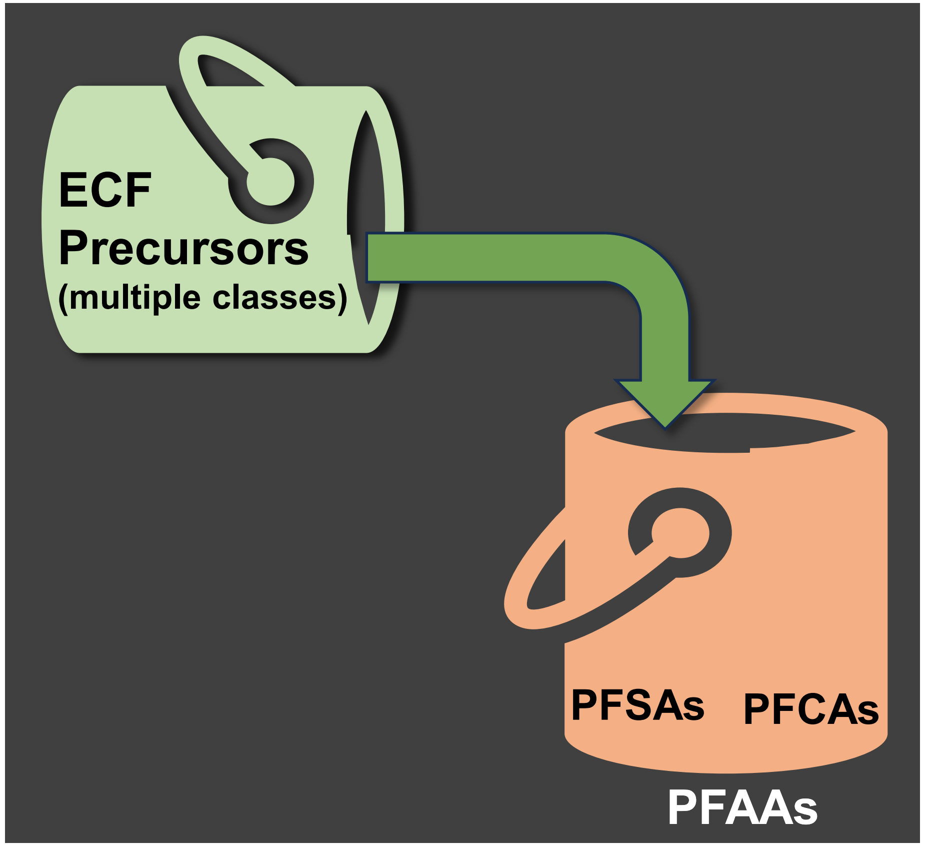
- General Acronym Definitions
  - We will focus on the EPA Method 1633 analyte list, since it is inclusive of PFAS in other DoD analyte lists
  - PFAAs: Perfluoroalkyl acids (perfluorinated)
    - PFSAs: Perfluoroalkyl sulfonic acids (e.g., perfluorooctane sulfonic acid - PFOS)
    - PFCAs: Perfluoroalkyl carboxylic acids (e.g., perfluorooctanoic acid - PFOA)
  - Precursors: PFAS that turn into other PFAS (polyfluorinated)
    - ECF: Electrochemical fluorination-based precursors
    - FT: Fluorotelomerization-based precursors
  - PFEAs: Per- and polyfluoroalkyl ether acids (“replacements”)

DoD: Department of Defense
EPA: United States Environmental Protection Agency

EPA Method 1633 Analyte List

ECF Precursors	PFSAs	PFCAs	FT Precursors	PFEAs
N-EtFOSE	PFDoDS	PFTeDA	8:2 FTS	11Cl-PF3OUdS
N-MeFOSE	PFDS	PFTrDA	6:2 FTS	9Cl-PF3ONS
N-EtFOSAA	PFNS	PFDoA	4:2 FTS	HFPO-DA
N-MeFOSAA	PFOS	PFUnA	7:3 FTCA	PFMBA
N-EtFOSA	PFHpS	PFDA	5:3 FTCA	PFMPA
N-MeFOSA	PFHxS	PFNA	3:3 FTCA	ADONA
FOSA	PFPeS	PFOA		NFDHA
	PFBS	PFHpA		PFEESA
		PFHxA		
		PFPeA		
		PFBA		

Generalized PFAS “Buckets” Part 1



ECF Precursors

- N-EtFOSE
- N-MeFOSE
- N-EtFOSAA
- N-MeFOSAA
- N-EtFOSA
- N-MeFOSA
- FOSA

PFSAs

- PFDoDS
- PFDS
- PFNS
- PFOS
- PFHpS
- PFHxS
- PFPeS
- PFBS

PFCAs

- PFTeDA
- PFTrDA
- PFDoA
- PFUnA
- PFDA
- PFNA
- PFOA
- PFHpA
- PFHxA
- PFPeA
- PFBA

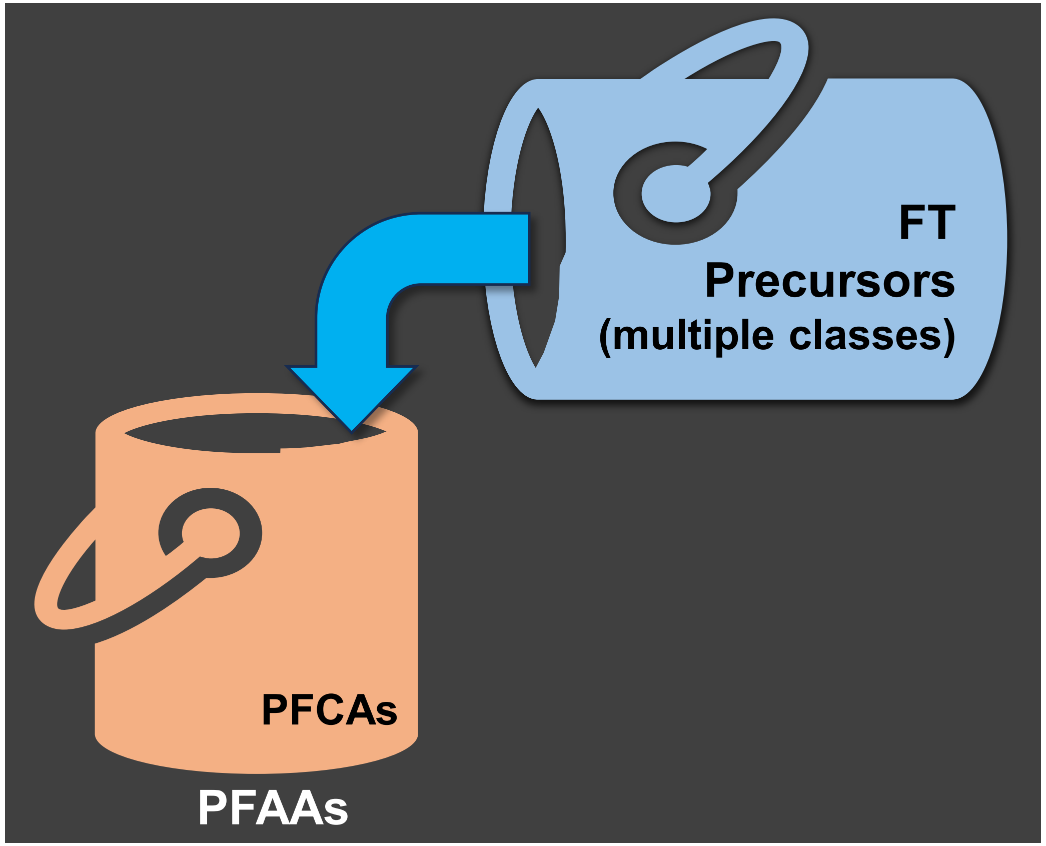
Generalized PFAS “Buckets” Part 2

PFCAs

- PFTeDA
- PFTrDA
- PFDoA
- PFUnA
- PFDA
- PFNA
- PFOA
- PFHpA
- PFHxA
- PFPeA
- PFBA

FT Precursors

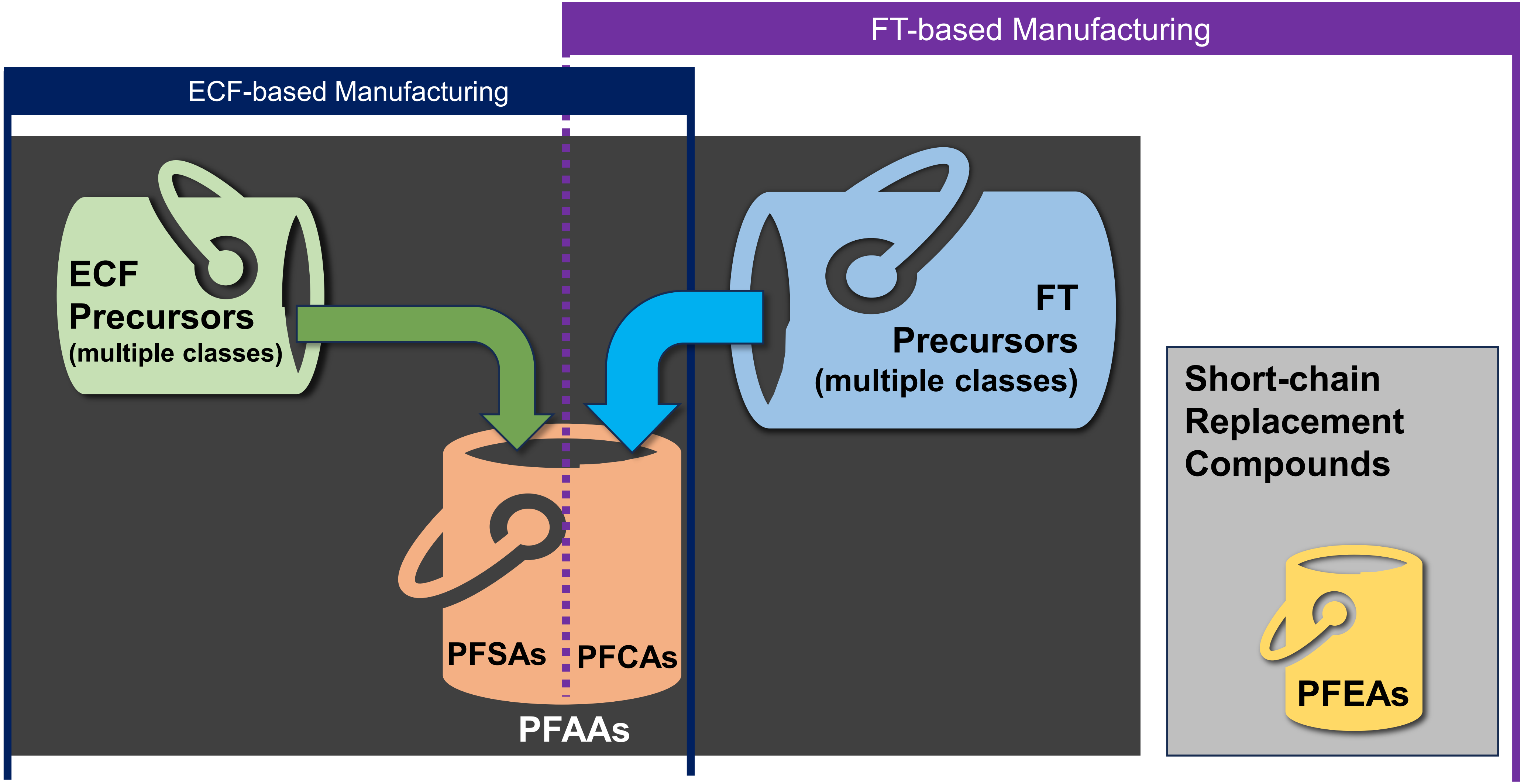
- 8:2 FTS
- 6:2 FTS
- 4:2 FTS
- 7:3 FTCA
- 5:3 FTCA
- 3:3 FTCA



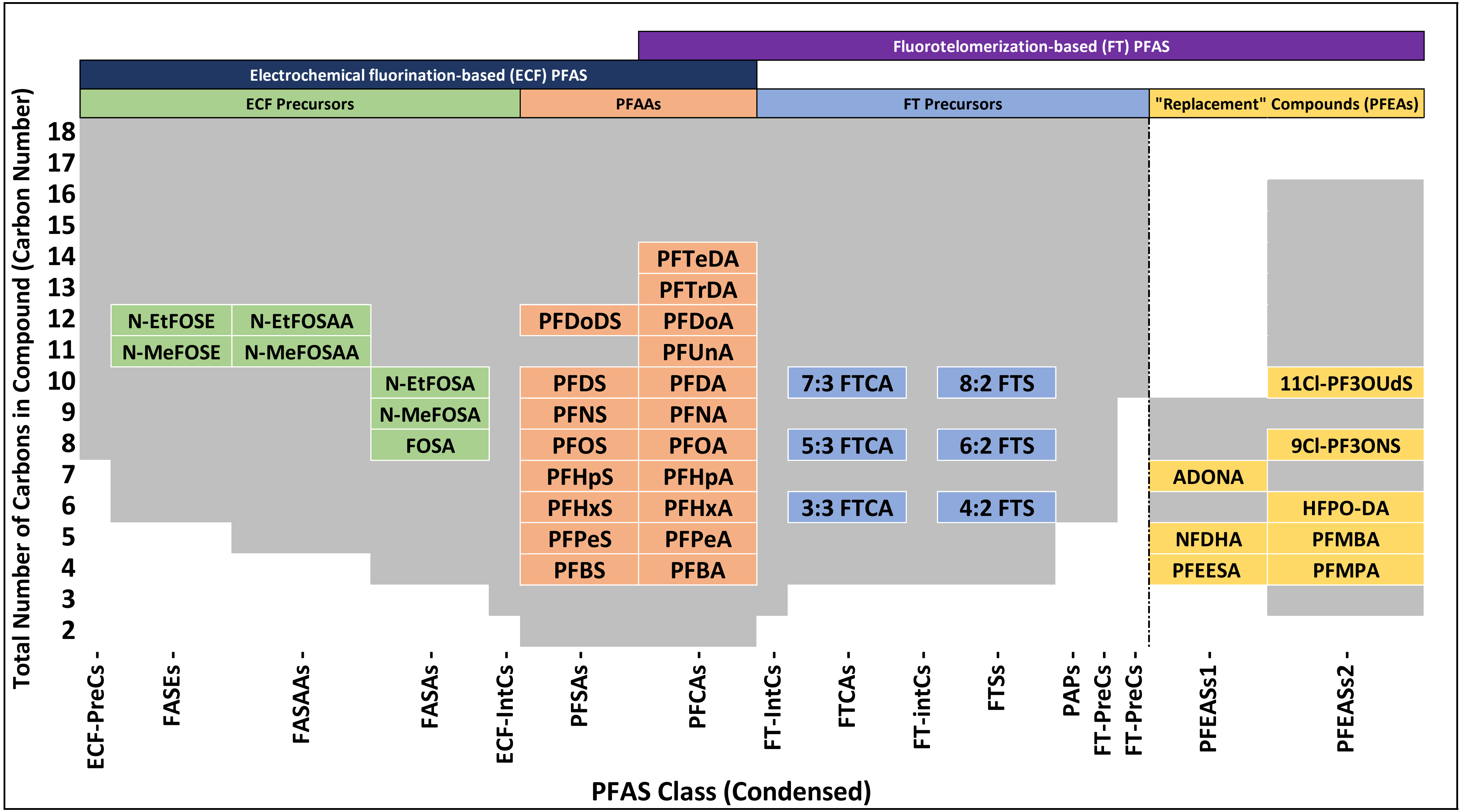
PFEAs

- 11Cl-PF3OUdS
- 9Cl-PF3ONS
- HFPO-DA
- PFMBA
- PFMPA
- ADONA
- NFDHA
- PFEESA

Generalized PFAS “Buckets” Combined



PFAS Family Tree (EPA Method 1633)



Note: Dark grey cells are approximate representations of other PFAS not analyzed by EPA Method 1633

Presentation Overview

- Part 1: Introduction to the PFAS Analyte List
- Part 2: PFAS Forensics: Fate and Transport Considerations
- Part 3: PFAS Background Definitions
- Part 4: Key Considerations for Assessing Background PFAS
    - Lunch Break
- Part 5: Putting it All Together: Source Areas vs. Background
- Part 6: PFAS Background at Navy Installations
- Wrap-Up

Objective

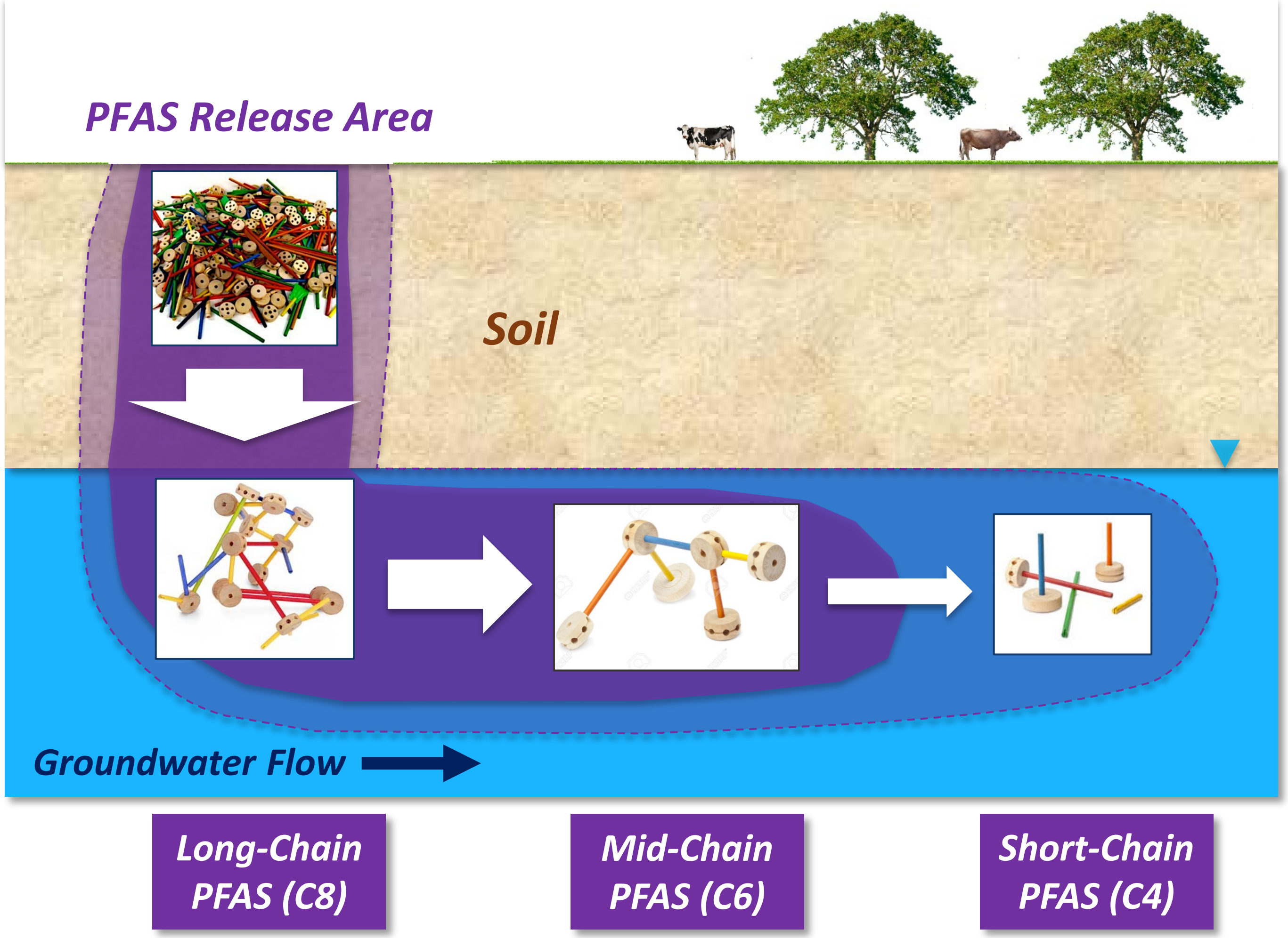
- Explain how PFAS fate and transport mechanisms can affect PFAS patterns over time/distance

(Image from Microsoft Office)

Basics of PFAS Environmental Behavior

Tinker toys represent complexity of PFAS along route of migration

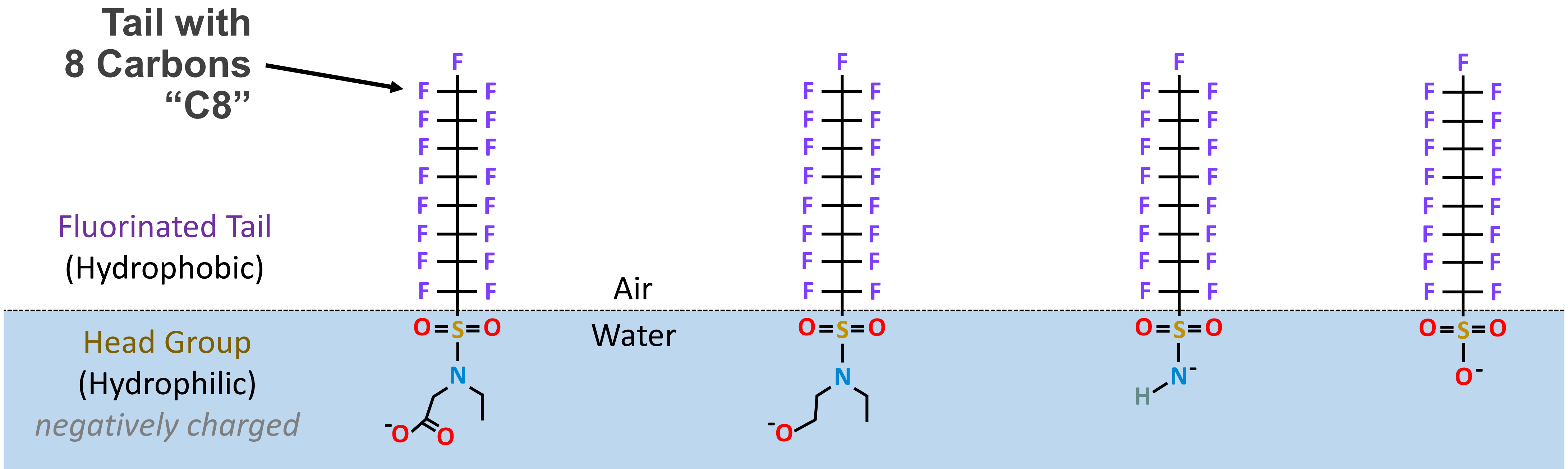
- Environmental factors cause long-chain PFAS to "stick" closer to source areas
- This causes PFAS patterns to change along routes of migration



Precursor Transformation to PFOS

Transformation Pathway (Rhodes et al. 2008) →

N-EtFOSE → N-EtFOSAA → FOSA → PFOS



Tail with 8 Carbons "C8"

Fluorinated Tail
(Hydrophobic)

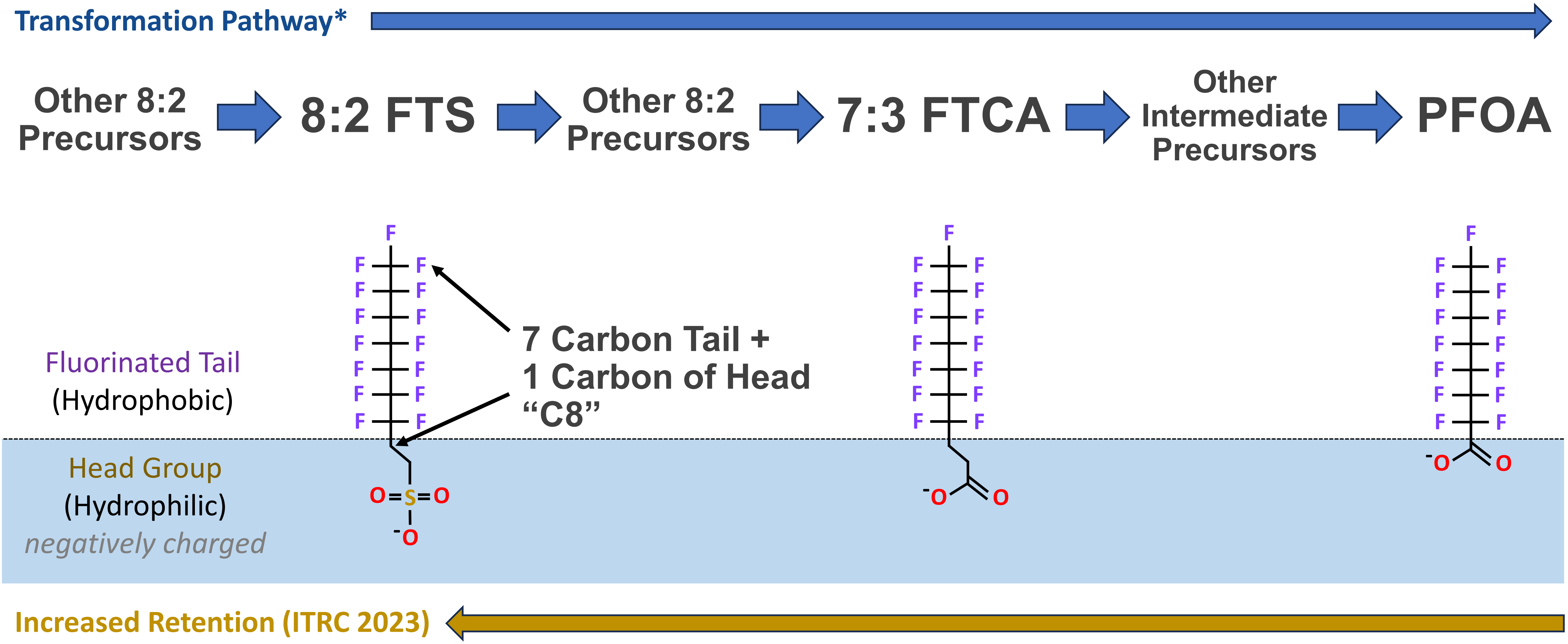
Head Group
(Hydrophilic)
negatively charged

Air

Water

Increased Retention (ITRC 2023) ←

Precursor Transformation to PFOA



Transformation Pathway*

Other 8:2 Precursors → 8:2 FTS → Other 8:2 Precursors → 7:3 FTCA → Other Intermediate Precursors → PFOA

Fluorinated Tail
(Hydrophobic)

Head Group
(Hydrophilic)
negatively charged

7 Carbon Tail +
1 Carbon of Head
"C8"

Increased Retention (ITRC 2023)

*(Harding-Marjanovic et al. 2015), (Dasu et al. 2012, 2013), (Li et al. 2018)

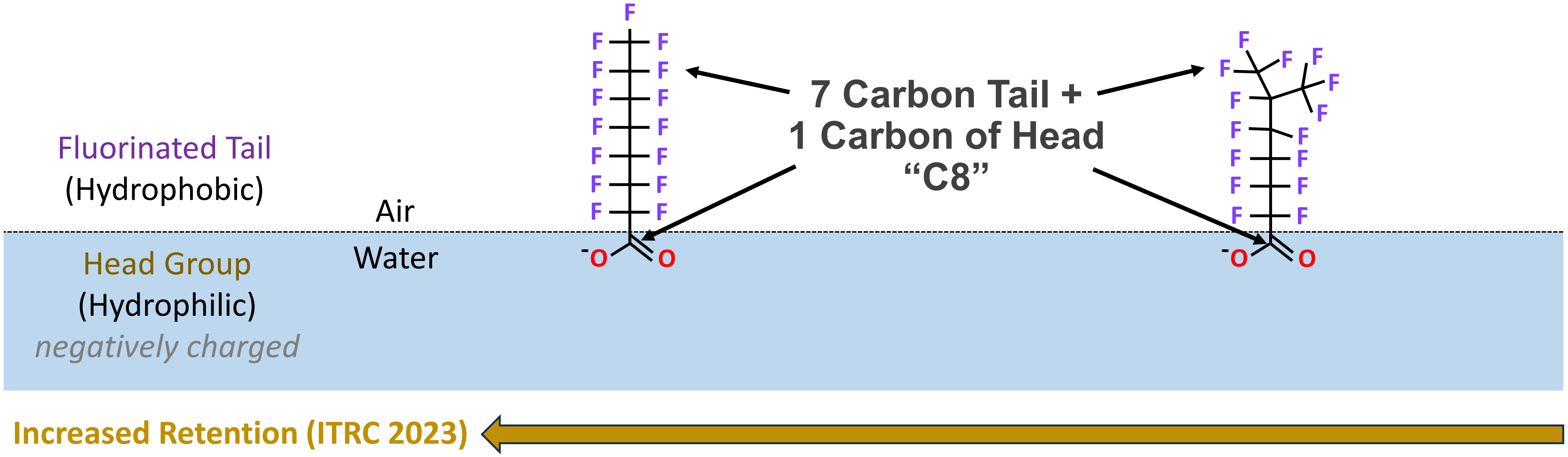
Branched and Linear Isomers

Linear PFOA

(ECF or FT-based)

Branched PFOA

(ECF-based)



Fluorinated Tail
(Hydrophobic)

Air

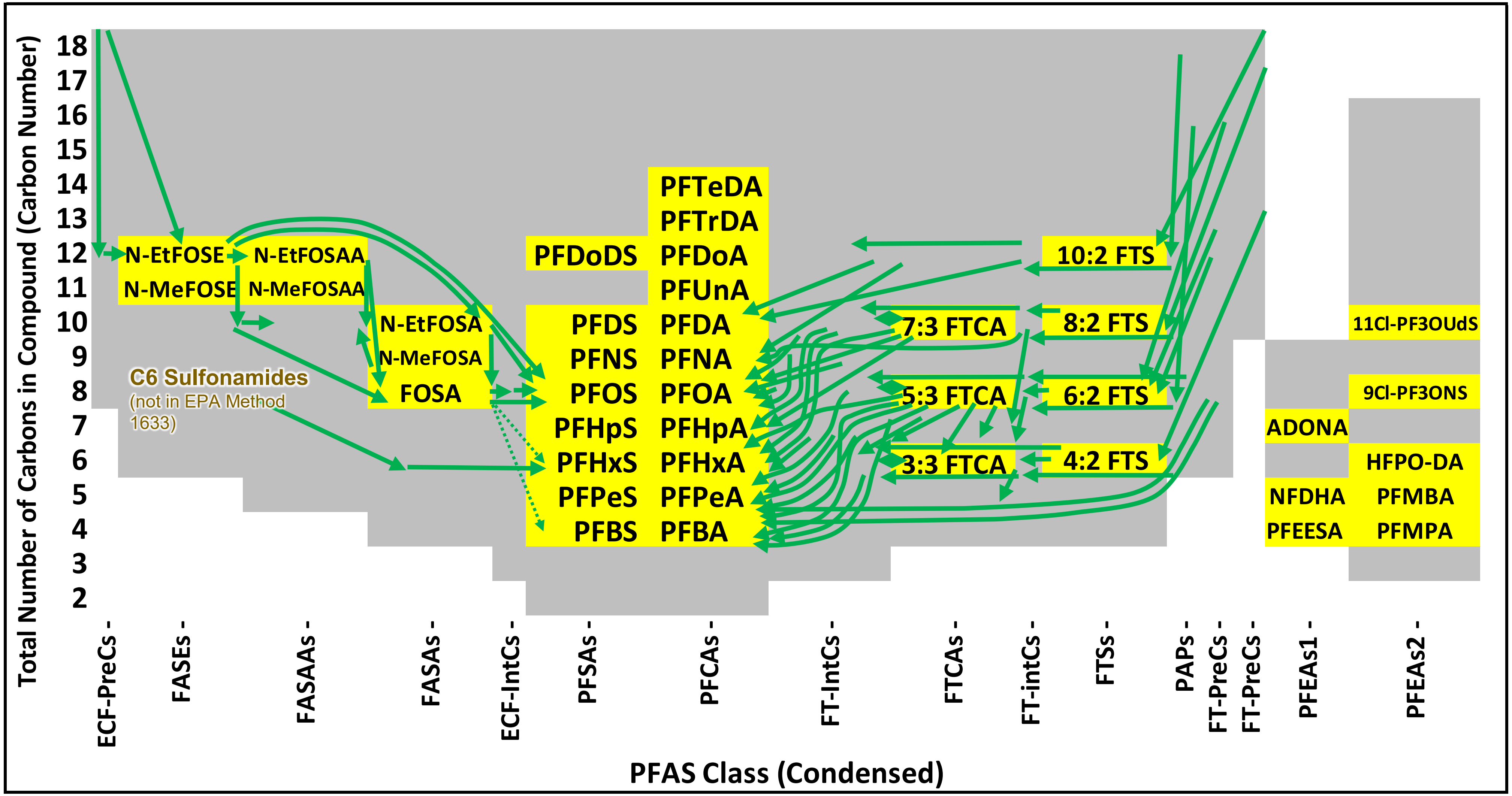
Water

Head Group
(Hydrophilic)
negatively charged

7 Carbon Tail +
1 Carbon of Head
“C8”

Increased Retention (ITRC 2023)

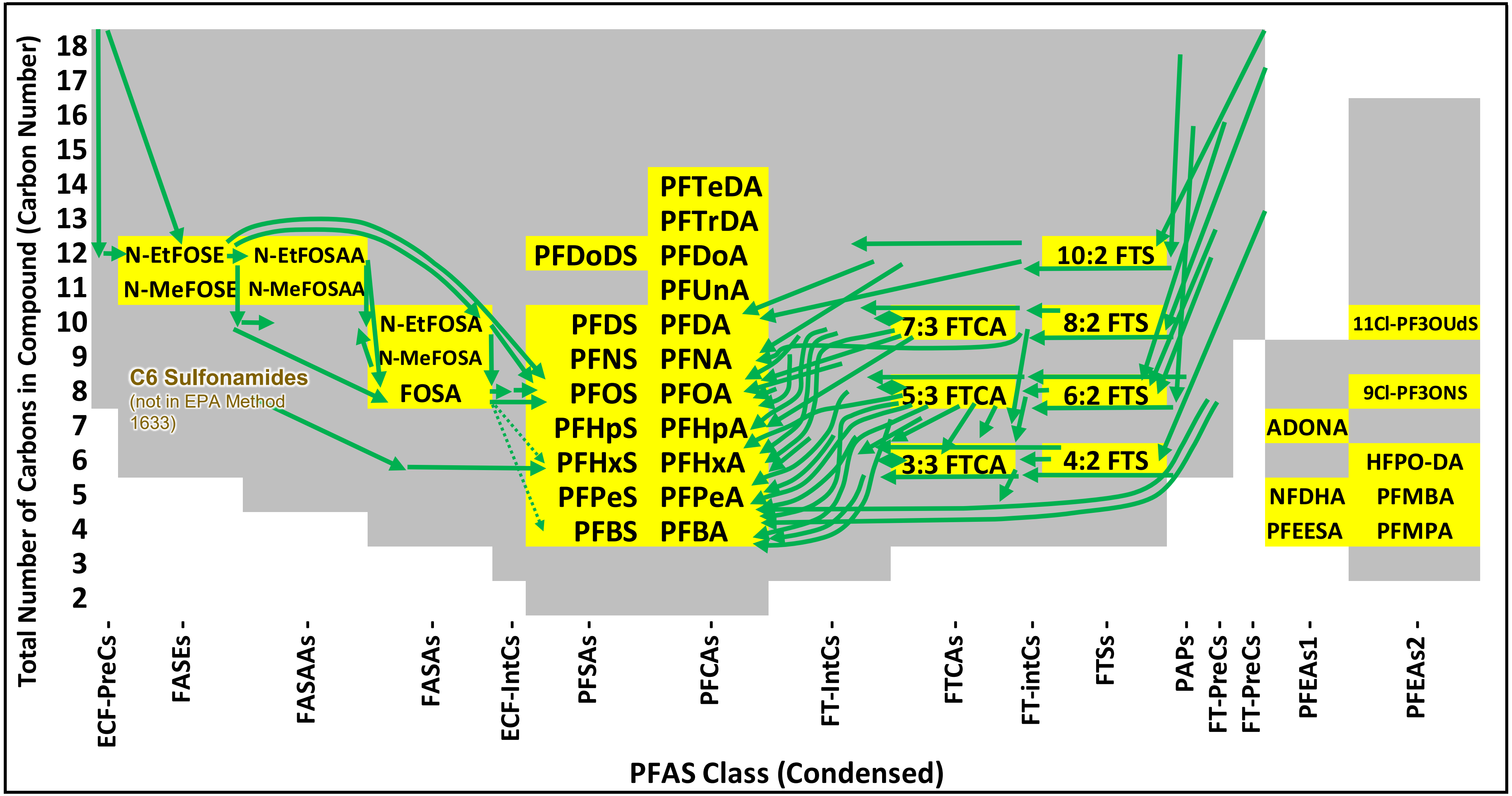
Precursor Transformation Overview



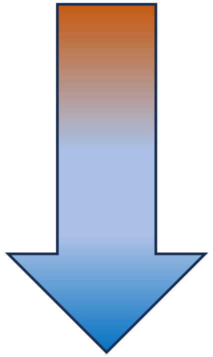
Arrows represent precursor transformation step, based on literature

Arrows the start in the gray space represent precursors not in EPA Method 1633

Retention and Precursor Transformation



Greater Retention

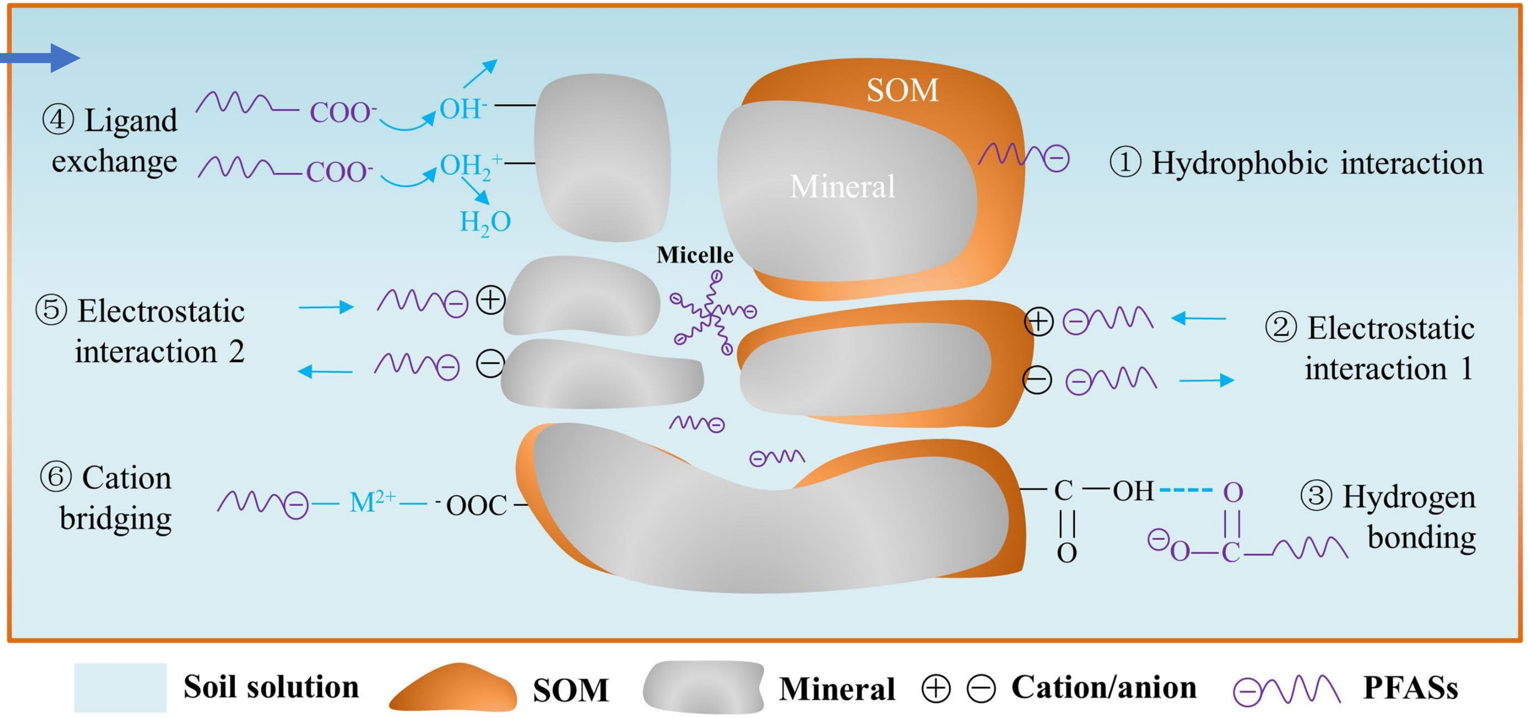


Less Retention

Retention Considerations

- Retention can be caused by sorption, air/water partitioning, or other factors

- Example of sorption
  - PFAS sorb to organic carbon on soils (more carbons = generally more sorption)



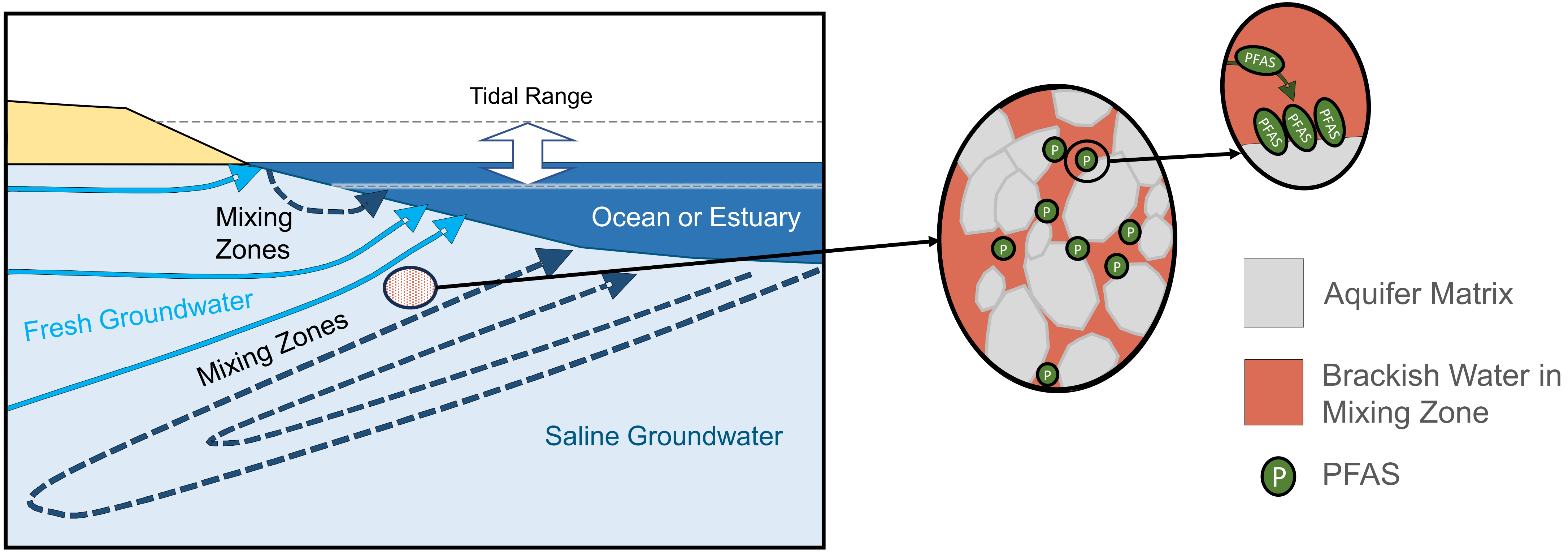
(Mei et al. 2021)

SOM: soil organic material

Other Retention Considerations

PFAS "Salting Out"

If a freshwater PFAS plume enters a mixing zone, it can trigger the salting out process that retains PFAS in aquifer matrix



For more information, see Final Report for SERDP Project ER22-3275 and Newell et al. 2022

PFAS Patterns

KEY POINT

Retention and precursor transformation affect PFAS patterns along routes of migration.

(Image from Microsoft Office)

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Knowledge Pre-Check: Questions 1–3

- Does the EPA definition of Background apply to PFAS?

  A) Yes B) No

- Does the 2004 Navy Policy on Background apply to PFAS?

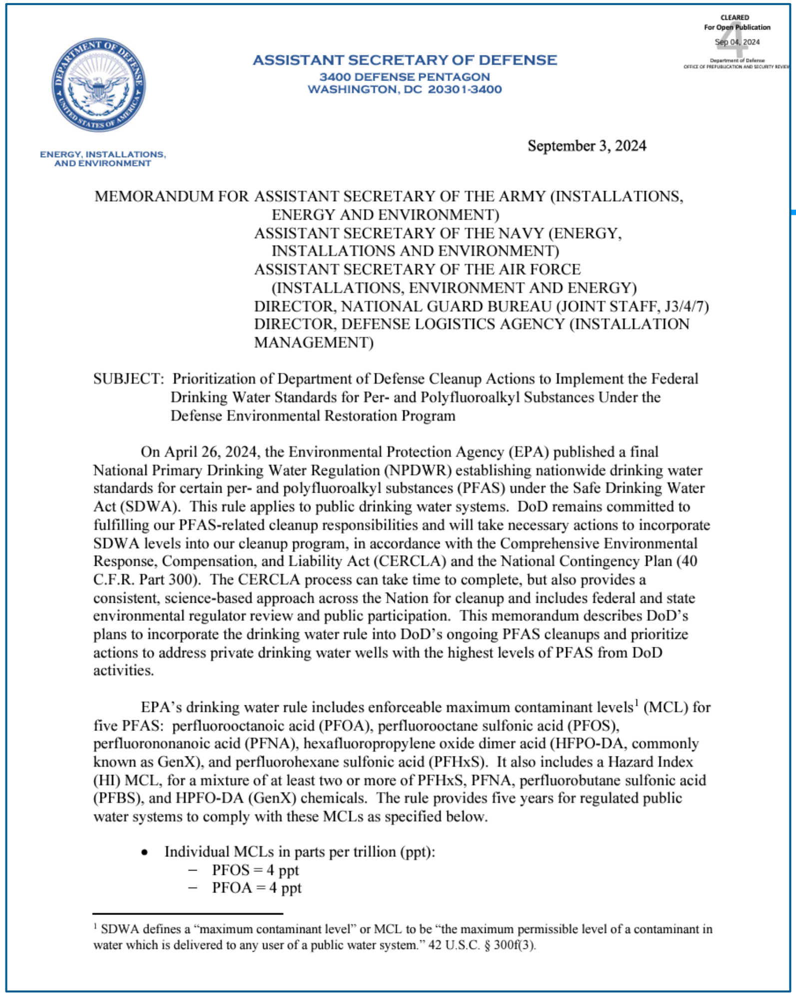
  A) Yes B) No

- Will Background PFAS be a component of remedial decision-making at DoD facilities?

  A) Yes B) No

DoD Memorandum on Background PFAS

- **PFAS background assessments will be a component of remedial decision-making at DoD facilities**
  - September 3, 2024, memo on prioritization of DoD Cleanup Actions to implement PFAS MCLs



CLEARED
For Open Publication
Sep 04, 2024
Department of Defense
OFFICE OF PREPUBLICATION AND SECURITY REVIEW

ASSISTANT SECRETARY OF DEFENSE
3400 DEFENSE PENTAGON
WASHINGTON, DC 20301-3400

ENERGY, INSTALLATIONS, AND ENVIRONMENT

September 3, 2024

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, NATIONAL GUARD BUREAU (JOINT STAFF, J3/4/7)
DIRECTOR, DEFENSE LOGISTICS AGENCY (INSTALLATION MANAGEMENT)

SUBJECT: Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program

On April 26, 2024, the Environmental Protection Agency (EPA) published a final National Primary Drinking Water Regulation (NPDWR) establishing nationwide drinking water standards for certain per- and polyfluoroalkyl substances (PFAS) under the Safe Drinking Water Act (SDWA). This rule applies to public drinking water systems. DoD remains committed to fulfilling our PFAS-related cleanup responsibilities and will take necessary actions to incorporate SDWA levels into our cleanup program, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (40 C.F.R. Part 300). The CERCLA process can take time to complete, but also provides a consistent, science-based approach across the Nation for cleanup and includes federal and state environmental regulator review and public participation. This memorandum describes DoD's plans to incorporate the drinking water rule into DoD's ongoing PFAS cleanups and prioritize actions to address private drinking water wells with the highest levels of PFAS from DoD activities.

EPA's drinking water rule includes enforceable maximum contaminant levels[1] (MCL) for five PFAS: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX), and perfluorohexane sulfonic acid (PFHxS). It also includes a Hazard Index (HI) MCL, for a mixture of at least two or more of PFHxS, PFNA, perfluorobutane sulfonic acid (PFBS), and HPFO-DA (GenX) chemicals. The rule provides five years for regulated public water systems to comply with these MCLs as specified below.

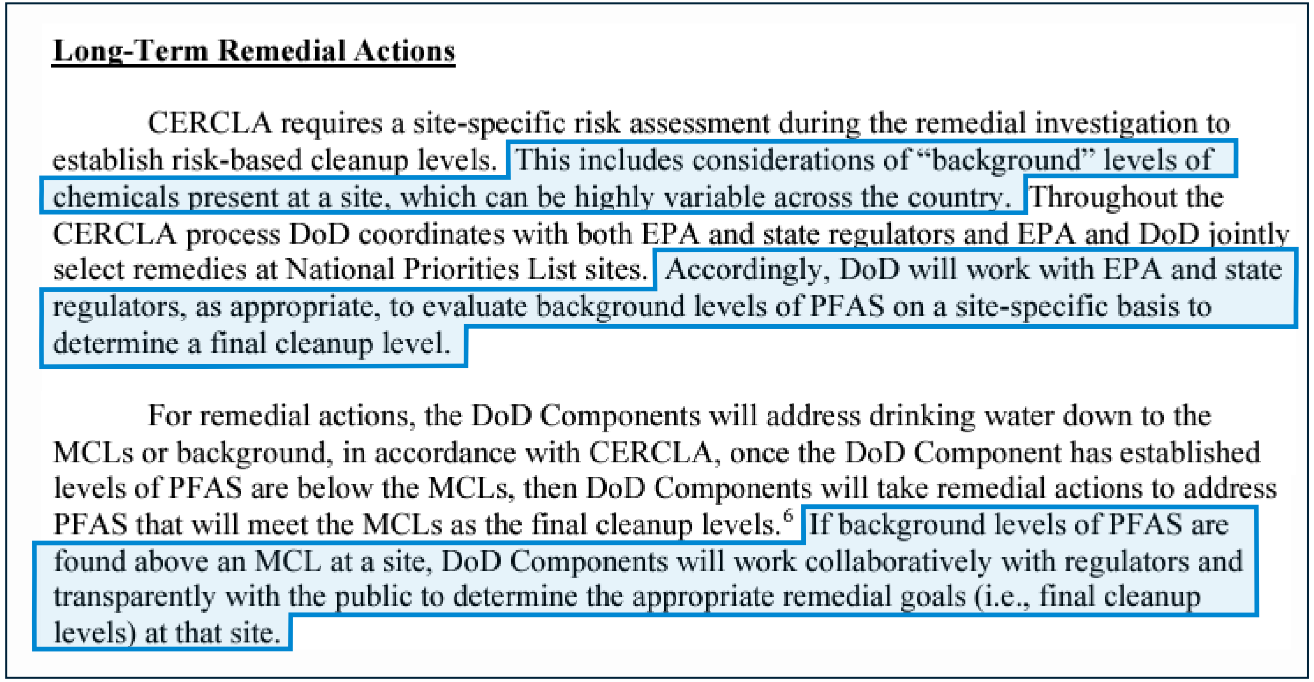
- Individual MCLs in parts per trillion (ppt):
  - PFOS = 4 ppt
  - PFOA = 4 ppt

---

[1] SDWA defines a "maximum contaminant level" or MCL to be "the maximum permissible level of a contaminant in water which is delivered to any user of a public water system." 42 U.S.C. § 300f(3).

(DoD 2024)

MCL: maximum contaminant level



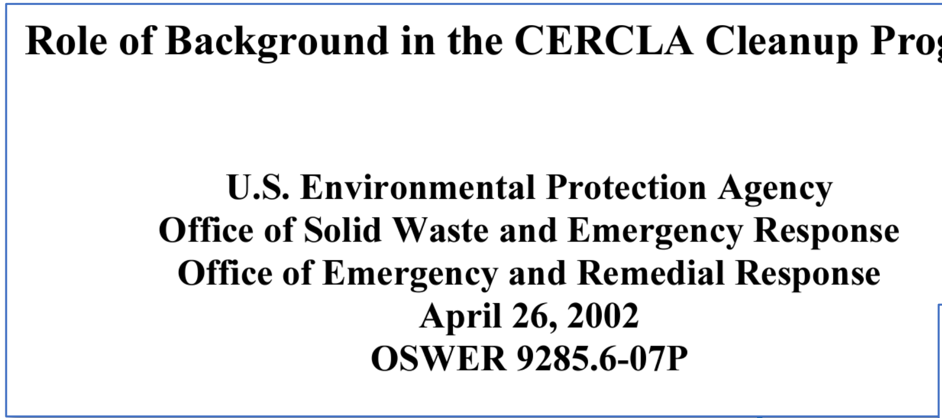
Long-Term Remedial Actions

CERCLA requires a site-specific risk assessment during the remedial investigation to establish risk-based cleanup levels. This includes considerations of "background" levels of chemicals present at a site, which can be highly variable across the country. Throughout the CERCLA process DoD coordinates with both EPA and state regulators and EPA and DoD jointly select remedies at National Priorities List sites. Accordingly, DoD will work with EPA and state regulators, as appropriate, to evaluate background levels of PFAS on a site-specific basis to determine a final cleanup level.

For remedial actions, the DoD Components will address drinking water down to the MCLs or background, in accordance with CERCLA, once the DoD Component has established levels of PFAS are below the MCLs, then DoD Components will take remedial actions to address PFAS that will meet the MCLs as the final cleanup levels.[6] If background levels of PFAS are found above an MCL at a site, DoD Components will work collaboratively with regulators and transparently with the public to determine the appropriate remedial goals (i.e., final cleanup levels) at that site.

(DoD 2024)

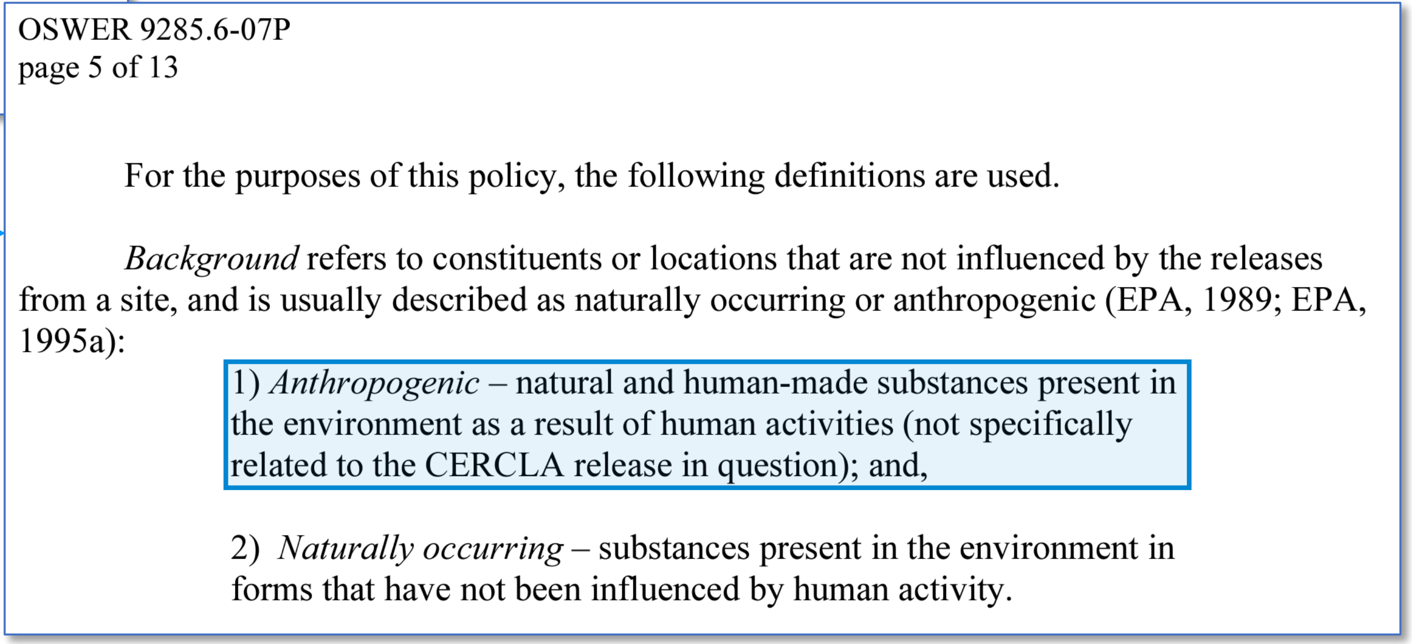
EPA Definition of Background



Role of Background in the CERCLA Cleanup Program

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Office of Emergency and Remedial Response
April 26, 2002
OSWER 9285.6-07P

(EPA 2002)



OSWER 9285.6-07P
page 5 of 13

For the purposes of this policy, the following definitions are used.

Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (EPA, 1989; EPA, 1995a):

1) *Anthropogenic* – natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question); and,

2) *Naturally occurring* – substances present in the environment in forms that have not been influenced by human activity.

(EPA 2002)

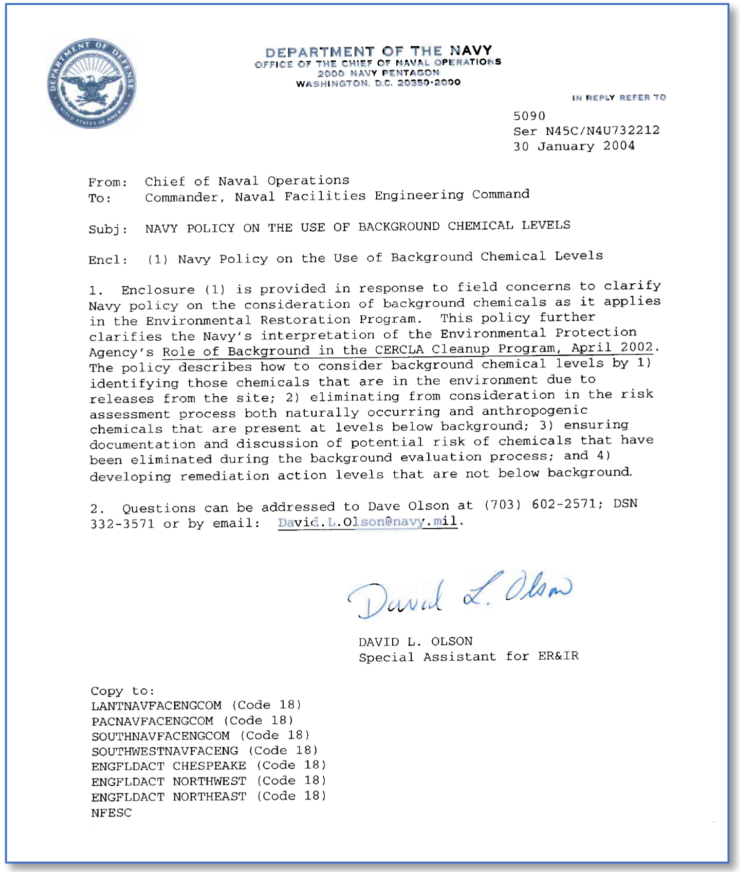
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
OSWER: Office of Solid Waste and Emergency Response

Definitions of Background PFAS

- **Anthropogenic PFAS** not related to the CERCLA site in question are defined as ***Background*** under OSWER 9285.6-07P
  - The term “Background” does apply to PFAS
- Background PFAS can potentially be from **nonpoint source(s) and/or point source(s)**
  - Nonpoint sources may include precipitation, urban runoff, runoff from agricultural land with biosolids application, etc.
  - The greatest concentrations may or may not be closest to background PFAS sources; therefore**, site-specific conditions should always be considered**

2004 Navy Policy on Background

- Key Points
  - Site chemical levels should be compared to background levels (this applies to PFAS)
  - **Site-related** COPCs are carried through to the **baseline risk assessment**
  - **Non-site-related** COPCs should be compared to risk-based screening benchmarks and **discussed in the risk characterization section**
  - **Site cleanup remedial goals are not set below background levels**



DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO
5090
Ser N45C/N4U732212
30 January 2004

From: Chief of Naval Operations
To: Commander, Naval Facilities Engineering Command

Subj: NAVY POLICY ON THE USE OF BACKGROUND CHEMICAL LEVELS

Encl: (1) Navy Policy on the Use of Background Chemical Levels

1. Enclosure (1) is provided in response to field concerns to clarify Navy policy on the consideration of background chemicals as it applies in the Environmental Restoration Program. This policy further clarifies the Navy's interpretation of the Environmental Protection Agency's Role of Background in the CERCLA Cleanup Program, April 2002. The policy describes how to consider background chemical levels by 1) identifying those chemicals that are in the environment due to releases from the site; 2) eliminating from consideration in the risk assessment process both naturally occurring and anthropogenic chemicals that are present at levels below background; 3) ensuring documentation and discussion of potential risk of chemicals that have been eliminated during the background evaluation process; and 4) developing remediation action levels that are not below background.

2. Questions can be addressed to Dave Olson at (703) 602-2571; DSN 332-3571 or by email: David.L.Olson@navy.mil.

David L. Olson

DAVID L. OLSON
Special Assistant for ER&IR

Copy to:
LANTNAVFACENGCOM (Code 18)
PACNAVFACENGCOM (Code 18)
SOUTHNAVFACENGCOM (Code 18)
SOUTHWESTNAVFACENG (Code 18)
ENGFLDACT CHESPEAKE (Code 18)
ENGFLDACT NORTHWEST (Code 18)
ENGFLDACT NORTHEAST (Code 18)
NFESC

(Navy 2004)

COPC(s): chemical(s) of potential concern

NAVFAC Background Guidance Documents

Human Health Risk Assessment	NAVFAC Resources on Human Health Risk Assessment Navy human health risk assessment policies and guidance including background
Background Chemicals	Navy Policy on the Use of Background Chemical Levels (January 2004) Clarifies the Navy's position on consideration of background chemical levels
Soil Background	NAVFAC Guidance for Environmental Background Analysis Volume I: Soil (April 2002) Provides instructions for characterizing background conditions at sites where past uses of the property have resulted in actual or suspected chemical releases to soil
Sediment Background	NAVFAC Guidance for Environmental Background Analysis: Volume II Sediment (April 2003) Provides instructions for the characterization of background conditions at sediment sites where past uses of the property may have resulted in chemical releases
Groundwater Background	NAVFAC Guidance for Environmental Background Analysis Volume III: Groundwater (April 2004) Provides instructions for characterizing groundwater background conditions and comparing datasets for impacted groundwater based on statistical methods and geochemical relationships
Indoor Air Background	NAVFAC Guidance for Environmental Background Analysis Volume IV: Vapor Intrusion Pathway (April 2011) Reviews methodologies for assessing potential background sources to indoor air as a part of the assessment of the vapor intrusion pathway

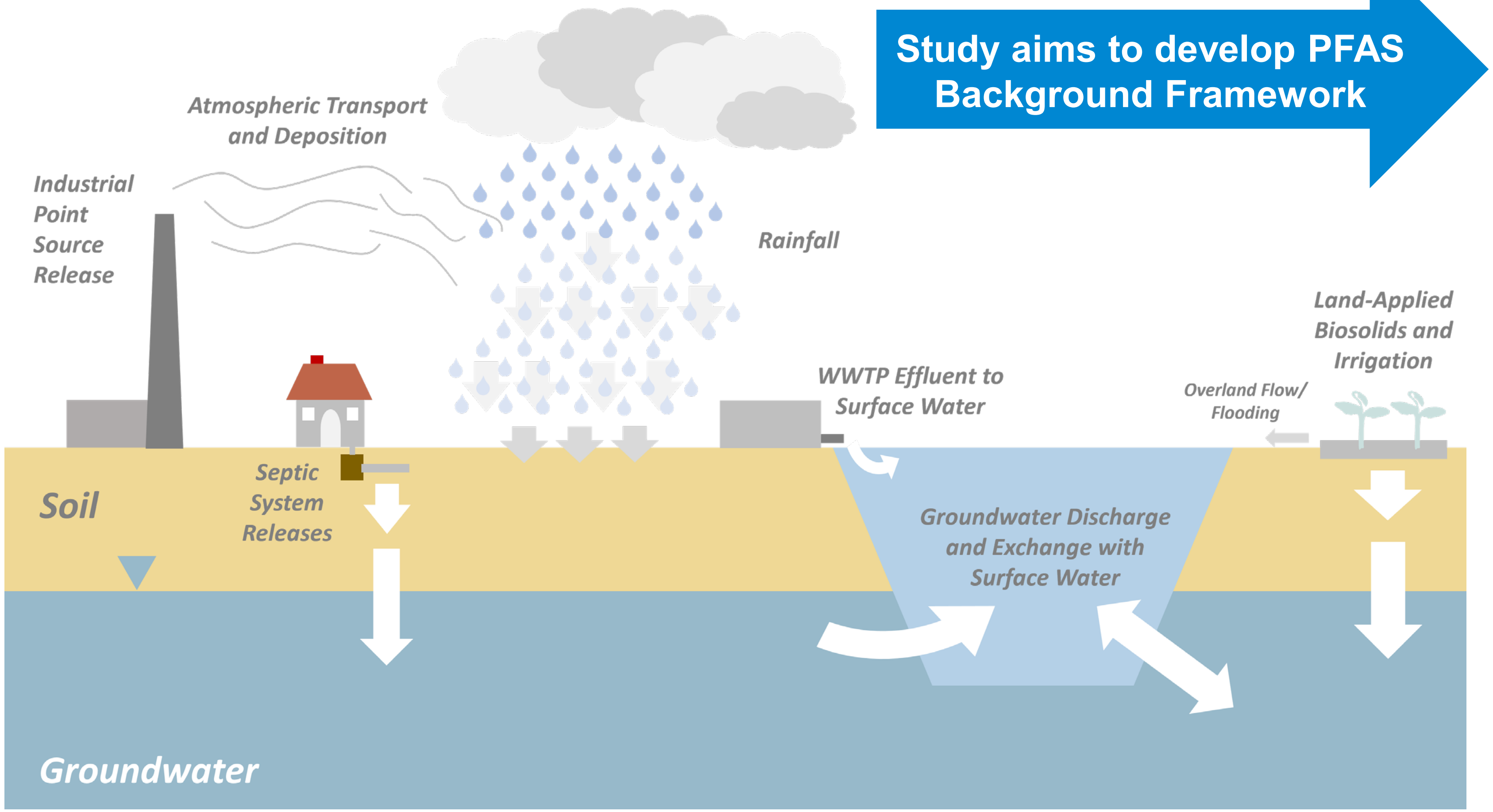
Background PFAS: Guidance and Research

- Guidance specific to conducting PFAS background studies has yet to be developed
- **ESTCP Project ER25-8813** aims to develop a framework for evaluating background PFAS
    - Joint effort by GSI, CDM Smith, and Colorado School of Mines (Dave Adamson is the Principal Investigator)
    - Project expected to begin soon

ESTCP: Environmental Security Technology Certification Program

ESTCP Project ER25-8813

Key Question – *How do we better identify the likely background sources of PFAS?*



Study aims to develop PFAS Background Framework

Key Elements *of Framework for Evaluating Background PFAS*

- How to develop PFAS-specific hypothesis testing and data quality objectives for the site
- Identifying potential regional and nonpoint source contributors to background PFAS
- Tiered approach for media-specific sampling and analysis plans, where higher tiers are associated with higher levels of effort
- Approaches for evaluating data to distinguish background sources and document contributions

Poll Questions 1–3 (Answers)

- Does the EPA definition of Background apply to PFAS?

  A) Yes B) No

- Does the 2004 Navy Policy on Background apply to PFAS?

  A) Yes B) No

- Will Background PFAS be a component of remedial decision-making at DoD facilities?

  A) Yes B) No

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Break

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Objective

- We will review peer-reviewed research articles that provide insights regarding the potential presence/sources of background PFAS

(Image from Microsoft Office)

Knowledge Pre-Check: Questions 4–6

- Can PFAS in precipitation exceed EPA MCLs?
  A) Yes B) No

- What sources of PFAS may contribute to background?
  A) Septic Tanks B) Biosolids C) Precipitation D) All of the above

- Will every PFAS background assessment rely on the same approach?
  A) Yes B) No

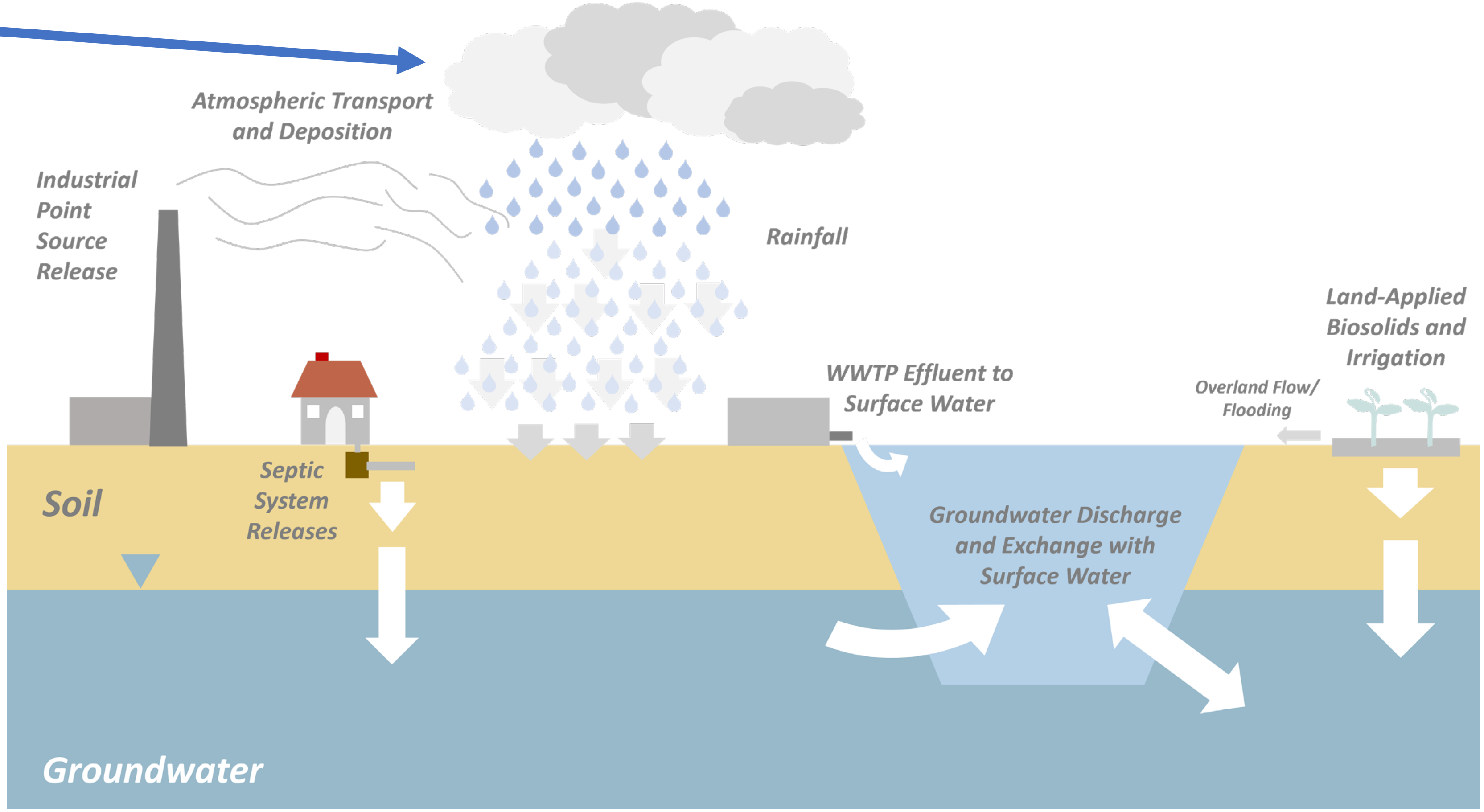
What Does the Scientific Literature Say?

- Can PFAS in precipitation exceed the EPA MCLs?
- What are some potential sources of background PFAS?
- What background concentration ranges might be observed?

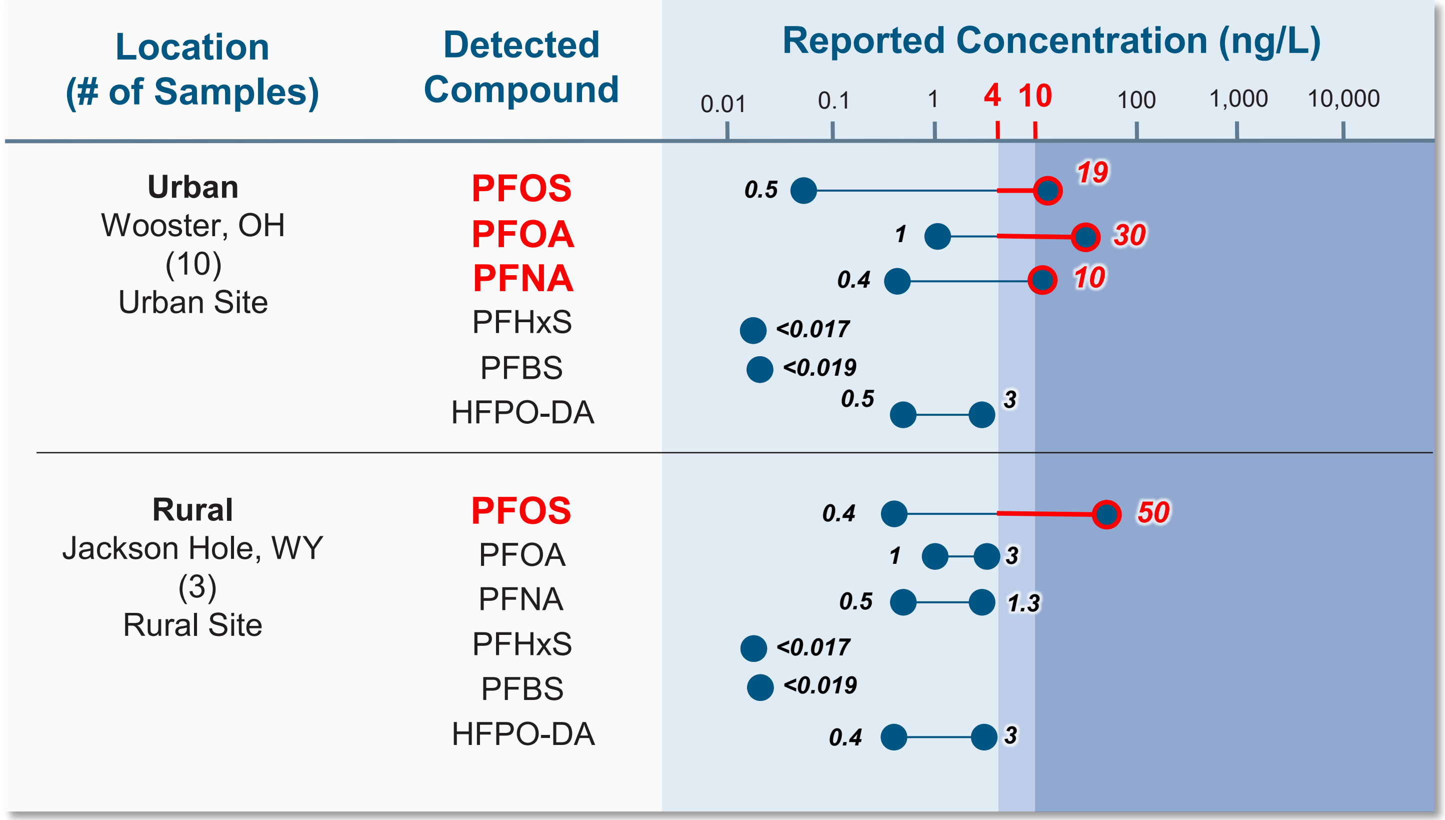
(Image from Microsoft Office)

PFAS in Precipitation

- Precipitation can be a source of background PFAS



Example Summary of PFAS in Precipitation



EPA MCL:
PFOS, PFOA = 4 ng/L
PFHxS, PFNA, HFPO-DA = 10 ng/L
Red Font = Precipitation Exceeds MCL

Data from:
Pike et al. (2021)

HFPO-DA: hexafluoropropylene oxide dimer acid
ND: nondetect

ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluoroctanesulfonic acid

PFHxS: perfluorohexanesulfonic acid
PFNA: perfluorononanoic acid

PFAS in Precipitation

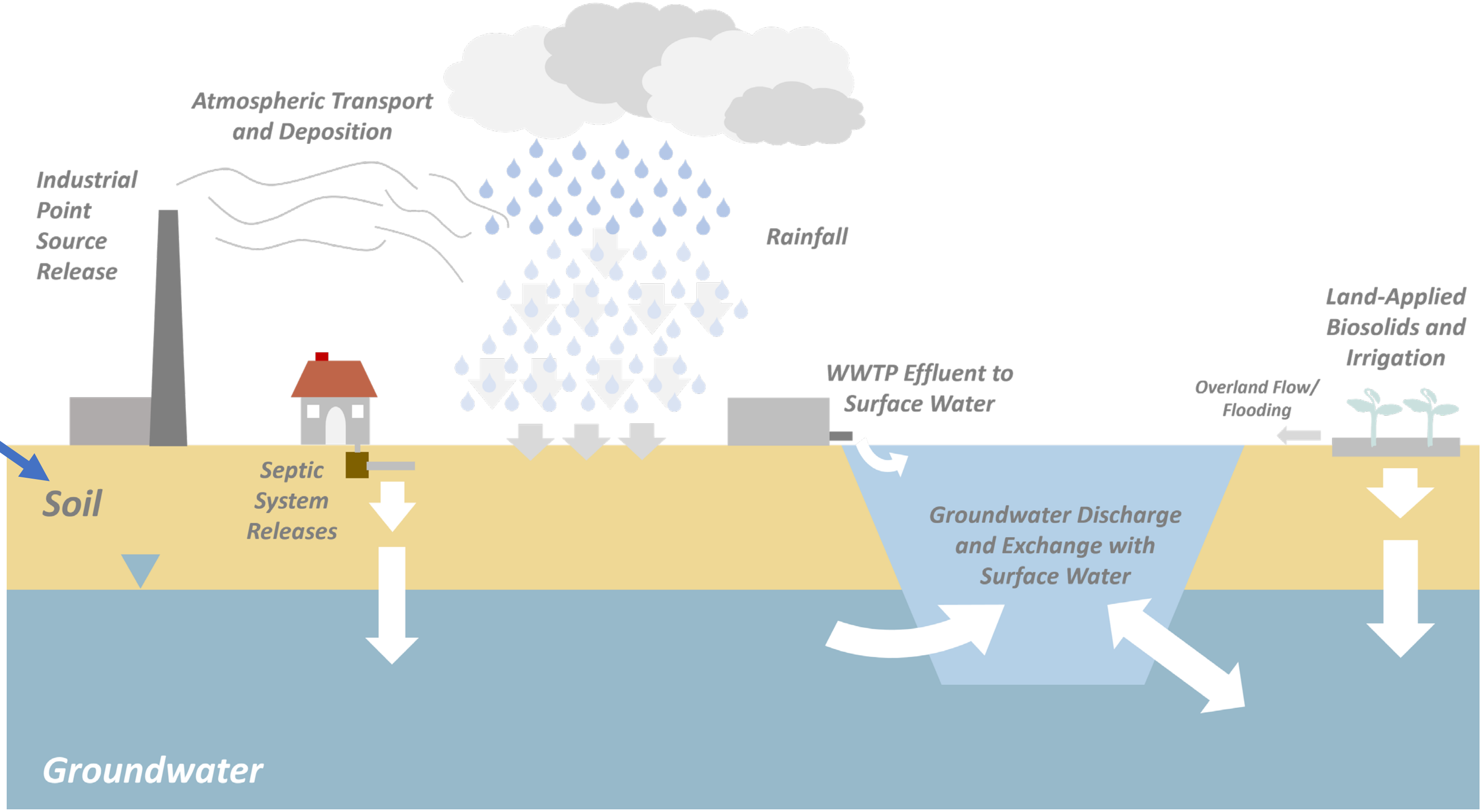
KEY POINT

PFAS in precipitation may exceed MCLs.

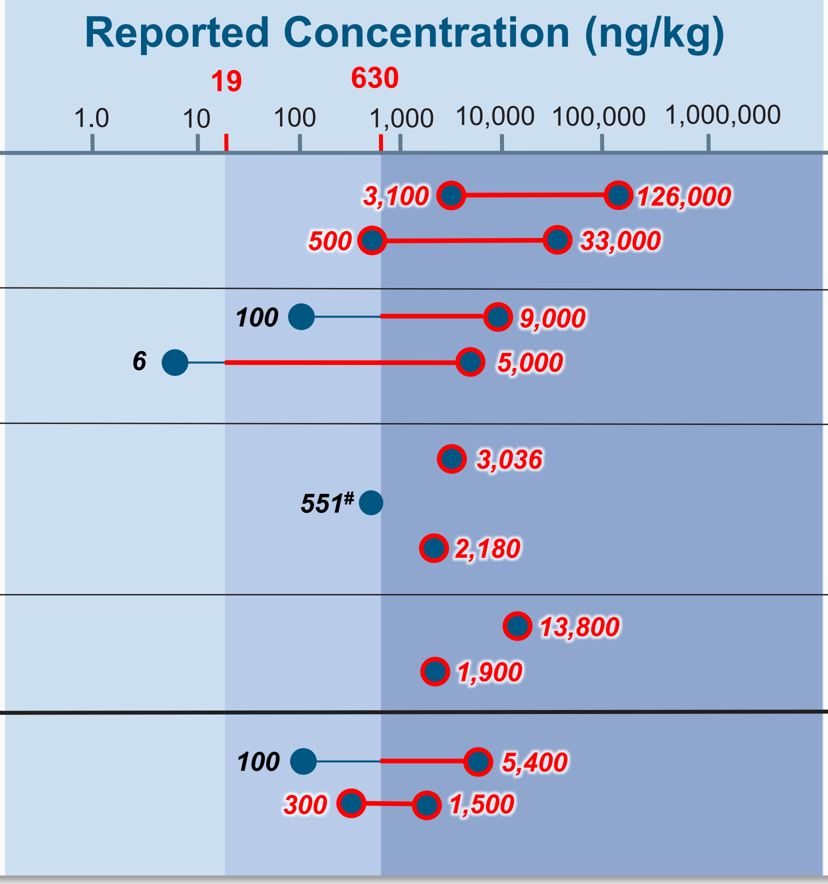
(Image from Microsoft Office)

Background PFAS in Soil

- Soil can be affected by background PFAS



Summary of Select Soil Background Studies



Reference	Detected Compound	Reported Concentration (ng/kg)	Location	Range or Threshold Value
Brusseau et al. (2020)	**PFOS** **PFOA**	3,100 – 126,000 500 – 33,000	United States (5 locations)	Range of Max C's for PFOS & PFOA
Zhu et al. (2022)	**PFOS** **PFOA**	100 – 9,000 6 – 5,000	Vermont	Range >40% detection frequency at 66 locations
Sanborn, Head & Assoc. (2022)	**PFOS** (urban) **PFOS** (non-urban) **PFOA**	3,036 551# 2,180	Maine	Threshold 95% Upper Tolerance Limit with 95% Coverage UTL90-95#
Anderson and Modiri (2024)	**PFOS** **PFOA**	13,800 1,900	DoD Study	Threshold (Max) Threshold (Min)
Brousseau et al. (2020)	**PFOS** **PFOA**	100 – 5,400 300 – 1,500	Tierra Del Fuego, & Antarctica (1), Nepal (1)	Range of Max C's for PFOS & PFOA

EPA November 2024 Residential Soil RSL: PFOA = 19 ng/kg, PFOS = 630 ng/kg

Red Font = Background Exceeds RSL

ng/kg: nanogram(s) per kilogram

RSL: regional screening level

PFAS in Soil

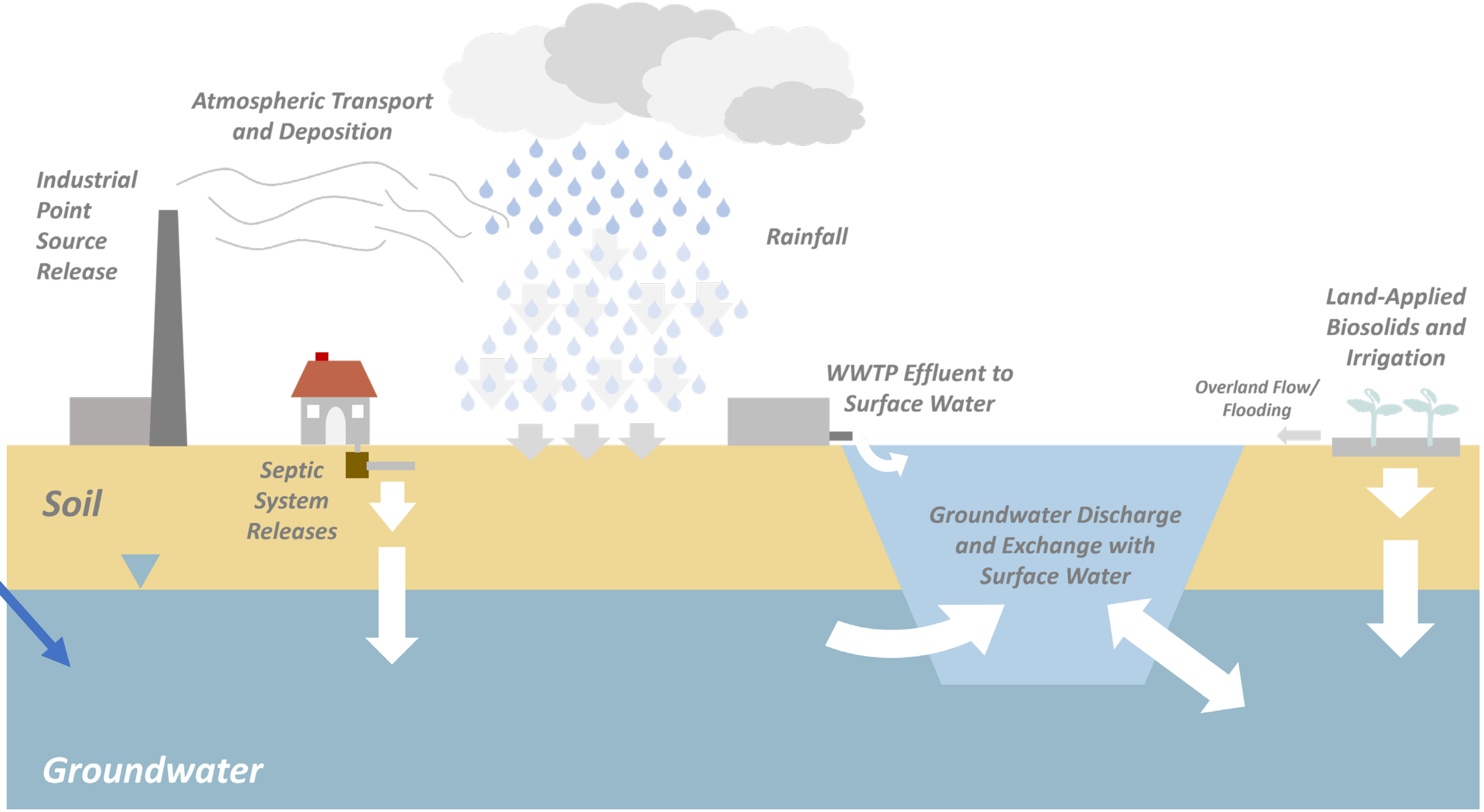
KEY POINT

Background PFAS in soil may exceed RSLs.

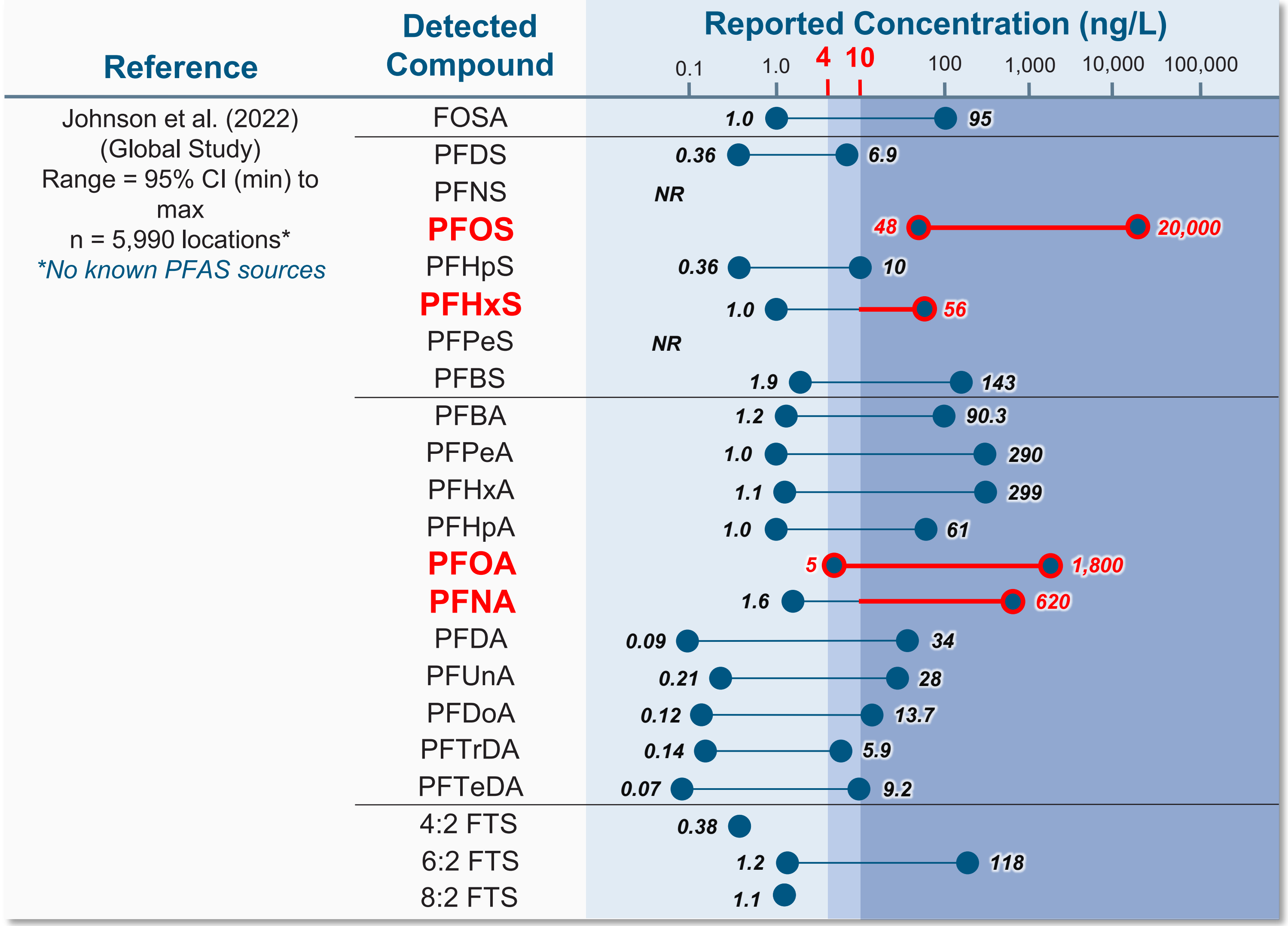
(Image from Microsoft Office)

Background PFAS in Groundwater

- Groundwater can be affected by background PFAS



Global Groundwater Background Study



Reference	Detected Compound	Reported Concentration (ng/L)	
Johnson et al. (2022) (Global Study) Range = 95% CI (min) to max n = 5,990 locations* **No known PFAS sources*	FOSA	1.0	95
	PFDS	0.36	6.9
	PFNS	NR	
	PFOS	48	20,000
	PFHpS	0.36	10
	PFHxS	1.0	56
	PFPeS	NR	
	PFBS	1.9	143
	PFBA	1.2	90.3
	PFPeA	1.0	290
	PFHxA	1.1	299
	PFHpA	1.0	61
	PFOA	5	1,800
	PFNA	1.6	620
	PFDA	0.09	34
	PFUnA	0.21	28
	PFDoA	0.12	13.7
	PFTrDA	0.14	5.9
	PFTeDA	0.07	9.2
	4:2 FTS	0.38	
	6:2 FTS	1.2	118
	8:2 FTS	1.1	

EPA MCL:
PFOS, PFOA = 4 ng/L
PFHxS, PFNA = 10 ng/L
Red Font = Background Exceeds MCL

CI: Confidence Interval

PFAS in Groundwater

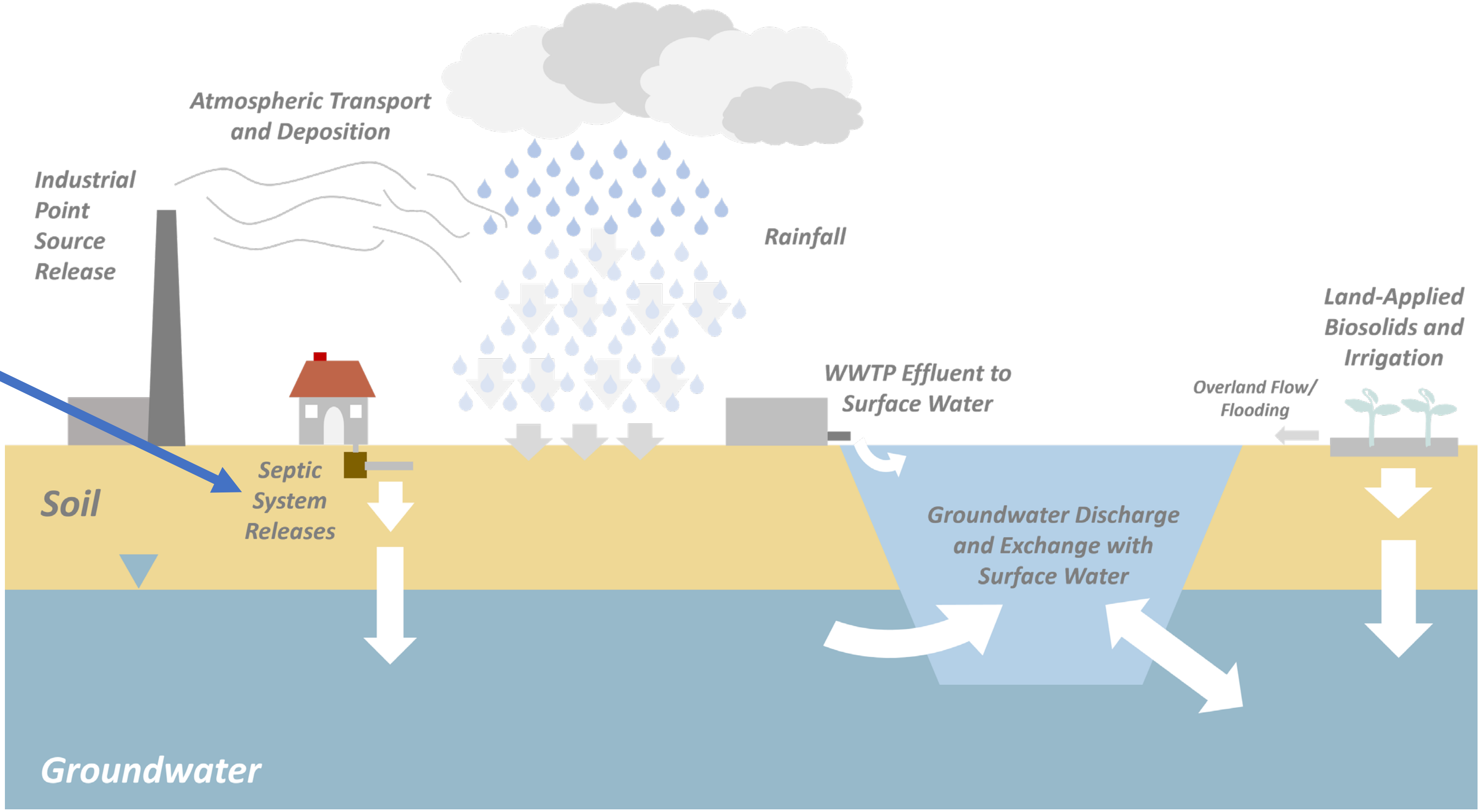
KEY POINT

Background PFAS in groundwater may exceed MCLs.

(Image from Microsoft Office)

Example of Background PFAS Source

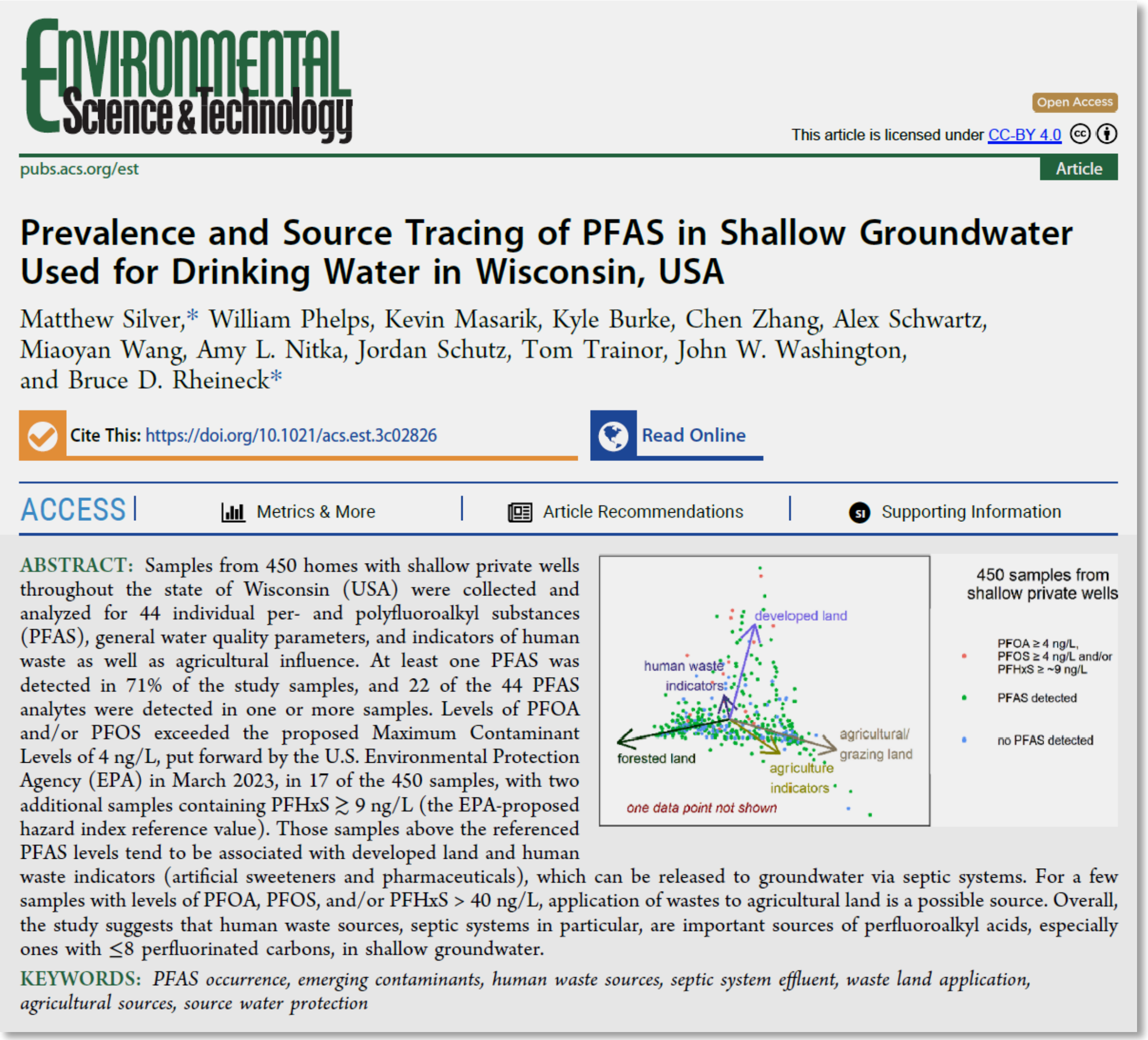
- Septic systems can be a source of background PFAS



Example of PFAS from Septic Tanks

- Samples from 450 private wells **more than 3 miles** from Wisconsin DNR sites with actionable PFAS concentrations

- **"Those samples above the referenced PFAS levels tend to be associated with developed land and human waste indicators (artificial sweeteners and pharmaceuticals)**, which can be released to groundwater via septic tanks."



ENVIRONMENTAL Science & Technology

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Article

Prevalence and Source Tracing of PFAS in Shallow Groundwater Used for Drinking Water in Wisconsin, USA

Matthew Silver,* William Phelps, Kevin Masarik, Kyle Burke, Chen Zhang, Alex Schwartz, Miaoyan Wang, Amy L. Nitka, Jordan Schutz, Tom Trainor, John W. Washington, and Bruce D. Rheineck*

Cite This: https://doi.org/10.1021/acs.est.3c02826

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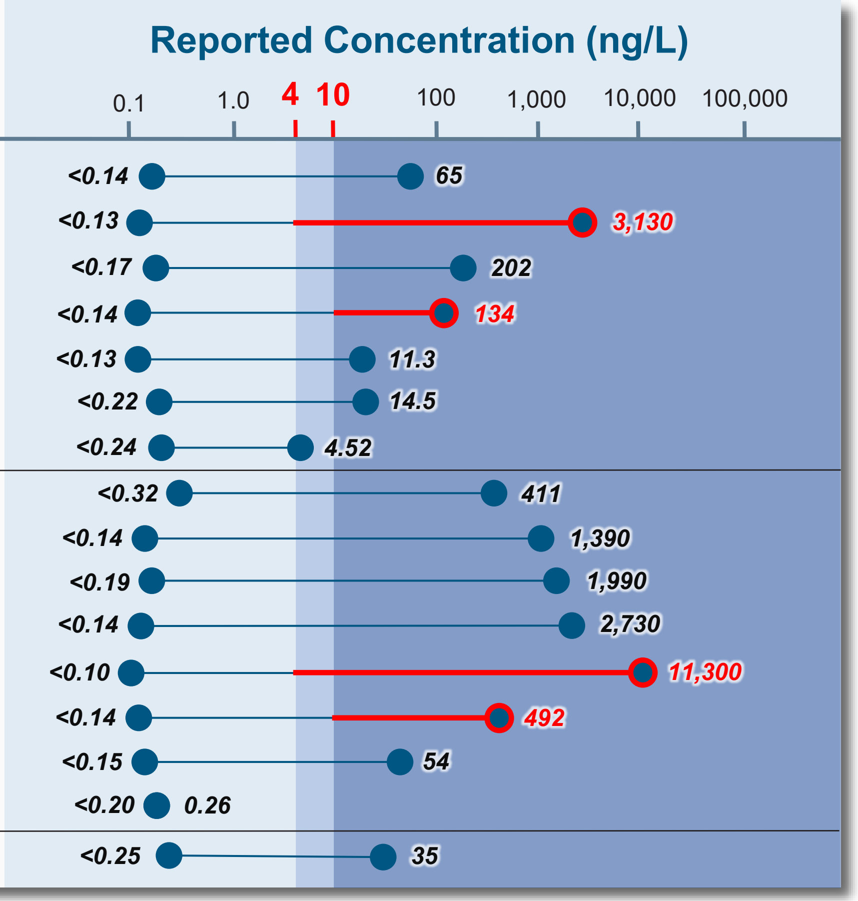
ABSTRACT: Samples from 450 homes with shallow private wells throughout the state of Wisconsin (USA) were collected and analyzed for 44 individual per- and polyfluoroalkyl substances (PFAS), general water quality parameters, and indicators of human waste as well as agricultural influence. At least one PFAS was detected in 71% of the study samples, and 22 of the 44 PFAS analytes were detected in one or more samples. Levels of PFOA and/or PFOS exceeded the proposed Maximum Contaminant Levels of 4 ng/L, put forward by the U.S. Environmental Protection Agency (EPA) in March 2023, in 17 of the 450 samples, with two additional samples containing PFHxS ≳ 9 ng/L (the EPA-proposed hazard index reference value). Those samples above the referenced PFAS levels tend to be associated with developed land and human waste indicators (artificial sweeteners and pharmaceuticals), which can be released to groundwater via septic systems. For a few samples with levels of PFOA, PFOS, and/or PFHxS > 40 ng/L, application of wastes to agricultural land is a possible source. Overall, the study suggests that human waste sources, septic systems in particular, are important sources of perfluoroalkyl acids, especially ones with ≤8 perfluorinated carbons, in shallow groundwater.

KEYWORDS: *PFAS occurrence, emerging contaminants, human waste sources, septic system effluent, waste land application, agricultural sources, source water protection*

(Silver et al. 2023)

DNR: Department of Natural Resources

PFAS in Groundwater near Septic Sources



Reference	Detected Compound	Reported Concentration (ng/L)	
Silver et al. (2023) (Wisconsin Septic Sites) n = 40 locations	FOSA	<0.14	65
	PFOS	<0.13	3,130
	PFHpS	<0.17	202
	PFHxS	<0.14	134
	PFPeS	<0.13	11.3
	PFBS	<0.22	14.5
	PFPrS	<0.24	4.52
	PFBA	<0.32	411
	PFPeA	<0.14	1,390
	PFHxA	<0.19	1,990
	PFHpA	<0.14	2,730
	PFOA	<0.10	11,300
	PFNA	<0.14	492
	PFDA	<0.15	54
	PFUnA	<0.20	0.26
	6:2 FTS	<0.25	35

EPA MCL:
PFOS, PFOA = 4 ng/L
PFHxS, PFNA = 10 ng/L
Red Font = Background Exceeds MCL

PFAS From Septic Sources

KEY POINT

Septic sources can contribute to background.

(Image from Microsoft Office)

Poll Questions 4–6 (Answers)

- Can PFAS in precipitation exceed EPA MCLs?

  A) Yes B) No

- What sources of PFAS may contribute to background?

  A) Septic Tanks B) Biosolids C) Precipitation **D) All of the above**

- Will every PFAS background assessment rely on the same approach?

  A) Yes **B) No**

Objective

- We will review key factors for assessing background PFAS

(Image from Microsoft Office)

Knowledge Pre-Check: Questions 7–9

- Adjacent land use should be considered when evaluating background PFAS?

  A) Yes B) No

- Non-PFAS markers may help identify background PFAS?

  A) Yes B) No

- Site-specific factors should be considered when selecting the Background Reference Area(s)?

  A) Yes B) No

Adjacent Land Use

Increased Potential for Background PFAS

- Adjacent land use with known or suspected PFAS use
- For example, biosolids application, septic tanks, AFFF use, wastewater treatment, landfills, metal plating, etc.

Information presented is not all inclusive and site-specific factors should be assessed.

(Image from Microsoft Office)

AFFF: Aqueous Film Forming Foam

Local and Regional Transport Mechanisms

Increased Potential for Background PFAS

- Potential PFAS migration pathways from precipitation, air deposition, upstream surface water, and/or upgradient groundwater

Information presented is not all inclusive and site-specific factors should be assessed.

(Image from Microsoft Office)

Vadose Zone Retention

Increased Potential for Background PFAS

- Increased soil retention increases likelihood of background soil PFAS and potentially decreases likelihood of background PFAS for groundwater and surface water
- PFAS soil retention increases with organic carbon, NAPL, multivalent cations, salinity, decreased saturation, etc.

Information presented is not all inclusive and site-specific factors should be assessed.

(Image from Microsoft Office)

NAPL: nonaqueous phase liquid

Surface Water/Groundwater Connectivity

Increased Potential for Background PFAS

- Long-range surface water transport through PFAS-susceptible environments (e.g., biosolids areas, urban/suburban runoff)
- Discharge to groundwater via a losing stream or via artificial recharge to groundwater
- Enhanced migration due to pumping wells
- Potential retention and/or dispersion within floodplains and wetlands

Information presented is not all inclusive and site-specific factors should be assessed.

(Image from Microsoft Office)

Natural Hazard-Related Trends

Increased Potential for Background PFAS

- Flooding and/or rising water tables may mobilize PFAS from point or nonpoint sources
- Prolonged drought and blowing dust (e.g., from biosolids areas) could potentially mobilize PFAS

Information presented is not all inclusive and site-specific factors should be assessed.

(Image from Microsoft Office)

USGS Studies Predicting PFAS in Groundwater

- USGS correlated non-PFAS chemical markers to the occurrence of PFAS (McMahon et al. 2022 and Tokranov et al. 2024)
- Chemical markers may be helpful for assessing PFAS background
  - Higher concentrations of tritium (“age”), chloride, sulfate, DOC, Mn, and Fe
  - Higher percentage of urban land use within 500 meters of the wells
  - Higher VOC and pharmaceutical detection frequencies
  - Estimated nitrogen loading from septic systems
  - Higher average annual natural groundwater recharge
  - Decreased depth to water

DOC: dissolved organic carbon
Fe: iron
Mn: manganese

USGS: United States Geological Survey
VOC: volatile organic compound

Poll Questions 7–9 (Answers)

- Adjacent land use should be considered when evaluating background PFAS?

  A) Yes B) No

- Non-PFAS markers may help identify background PFAS?

  A) Yes B) No

- Site-specific factors should be considered when selecting the Background Reference Area(s)?

  A) Yes B) No

Presentation Overview

- Part 1: Introduction to the PFAS Analyte List
- Part 2: PFAS Forensics: Fate and Transport Considerations
- Part 3: PFAS Background Definitions
- Part 4: Key Considerations for Assessing Background PFAS
    - Lunch Break
- Part 5: Putting it All Together: Source Areas vs. Background
- Part 6: NAVFAC PFAS Background Case Study
- Wrap-Up

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Lunch Break

Welcome Back

(Image from Microsoft Office)

Presentation Overview

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- Wrap-Up

Objectives

- Explain how to identify PFAS data patterns that can be used to identify source areas
- Explain how PFAS fate and transport mechanisms can affect PFAS patterns over time/distance
- An example will be presented of how to
  - Identify PFAS source areas
  - Consider whether background PFAS may be contributing to observed PFAS concentrations

Knowledge Pre-Check: Questions 10–12

- Is AFFF the only source of PFAS?

  A) Yes B) No

- PFAS patterns in soil will be identical to PFAS patterns in groundwater?

  A) Yes B) No

- Retention and precursor transformation will affect PFAS patterns?

  A) Yes B) No

Source Area Identification vs. Background

- It is important to understand **patterns associated with PFAS source areas versus those from background PFAS**
  - Is the observed PFAS from a site release or from background?
  - What PFAS-specific trends are expected to be observed as PFAS migrates through environmental media?
  - **What PFAS patterns may be useful to identify when an additional PFAS source is present?**

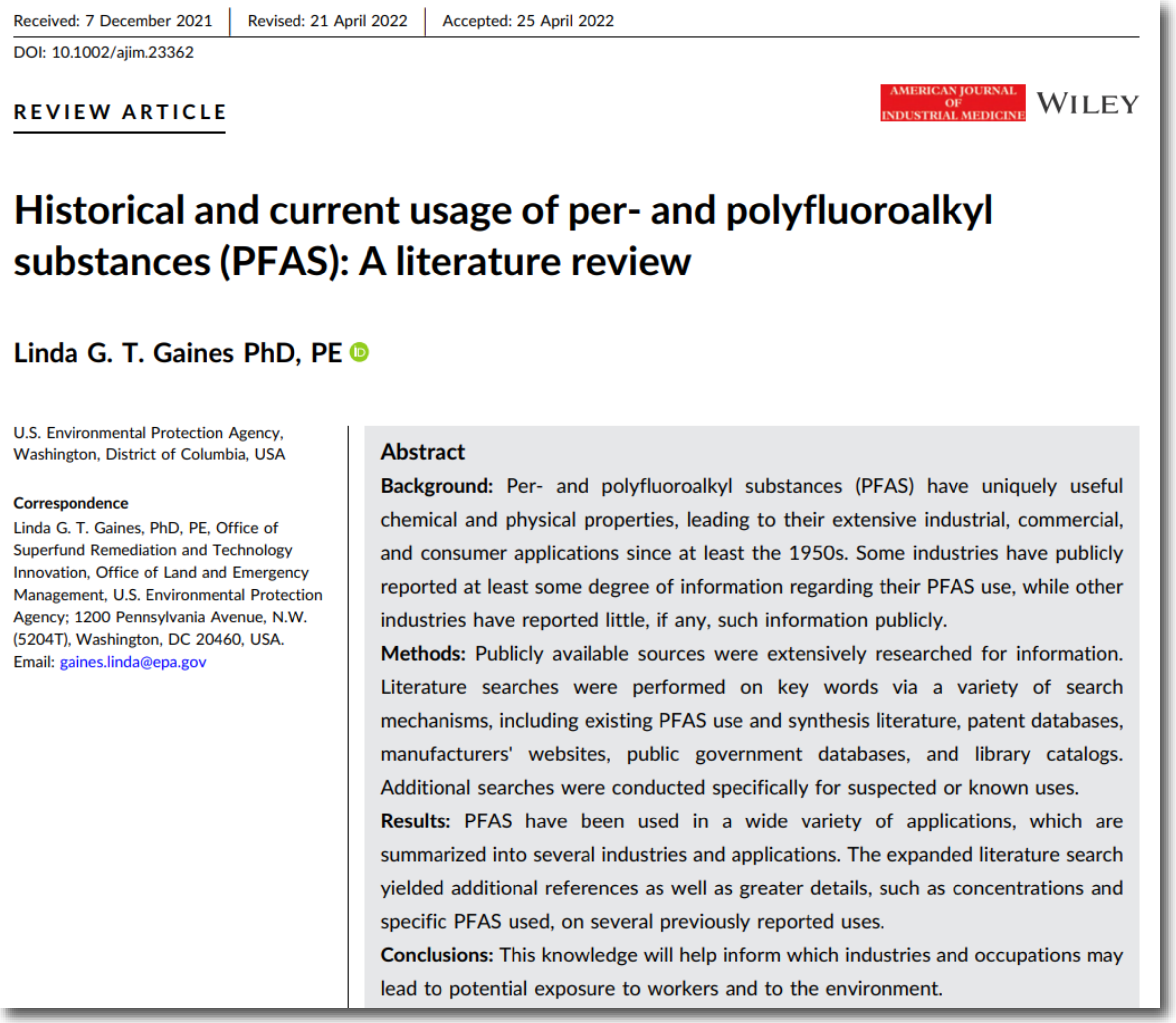
KEY POINT

General principles of source area identification for other chemicals can apply to PFAS—we just need to know what to look for.

What are Potential Sources of PFAS?

- It is important to be aware of all potential sources of PFAS when conducting investigation and remediation activities
- Potential for background PFAS sources may exist near DoD facilities
  - Literature indicates there are numerous potential PFAS sources that could contribute to background
  - Adjacent land use and other factors should be considered during the site-specific sampling design prior to assessing Background PFAS

(Gaines 2022)



Received: 7 December 2021 | Revised: 21 April 2022 | Accepted: 25 April 2022
DOI: 10.1002/ajim.23362

REVIEW ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Historical and current usage of per- and polyfluoroalkyl substances (PFAS): A literature review

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Abstract

Background: Per- and polyfluoroalkyl substances (PFAS) have uniquely useful chemical and physical properties, leading to their extensive industrial, commercial, and consumer applications since at least the 1950s. Some industries have publicly reported at least some degree of information regarding their PFAS use, while other industries have reported little, if any, such information publicly.

Methods: Publicly available sources were extensively researched for information. Literature searches were performed on key words via a variety of search mechanisms, including existing PFAS use and synthesis literature, patent databases, manufacturers' websites, public government databases, and library catalogs. Additional searches were conducted specifically for suspected or known uses.

Results: PFAS have been used in a wide variety of applications, which are summarized into several industries and applications. The expanded literature search yielded additional references as well as greater details, such as concentrations and specific PFAS used, on several previously reported uses.

Conclusions: This knowledge will help inform which industries and occupations may lead to potential exposure to workers and to the environment.

Literature Review of Potential PFAS "Sources"

Priority

- **AFFF**

Common Sources

- **Metal Plating and Machining**
- **Landfills**
- **Septage and Wastewater**
  - **Personal Care Products and Cosmetics**
- **Paper and Packaging Products**
- **Textiles and Carpets**

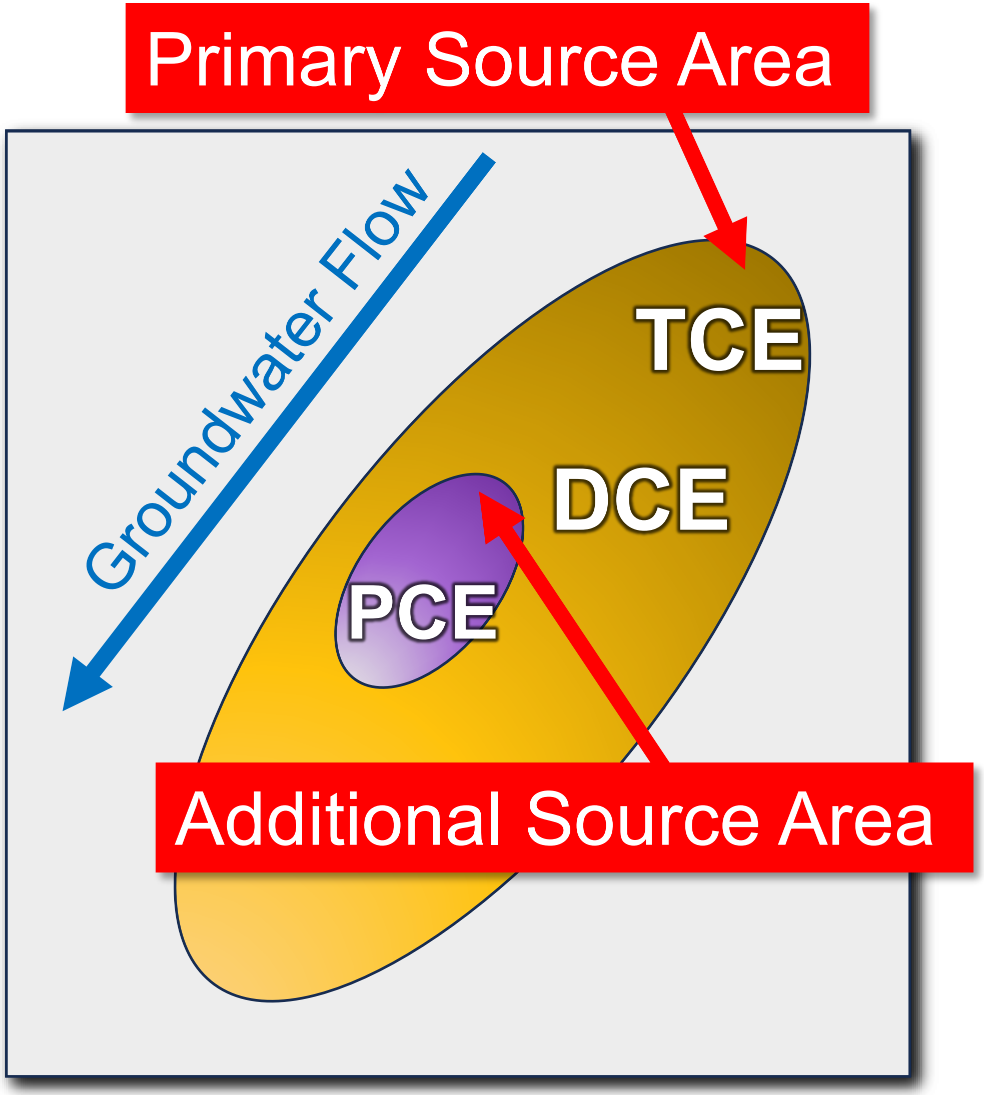
Modified from Glüge et al. (2020) and Gaines (2022) – this list is not intended to be all inclusive and may not be applicable in some cases

Other Sources

- Pesticides and Herbicides
- Dry Cleaning
- Coatings and Adhesives
- Cleaning Agents and Waxes
- Transportation Industry
- Plastics and Rubbers
- Printing, Etching, and Photography
- Medical Sector
- Electronics and Energy Sector
- Building and Construction Industry
- Mining, Oil, and Gas

Lessons Learned from Chlorinated Solvents

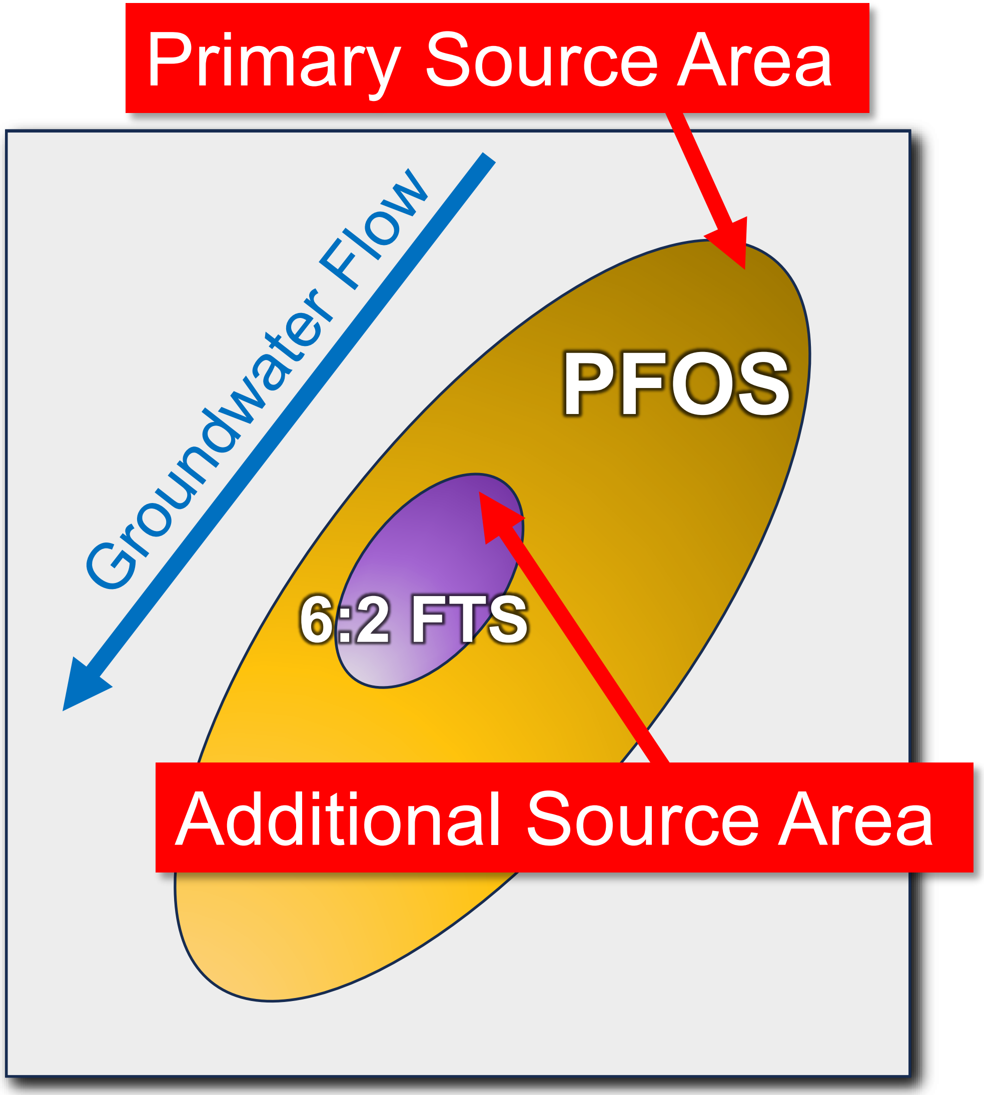
- **Imagine a TCE source area where PCE is subsequently detected downgradient of the primary TCE source area**
  - We know the transformation pathway follows this logic:
    PCE → TCE → DCE → vinyl chloride
  - Based on expected chemical patterns, the downgradient PCE area is likely a separate source (assuming no preferential pathways, etc.)



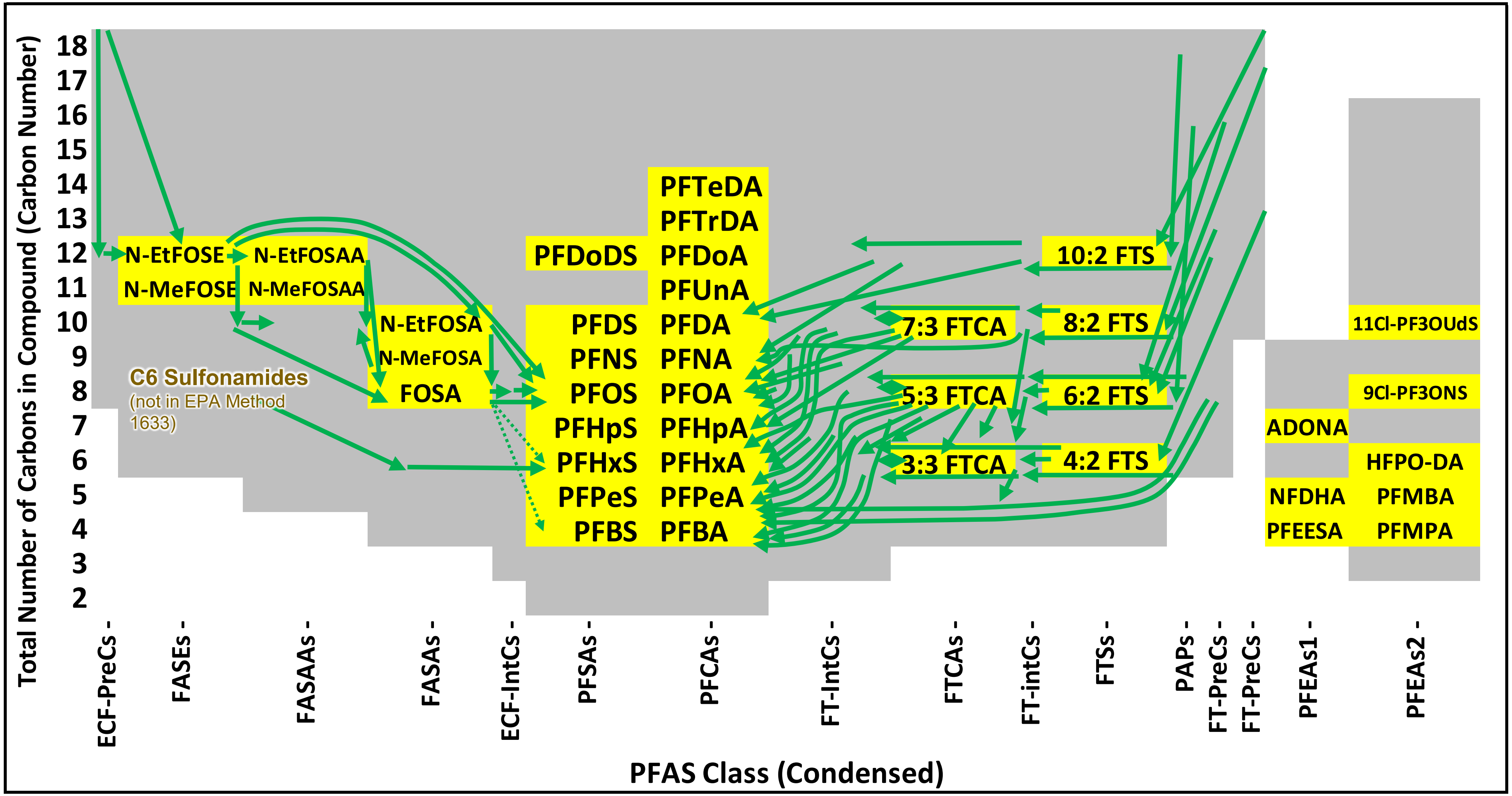
DCE: dichloroethylene (e.g., cis-1,2-DCE)
PCE: tetrachloroethylene
TCE: trichloroethylene

ECF-based vs. FT-based AFFF Source Areas

- **Some PFAS-containing products have chemical patterns that can be used in a similar way**
  - For example, ECF-based products (with PFOS) can have different PFAS signatures compared to FT-based products (with identifiable compounds such as 6:2 FTS)
  - We will explore this in more detail in subsequent slides



Precursor Transformation and Retention

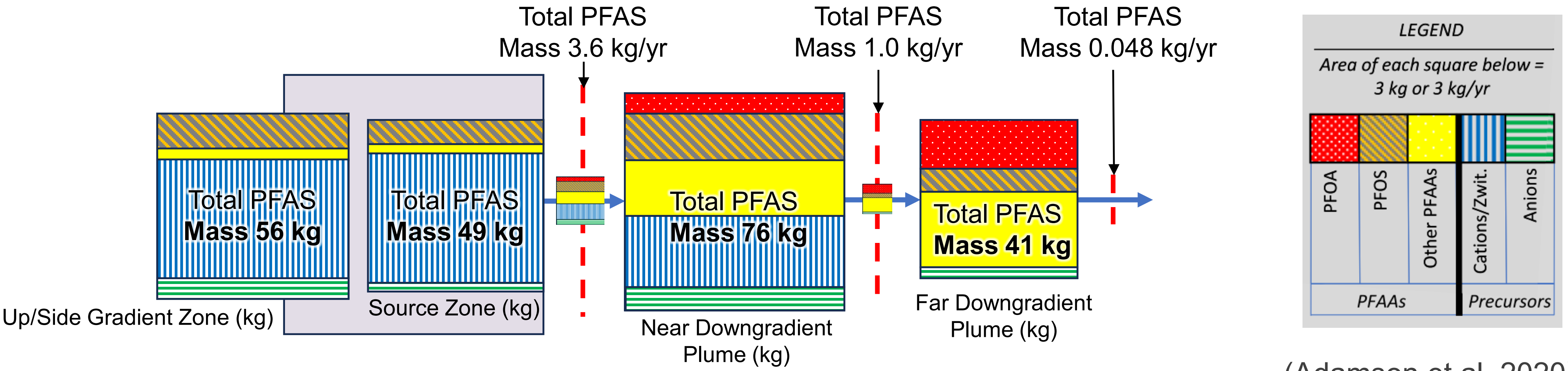


Greater Retention

Less Retention

Spatial Distribution of PFAS

- Precursors & long-chain PFAAs tend to stay closer to source area
- Short-chain PFAAs tend to migrate farther from the source area
- PFCAs tend to migrate farther than PFSAs of similar chain length



(Adamson et al. 2020)

Soil vs. Groundwater PFAS Patterns

- Observed soil PFAS patterns are often different than underlying groundwater patterns from same source area
  - **Longer-chain PFAS and precursors** (i.e., PFAS with higher carbon numbers) **tend to be preferentially retained in soil compared to groundwater**, which may lead to different soil vs. groundwater patterns
  - PFAS patterns should be evaluated using multiple lines of evidence with consideration for expected compound-specific fate and transport effects

KEY POINT

PFAS patterns being different in soil versus groundwater does not exclude the PFAS being from the same source.

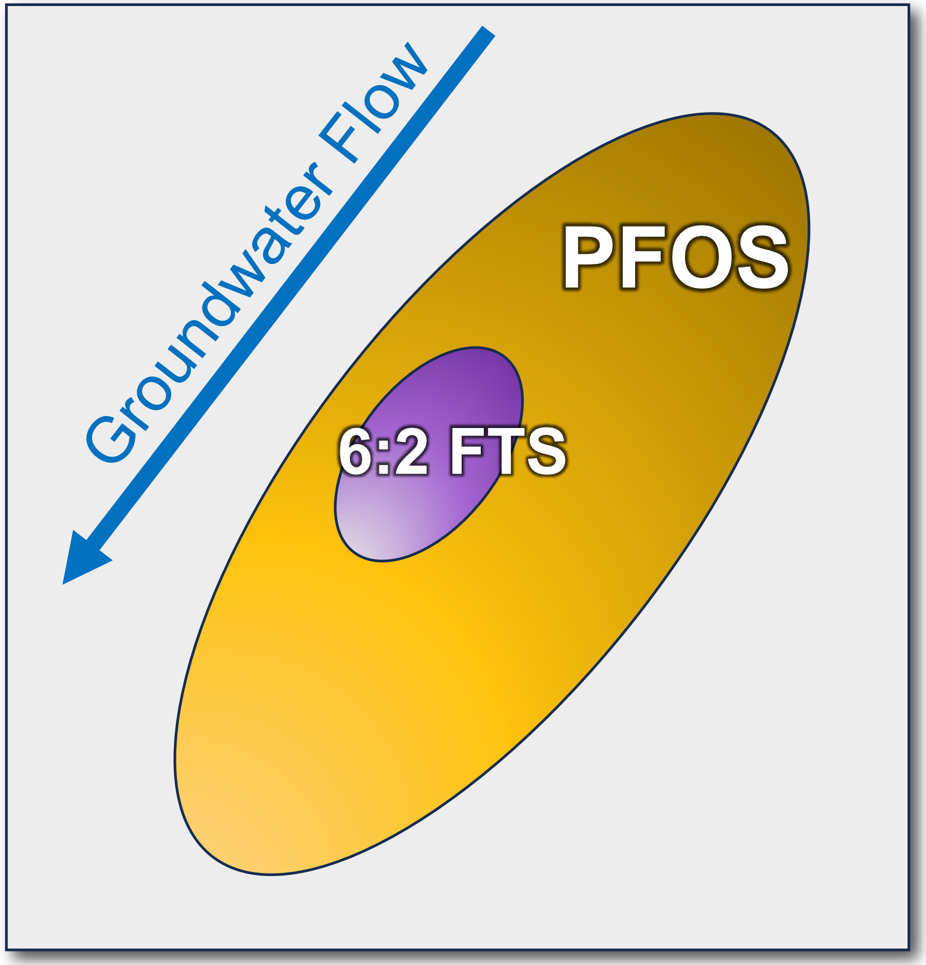
PFAS Forensics Considerations

- The ratios and metrics described in the subsequent slides are based on potentially relevant PFAS fate and transport mechanisms, as described in Gamlin et al. (2024)
- This approach may **aid in identifying potential PFAS source areas** and is based on the standard EPA Method 1633 analyte lists
- Some PFAS used in this approach may not have toxicity values, and **the ratios and metrics presented do not represent a quantification of risk**

PFAS Forensics Considerations

Example 1: Understanding PFAS Classes

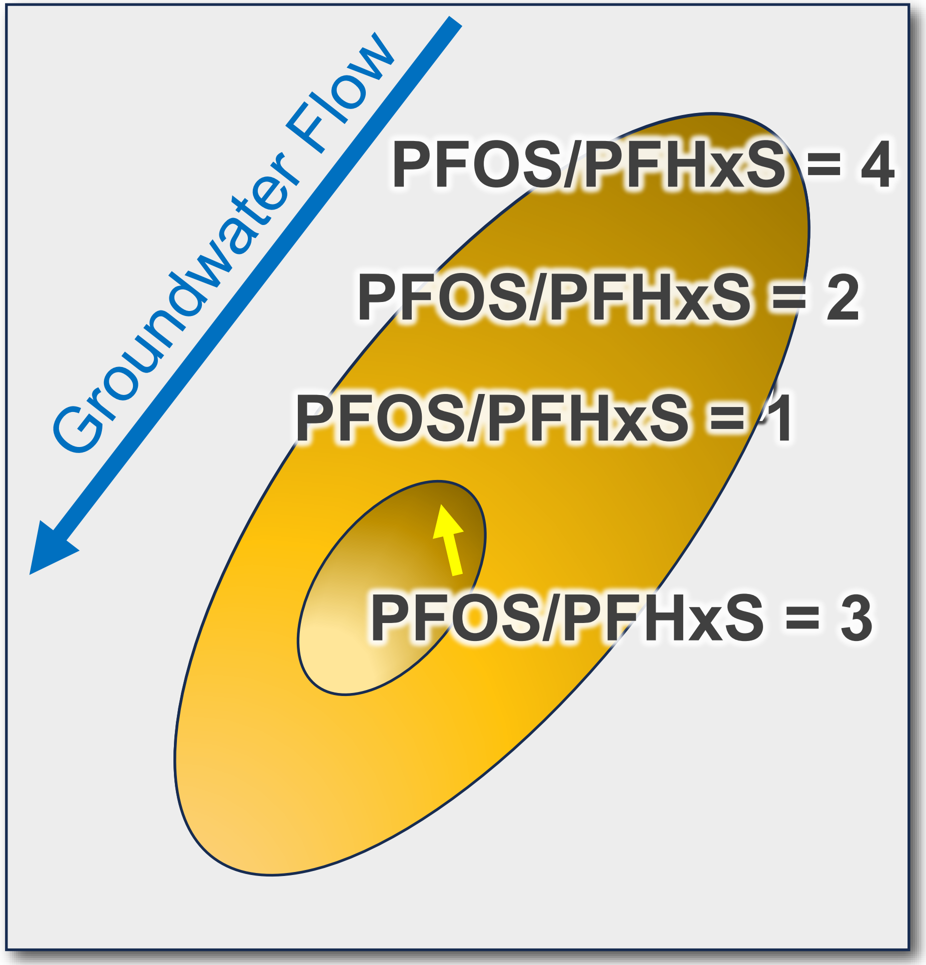
- Certain PFAS can be used to identify different AFFF products released within a mixed AFFF groundwater plume
- In this example, the upgradient plume is dominated by PFOS from an ECF AFFF source zone
- Assuming no preferential pathways, the downgradient detection of 6:2 FTS (not from ECF AFFF) in groundwater may indicate a separate AFFF release area (this should be confirmed with other lines of evidence)



PFAS Forensics Considerations

Example 2: Understanding PFAS Ratios

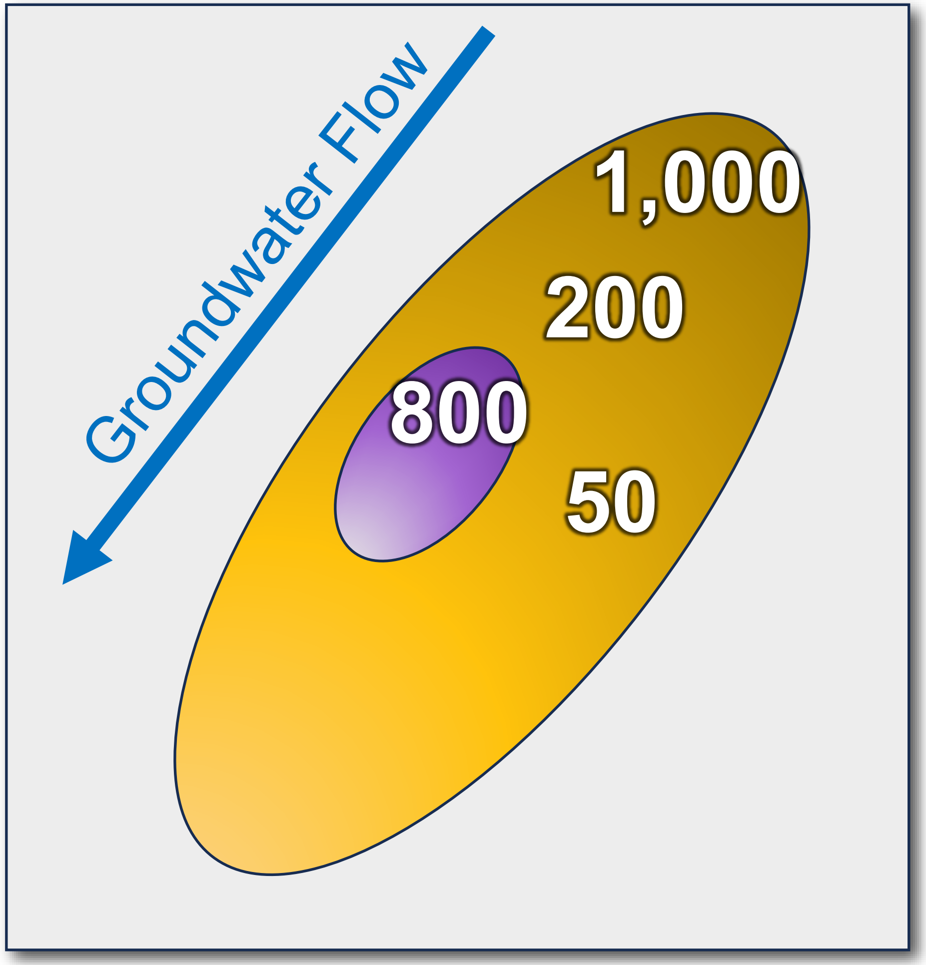
- The ratio of PFOS/PFHxS typically decreases along a flow path, as PFOS and its precursors are preferentially retained compared to PFHxS and its precursors (see Gamlin et al. 2024)
- In this example, the PFOS/PFHxS ratio decreases from 4 to 2 to 1, and then farther downgradient it increases to 3
- Assuming no preferential pathways, the downgradient increase in the PFOS/PFHxS ratio may indicate a separate downgradient source area (this should be confirmed with other lines of evidence, such as overall concentrations, etc.)



PFAS Forensics Considerations

Example 3: Understanding Sum of PFAS

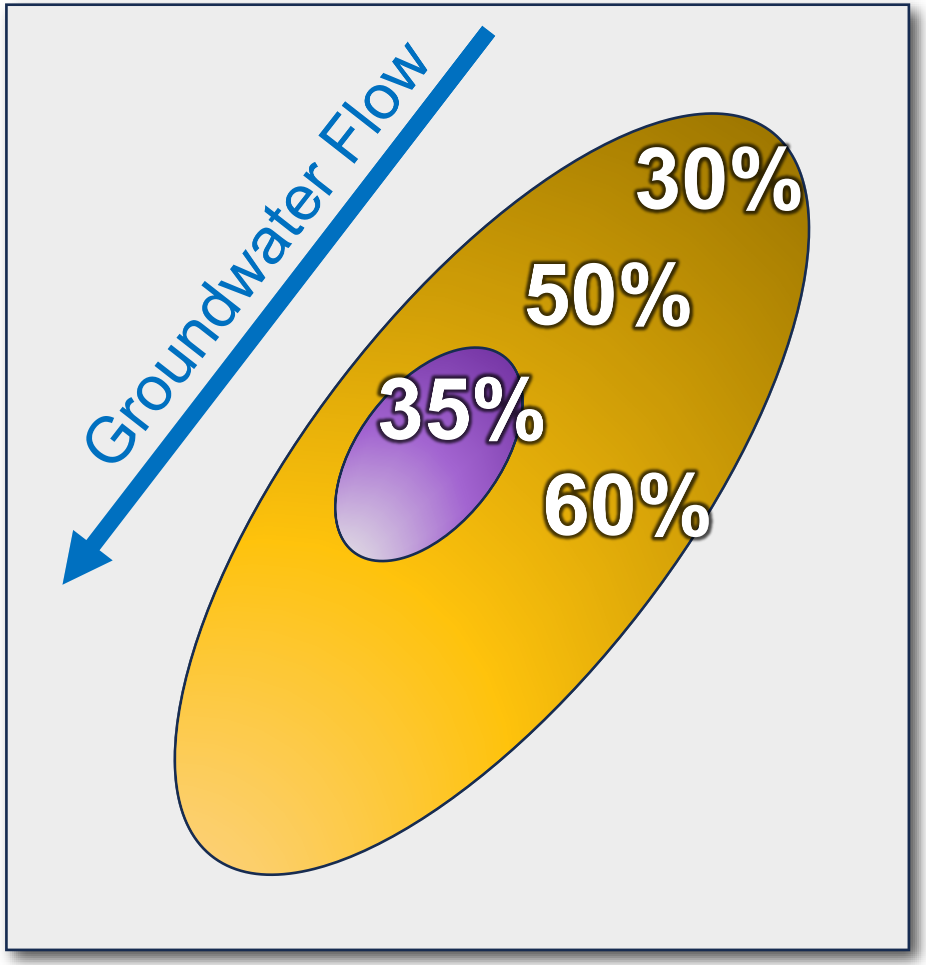
- Does not indicate risk, just a tool for helping to identify source areas
- The sum of PFAS may be useful for identifying additional source areas (assuming equivalent analyte lists are used)
- In this example, the upgradient portion of the plume decreases from 1,000 ng/L to 200 ng/L, before increasing to 800 ng/L
- Assuming no preferential pathways, the increase to 800 ng/L may indicate a separate source area (this should be confirmed with other lines of evidence)



PFAS Forensics Considerations

Example 4: Understanding PFAS Metrics

- The percent of PFAAs with 6 or less carbons, and their precursors (%≤C6) will generally increase along a flow path due to the preferential retention of longer-chain PFAS
- In this example, the %≤C6 in the upgradient portion of the plume increases from 30% to 50%, before decreasing to 35%
- Assuming no preferential pathways, the decrease to 35% may indicate a separate source area (this should be confirmed with other lines of evidence)



Poll Questions 10–12 (Answers)

- Is AFFF the only source of PFAS?

  A) Yes **B) No**

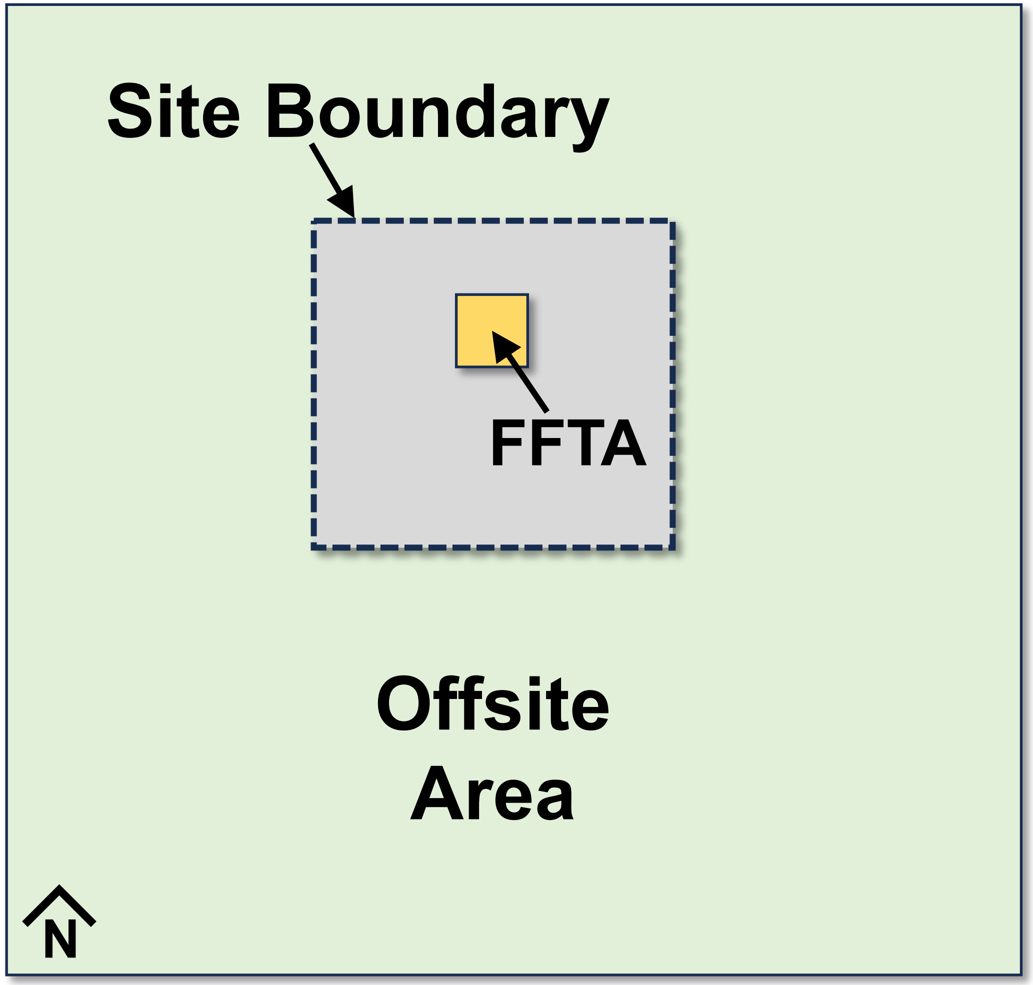
- PFAS patterns in soil will be identical to PFAS patterns in groundwater?

  A) Yes **B) No**

- Retention and precursor transformation will affect PFAS patterns?

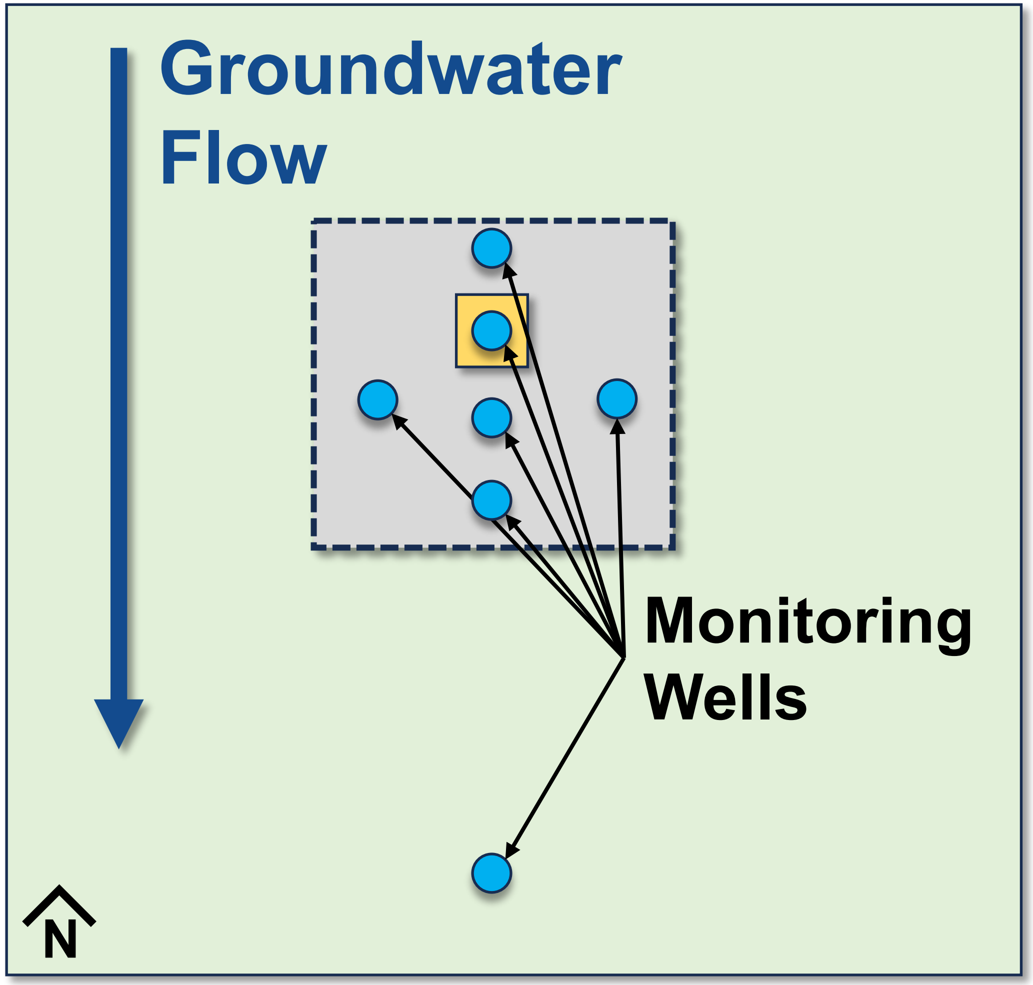
  A) Yes B) No

Hypothetical PFAS Background Assessment



- Next, we will use what we have learned and walk through a simplified, hypothetical example of PFAS patterns that may be present near a former fire training area (FFTA)

Hypothetical PFAS Background Assessment



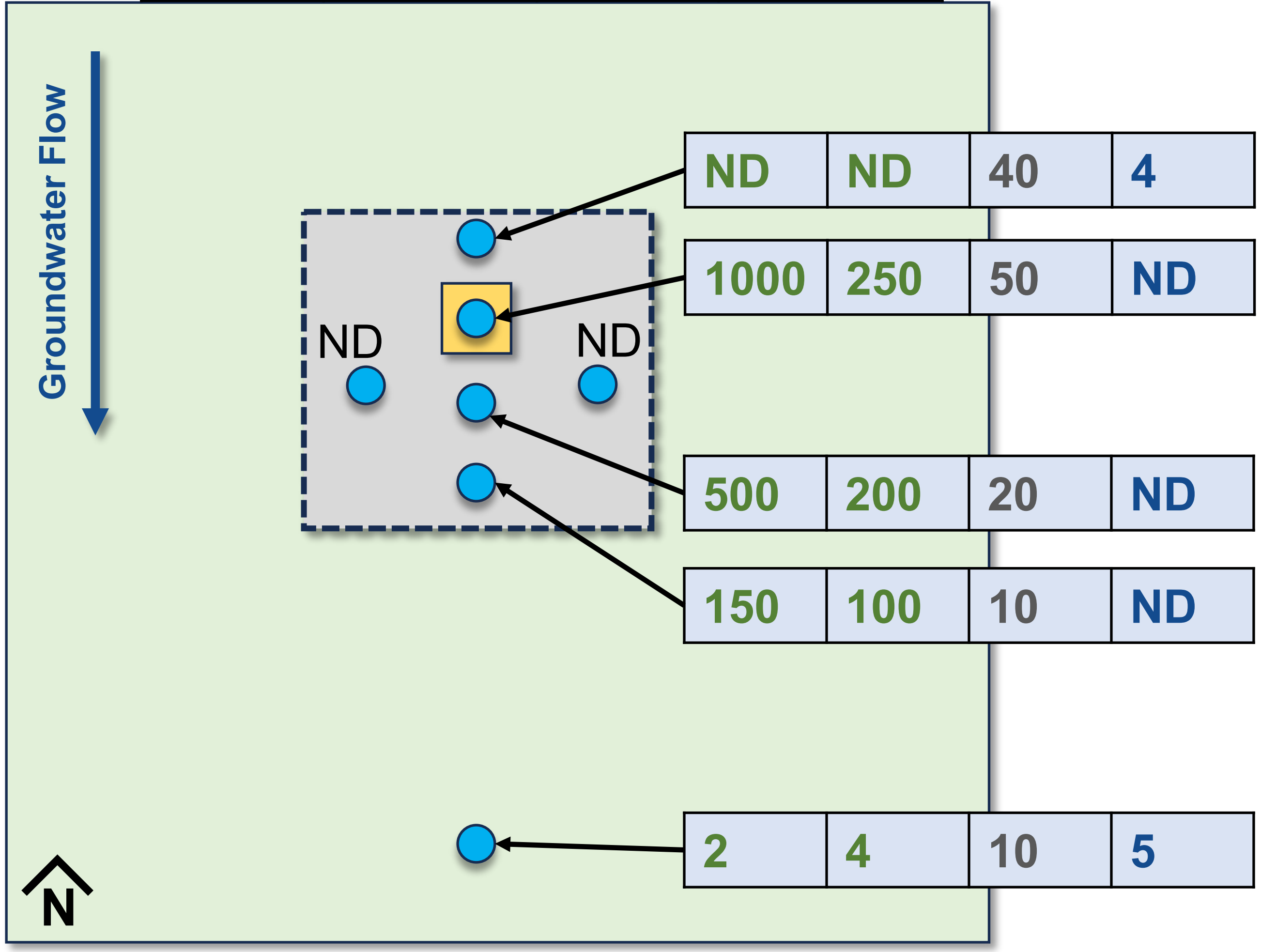
- Site Setting
  - Groundwater flow is to the south in a shallow, unconfined aquifer with stable water levels
  - No preferential pathways have been identified
  - Monitoring wells have been installed upgradient, downgradient and cross-gradient to the FFTA
  - The offsite area is a mix of commercial and industrial land use

Hypothetical PFAS Background Assessment

Key =

PFOS	PFHxS	PFOA	6:2 FTS

Color: ECF-based PFAS, ECF- or FT-based PFAS, FT-based PFAS



ND	ND	40	4
1000	250	50	ND
500	200	20	ND
150	100	10	ND
2	4	10	5

PFOA and 6:2 FTS detected upgradient?

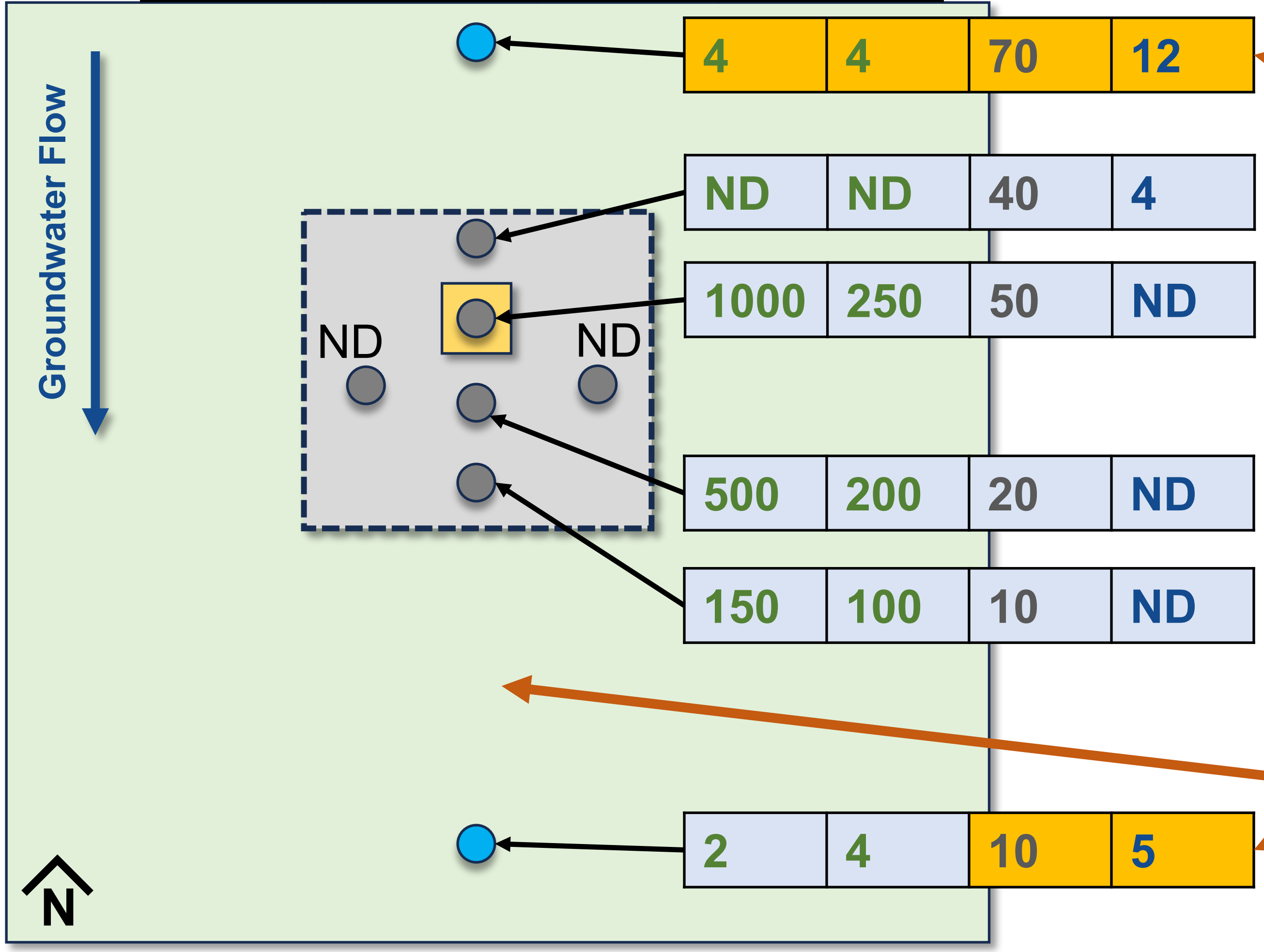
PFOS and PFHxS dominant with no 6:2 FTS, this indicates ECF AFFF may have been released

PFOA and 6:2 FTS are higher than expected?

Concentrations in ng/L

Hypothetical PFAS Background Assessment

Key = PFOS | PFHxS | PFOA | 6:2 FTS — Color: ECF-based PFAS, ECF- or FT-based PFAS, FT-based PFAS



PFOS	PFHxS	PFOA	6:2 FTS
4	4	70	12
ND	ND	40	4
1000	250	50	ND
500	200	20	ND
150	100	10	ND
2	4	10	5

Well installed for background assessment, indicates background PFAS

Downgradient well indicates background PFAS should be further evaluated to explain PFOA and 6:2 FTS detections

Concentrations in ng/L

PFAS Data Evaluation

KEY POINT

PFAS often behave in predictable ways along routes of migration, resulting in patterns that can be helpful during identification of sources versus background.

(Image from Microsoft Office)

Naval Facilities Engineering Systems Command

Engineering and Expeditionary Warfare Center

Break

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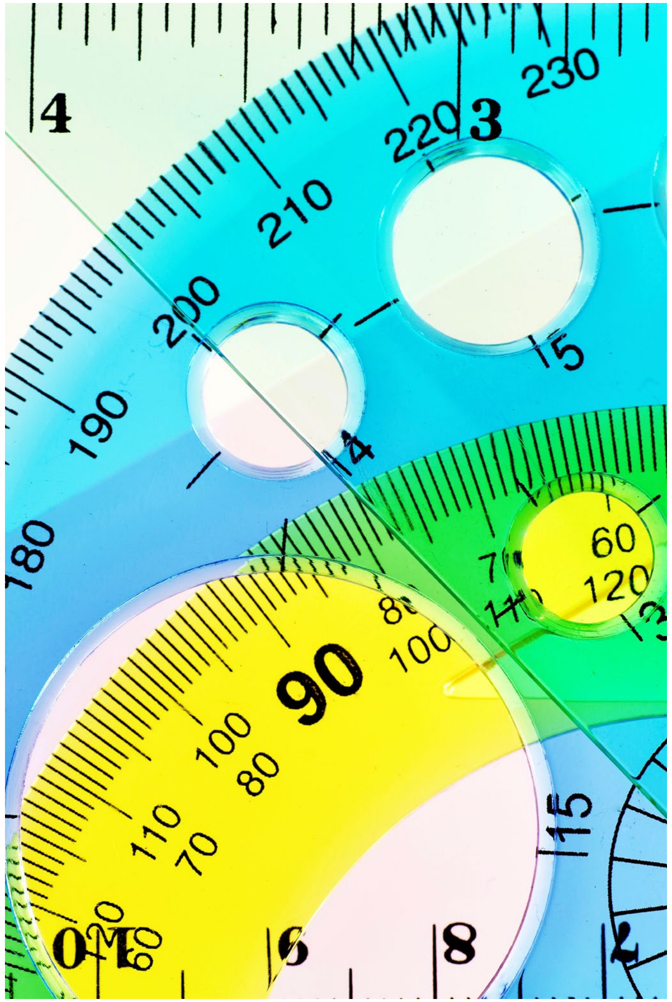
Background Study Reference Area(s)

- No specific guidance for selecting PFAS Background Study Reference Areas (yet)
- Scale Considerations
  - Will require review of site-specific conditions
  - Large Site: Sites with watershed-scale considerations may require sampling at greater distances away from site
  - Small Site: Will focus on selecting representative sampling areas outside of the PFAS release area

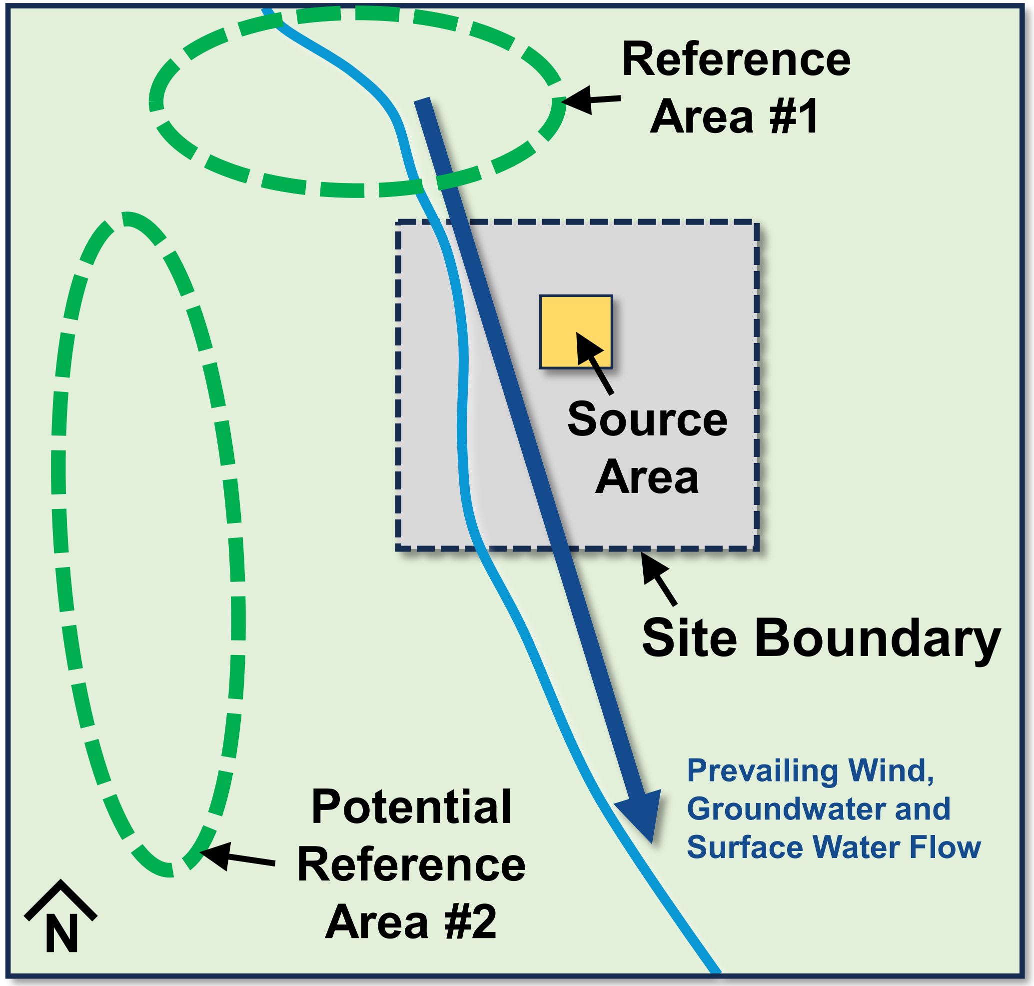


(Image from Microsoft Office)

Determining Background Reference Area(s)

- The **Background Reference Area(s)** should **have similar physical, chemical, geological, and biological characteristics of the site being investigated**, but should not be affected by site activities (CERCLA reference, but Navy uses this term)
  - Different areas may be required depending on the media affected by site activities (e.g., soil vs. surface water vs. groundwater)

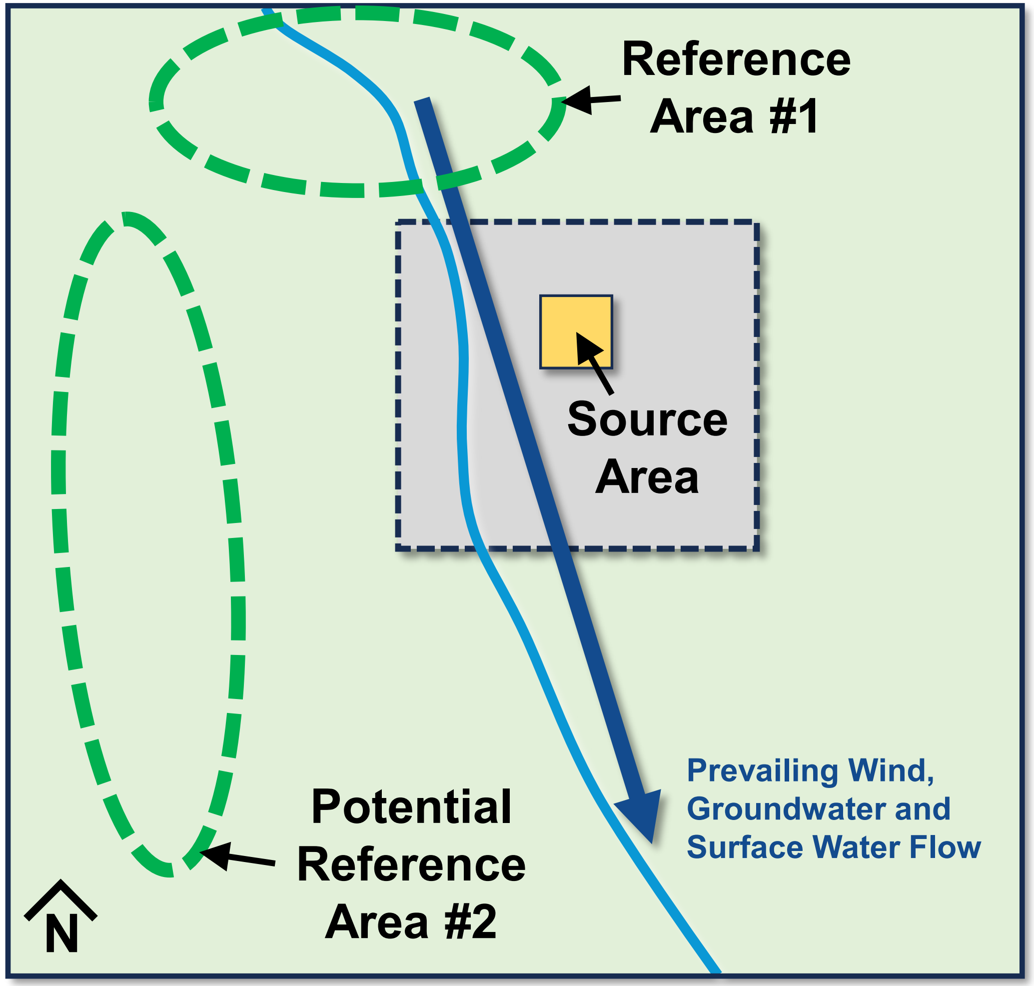
Generic Example: Requires Site-Specific Consideration



Selecting Background Sampling Locations

- Potential site-specific assessment may include
  - Precipitation (prevailing wind can vary)
  - Upstream/adjacent surface water
  - Upgradient/adjacent groundwater
  - Potential down/cross-gradient groundwater depending on offsite land use(s)
  - Soil (and potentially porewater) at appropriate distance(s) from release area(s)
  - Assessment of non-PFAS markers that may be indicative of background PFAS

Generic Example: Requires Site-Specific Consideration



Statistical Methods

- Due to inherent **variability in data**, background levels are **statistical calculations and incorporate uncertainty** (which may be large)
- Refer to EPA “Role of Background in the CERCLA Cleanup Program” (2002), or other required guidance, to determine appropriate statistical evaluation of the background data
- In some cases, multiple sampling events may be required

Selecting Background Sampling Locations

KEY POINT

The design of PFAS background studies will require consideration of site-specific factors.

(Image from Microsoft Office)

Background Case Study In Progress

PFAS Background at Navy Installations:
Precipitation and Ambient Soils Research

- NAVFAC EXWC
  - Nicolette Andrzejczyk, PhD, EXWC PI
  - Arun Gavaskar

- WSP
  - Usha Vedagiri, PhD, PI
  - Michael Fuerte
  - Dean Lay
  - Joshua Klein
  - Sean Gormley
  - Konrad Quast
  - Lansana Coulibaly

PI: principal investigator

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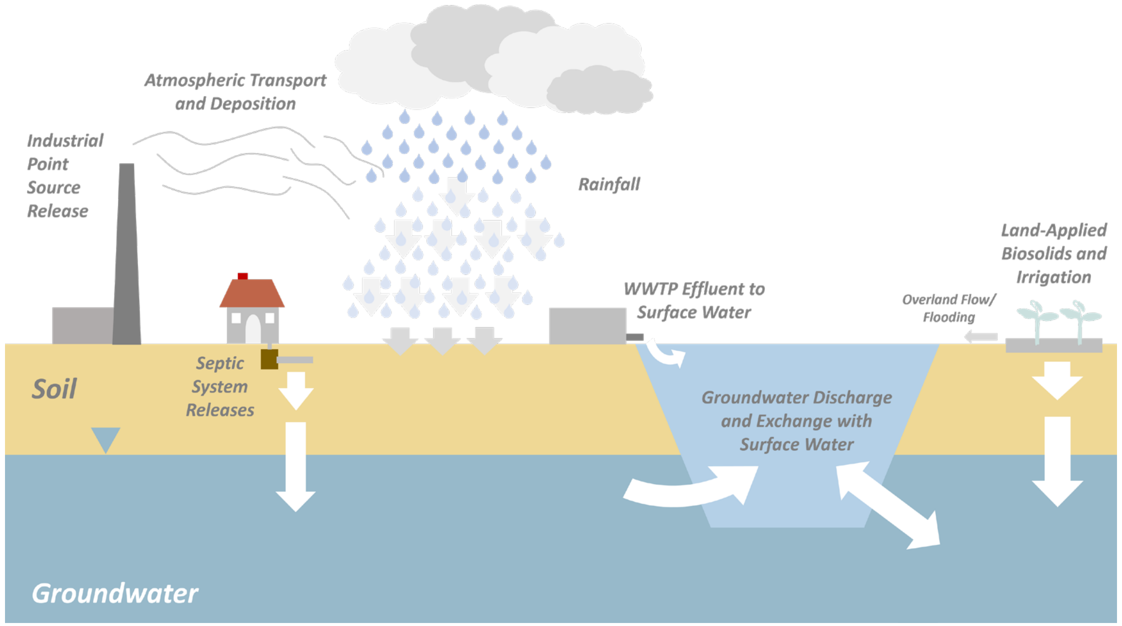
Wrap-Up #1

Background

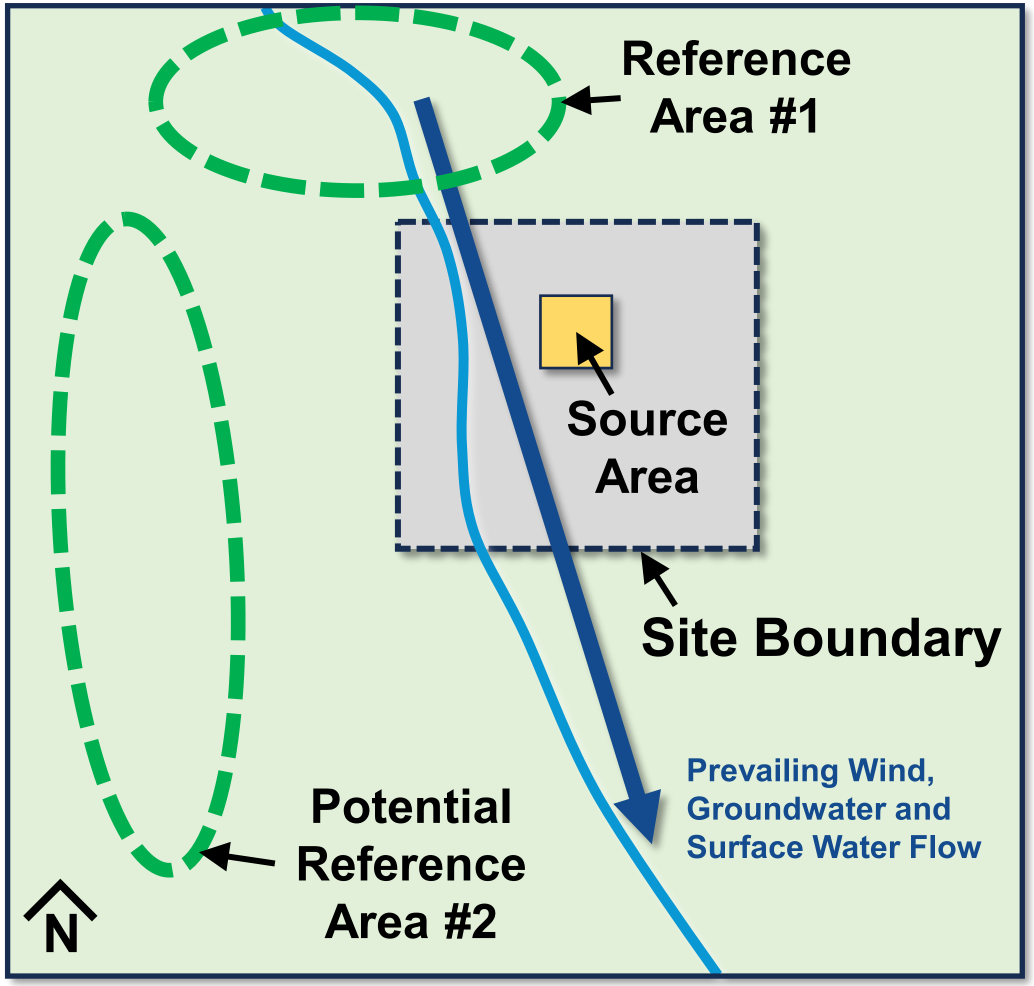
- Background PFAS assessments will be a component of PFAS Remedial Investigations
- Background guidance specific to PFAS is evolving (stay tuned for NAVFAC studies and ESTCP project ER25-8813)



Wrap-Up #2

Background

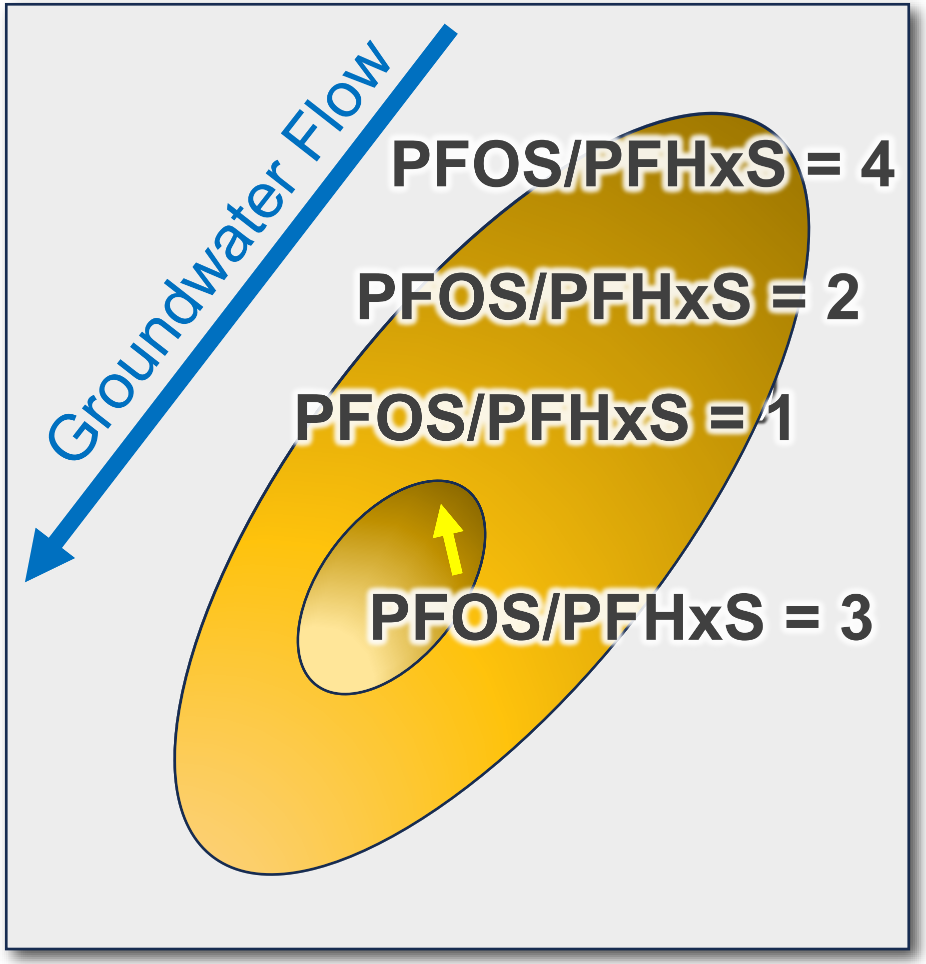
- Background PFAS concentrations can exceed regulatory standards in precipitation, soil, surface water, and groundwater
- Carefully plan your background investigation area based on site-specific considerations



Wrap-Up #3

Forensics

- Identification of PFAS source areas should include consideration of fate and transport effects along routes of migration
- Use multiple lines of evidence to confirm source areas have been properly identified



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Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Questions

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Remediation of PFAS-Impacted Solids

Jovan Popovic, PhD, NAVFAC EXWC
John Kornuc, PhD, NAVFAC EXWC

RITS 2025

Disclaimer

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Information in this presentation is current as of May 30, 2025.

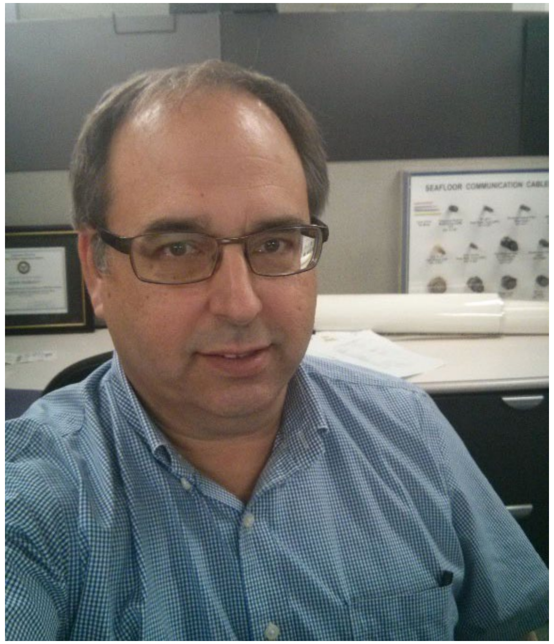
EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Jovan Popovic, PhD
NAVFAC EXWC

- Environmental Engineer
- ~10 years experience

John Kornuc, PhD
NAVFAC EXWC



- Scientist
- ~40 years experience

Presentation Overview

- Introduction
- Technologies for Solids Treatment
  - Established Technologies for PFAS-Impacted Solids
  - On-Base Pilot Study Testing for PFAS Technologies
- Case Studies
- Guidelines for Selecting Solids Treatment Technologies
- Summary/Key Takeaways

Past PFAS RITS

2015	• Emerging Information on Emerging Chemicals
2016	• Managing Per- and Polyfluoroalkyl Substances (PFAS) at Navy Sites
2017	• Risk Communication for PFAS Sites
2018	• PFAS Remediation: Technologies, Guidance, and Application
2019	• Managing Emerging Chemicals at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites • PFAS Site Characterization
2021	• Best Practices for Conducting PFAS Remedial Investigations
2022	• Navigating the 2021 EPA PFAS Strategic Roadmap • Emerging Technologies for PFAS Treatment
2023	• Best Practices for PFAS Sampling and Data Interpretation
2024	• Considerations for Conducting Ecological Risk Assessments (ERAs) at PFAS sites • Considerations for Human Health Risk Assessments (HHRAs) During Remedial Investigations at PFAS Sites

Purpose of Presentation

- Inform audience on emerging strategies for managing PFAS-impacted soils/solids, considering existing constraints

(National Archives 2017)

(National Archives 2011)

Commonly Encountered Sources of PFAS-Impacted Solids

When might we encounter PFAS-impacted solids?

- Remediation under CERCLA
- TCRAs and NTCRAs
- IDW
- Excavations

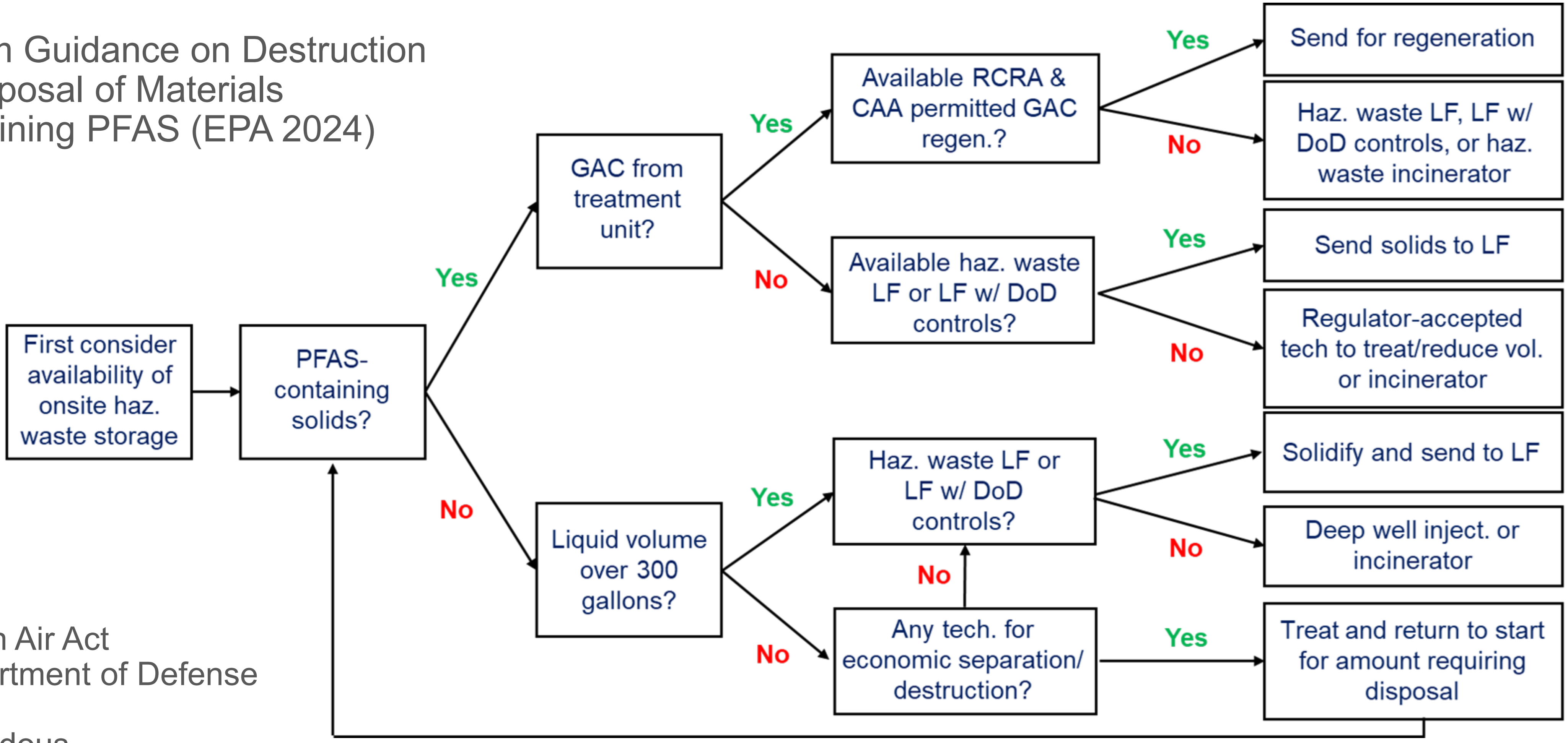
What types of solids may we encounter?

- Soils and sediments; in place or excavated
- Spent filtration media (e.g., GAC, ion exchange resin)
- IDW soils
- Excavated solids; concrete and asphalt
- Biosolids
- Bag filters
- Other materials with residual AFFF

AFFF: Aqueous Film Forming Foam
GAC: granular activated carbon
IDW: investigation-derived waste
NTRCA: Non-Time-Critical Removal Action
TCRA: Time-Critical Removal Action

Interim PFAS Disposal Decision Tree

- Interim Guidance on Destruction or Disposal of Materials Containing PFAS (EPA 2024)



First consider availability of onsite haz. waste storage

PFAS-containing solids?

Yes

GAC from treatment unit?

Yes

Available RCRA & CAA permitted GAC regen.?

Yes

Send for regeneration

No

Haz. waste LF, LF w/ DoD controls, or haz. waste incinerator

No

Available haz. waste LF or LF w/ DoD controls?

Yes

Send solids to LF

No

Regulator-accepted tech to treat/reduce vol. or incinerator

No

Liquid volume over 300 gallons?

Yes

Haz. waste LF or LF w/ DoD controls?

Yes

Solidify and send to LF

No

Deep well inject. or incinerator

No

Any tech. for economic separation/ destruction?

No

Yes

Treat and return to start for amount requiring disposal

CAA: Clean Air Act
DoD: Department of Defense
LF: landfill
haz.: hazardous
inject.: injection
RCRA: Resource Conservation and Recovery Act
regen.: regeneration

KEY POINT **There is a temporary moratorium on incineration of PFAS-impacted material (2022 NDAA, Sect. 343).**

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Currently Available Technologies for Solids Treatment and Disposal

- Established Technologies
  - Landfilling
  - Incineration*

(National Archives 2007)

- Technologies at Pilot Study Level for PFAS
  - Thermal desorption
  - Smoldering
  - Soil washing
  - Stabilization

* Not covered in this presentation

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Landfilling

- Disposal in permitted hazardous or solid waste landfill with controls specified in DoD PFAS guidance
  - Consult DLA Qualified Facilities List
- Waste can be landfilled as is or stabilized prior to landfilling
  - Note: stabilization to be covered in subsequent section
- Waste must be profiled (parameters may vary by receiving facility)
  - PFAS
  - VOCs
  - SVOCs
  - PCBs
  - CN + S reactivity
  - Total solids
  - RCRA 8 metals (mercury, arsenic, barium, cadmium, chromium, lead, selenium, silver)
  - Ignitability
  - pH

CN + S: cyanide and sulfide
DLA: Defense Logistics Agency
PCB: polychlorinated biphenyl
SVOC: semivolatile organic compound
VOC: volatile organic compound

Landfilling

Challenges	Best Practices
• ***Make contact with facility to determine requirements!*** • Can be expensive (increase in cost specifically for PFAS-impacted waste) • No definitive answers on acceptable levels for landfills • Landfill can change their mind • Limited landfills available • Landfills sometimes limit quantities and concentrations • Logistics to multiple landfills based on level also a challenge	• If possible, separate high concentration materials • Waste profiling required varies by landfill, so communicate with landfill early • Consider closest landfills first to avoid higher transportation costs

Good to know

- Landfills are implementing back-end leachate management
- Landscape may change depending on leachate regulations

Naval Auxiliary Landing Field Fentress (Virginia)

- Source of soil: NALF Fentress Soil removed from inside a caisson to 29.5 ft bgs to install the gate (large monitoring well)
- Volume of soil: 14.37 tons
- Average Target PFAS concentration: ~30 µg/kg
- Soil treatment: Stabilization
- Landfill used: Sent to a Subtitle D Landfill (PFAS detections below landfill limit)
- Waste profiling requirements: Flash point, pH, reactive, TPH, PFAS
- Cost (2024): ~$5,400.00 (just treatment and disposal)
- General: Easy process worked with contractor. Disposal was fast.

KEY POINT

Communicate with contractor and landfill early to understand requirements and availability.

µg/kg: micrograms per kilogram
ft bgs: feet below ground surface
NALF: Naval Auxiliary Landing Field
TPH: total petroleum hydrocarbons

Naval Station Newport: Tank Farm 5 (Rhode Island)

- Source of soil: Excavated materials at Naval Station Newport at Tank Farm 5 property
- Volume of soil: 52,342 tons
- PFAS concentration: Ranged from nondetect to 5 µg/kg
- Landfill used: 17,978 tons to Subtitle C, 14,455 tons to Subtitle D #1, 19,910 tons to Subtitle D #2
- Waste profiling requirements: Composite PFAS waste characterization samples were collected at 1/400 cubic yards, and discrete PCB samples were collected at 1/200 cubic yards

- Cost (2022–2023)
  - $17,092,440 (CTO total)
  - $14,520,043 (T&D)
- General
  - Sub D landfill #1 had stricter limits with restricted PFAS levels
  - Sub D landfill #2 still has availability, but limited to ppt levels
  - Sub C landfill used currently accepts on case-by-case basis (<1 ppm)

KEY POINT

Use of multiple landfills or landfill types may be required.

CTO: contract task order
ppm: parts per million
ppt: parts per trillion
T&D: transport and disposal

Cutler Site 10 NSA Fire Station (Maine)

- Source of soil: Site 10 PFAS RI fieldwork activities (drilling [soil/rock cutting], debris remaining from IDW activities)
- Volume of soil: 8 tons
- PFAS concentration: IDW soil sample collected had nondetect results for the 29 PFAS compounds analyzed. RI maximum concentration: 78 µg/kg
- Landfill used: Disposal as non-RCRA, non-DOT Regulated Material (containing PFAS; Subtitle C landfill)
- Waste profiling requirements: PFAS, VOCs, SVOCs, PCBs, CN + S reactivity, total solids, RCRA 8 metals (mercury, arsenic, barium, cadmium, chromium, lead, selenium, silver), ignitability, pH
- Cost (2022–2023): Approximately $27,300 (includes rolloff rental, delivery and removal of rolloff containers, waste characterization, and load and disposal of rolloff soils)
- General: Expensive/high cost due to remote Cutler, Maine, location and limited disposal facilities accepting PFAS waste at that time

KEY POINT

Michigan was the closest state that accepted PFAS-impacted soil (~1,000 miles away).

DOT: Department of Transportation
NSA: Naval Support Action
RI: remedial investigation

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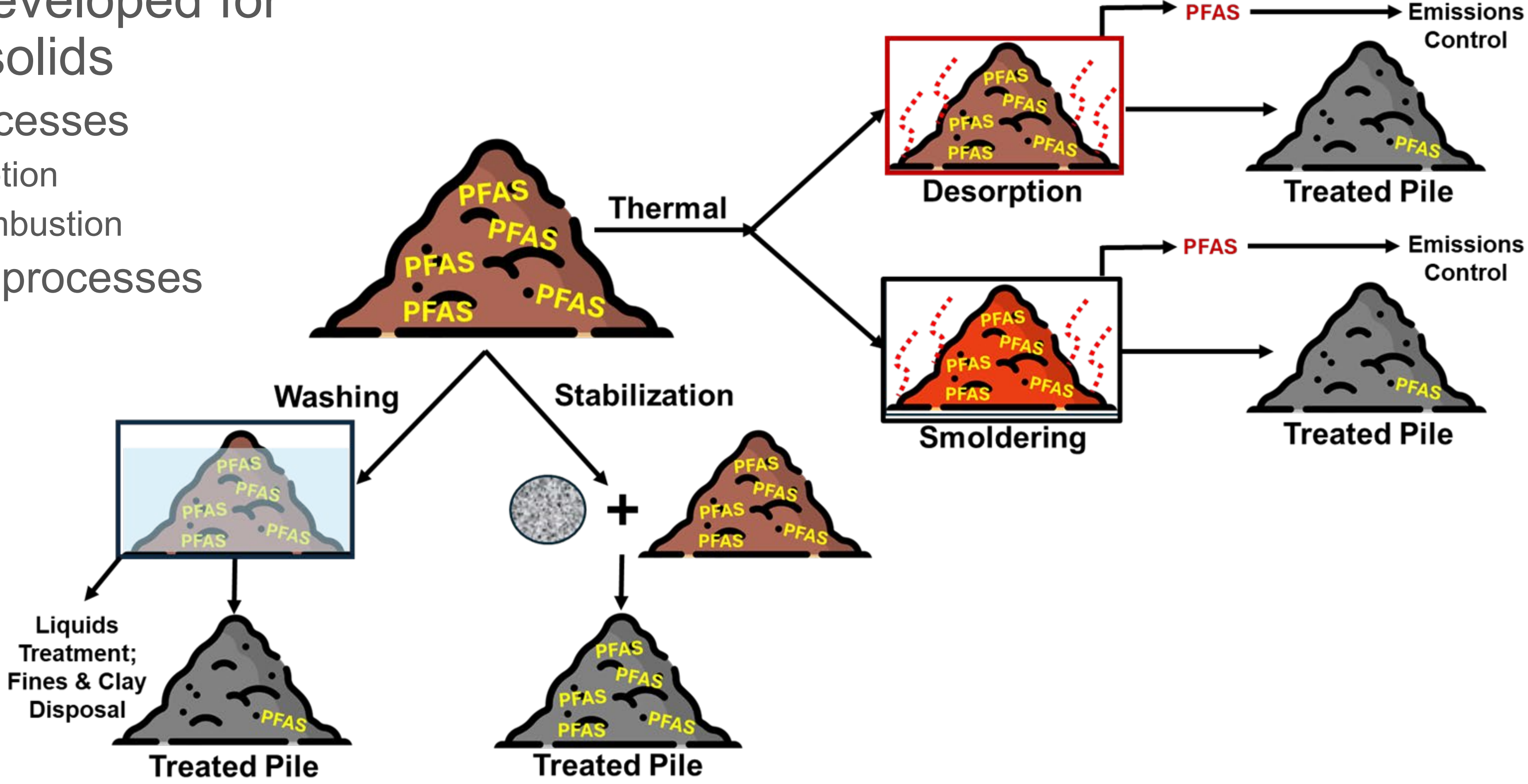
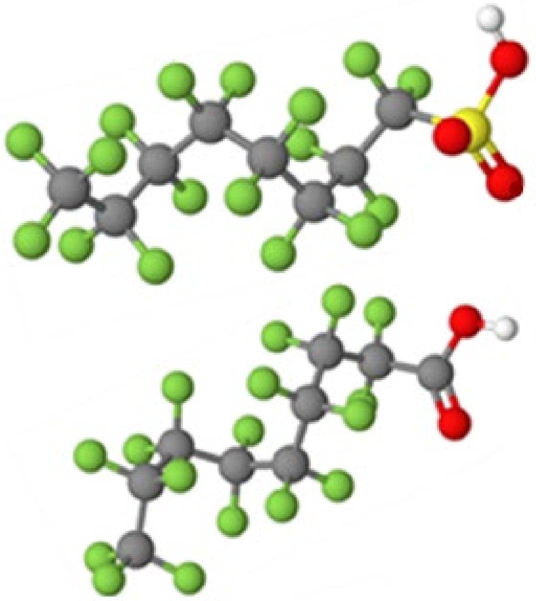
Solids Treatment Technologies Under Development

- Covering four technologies currently being developed for PFAS-impacted solids
  - Two thermal processes
    - Thermal desorption
    - Smoldering combustion
  - Two nonthermal processes
    - Stabilization
    - Soil washing
- What are some considerations when assessing performance?



Solids Treatment Performance Monitoring

- Considerations for factors affecting treatment performance
  - Thermal desorption/destruction-specific
    - Moisture content and effects on process efficiency
    - Monitoring vapor emissions for desorbed PFAS, unintended decomposition products (e.g., PICs/PIDs);
    - HF production (e.g., Method 26A, Hydrogen Halide and Halogen - Isokinetic Method)
      - Fluorine mass balance
      - Emissions and compromised reactor integrity (corrosivity)
    - Co-contaminants affecting desorption/destruction efficiencies
  - Stabilization/sequestration-specific
    - Presence/absence of certain soil constituents may impact PFAS leaching
  - Presence of precursors
    - Variability with destruction and removal efficiency (e.g., transformation into target analytes)
    - Screening may help elucidate certain performance limitations



PIC(s)/PID(s): product(s) of incomplete combustion/destruction
HF: hydrofluoric acid

Solids Treatment Performance Monitoring

- Leachability as a performance measurement for treated solids
  - Behavior of impacted solids; assess “long-term” stability of solids in presence and absence of amendment and/or treatment
  - Implications associated with storing impacted materials, reuse, and disposal options
  - State standards vs. K_{oc} for screening (e.g., NJDEP 2023)
- Many bench-scale, “standardized” leachability methods may not be representative of conditions encountered in the field, leading to overprediction
  - Disruptions to soil structure and air-water interfacial accumulation
  - Use of synthetic reagents or reagent water to simulate leaching
  - No validated methods for PFAS leaching yet, but some tests may provide valuable data for performance, especially if many describe “worst case” scenario

KEY POINT

Multivalidation lab studies underway for adapted LEAF leachability methods. Current recommendation is to not use leachability methods at this time.

K_{oc}: organic carbon partition coefficient
LEAF: Leaching Environmental Assessment Framework

Emissions Sampling for PFAS (Thermal)

	Emerging PFAS Emissions Sampling Methods		
	OTM-45	**OTM-50**	**“Future” OTM-55**
PFAS/ Analytes Sampled	- EPA 1633 analytes - Polar semi-volatile and particulate-bound PFAS - “Whole” PFAS	- Partial degradation products (e.g., PICs/PIDs) - Volatile fluorinated compounds	- Targeted analysis for nonpolar semivolatile PFAS (e.g., fluorotelomer alcohols) - Methylene chloride
Application Notes	- Not intended for processes where transformation or partial destruction encountered	- Includes non-targeted analysis; uses NIST library - Not for completely mineralized PFAS - Impingers used if acid gas and/or >3% H_2O present in vapor	- In development
Analysis	- LC-MS/MS for target analytes	- Passivated stainless canister sampling with GC-MS analysis	- Method 0010 sampling with Method 8270 analysis
Potential Streams	- Stack sampling of thermal desorption systems	- Stack sampling of thermal desorption systems, smoldering, incinerator, etc.	- Stack sampling thermal and incinerator systems

ELAP: Environmental Laboratory Accreditation Program
EPA: United States Environmental Protection Agency
GC-MS: gas chromatograph-mass spectrometry
LC-MS/MS: liquid chromatography tandem mass spectrometer
NIST: National Institute of Standards and Technology
OTM: Other Test Method

KEY POINT

There are no DoD ELAP laboratories currently accredited for any “OTM” methods.

Knowledge Check

What is the name of the method that is used to isokinetically sample hydrofluoric acid emissions?

A. “Future” OTM-55
B. 26A
C. 1633
D. OTM-50

Knowledge Check

What is the name of the method that is used to isokinetically sample hydrofluoric acid emissions?

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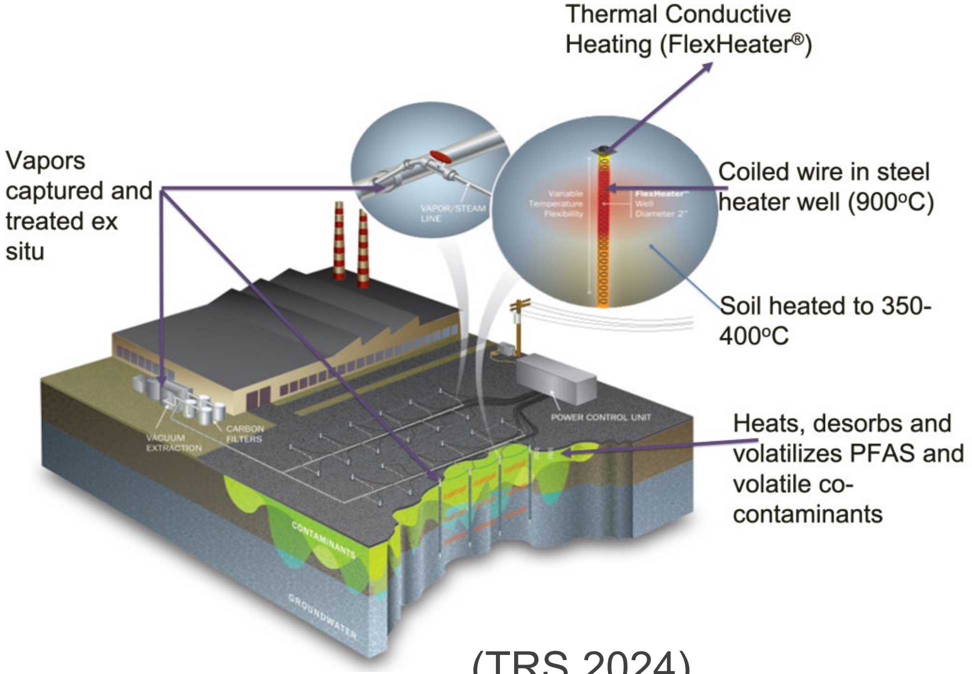
D. OTM-50

Thermal Desorption

- Process where PFAS-impacted media (e.g., soil, GAC) is heated to temperatures of ~350–600 ºC to drive PFAS into the vapor phase; vapor phase generally captured and treated
  - Destruction not characteristic of thermal desorption processes, but partial decomposition products may form to some extent
  - Alkali salt (e.g., $Ca[OH]_2$, CaO) supplementation may promote low temperature mineralization of PFAS
- May be performed in situ or ex situ
  - Ex situ
    - Containerized systems (e.g., batch, rotary kiln)
    - Direct treatment of stockpiles with electric heating elements
  - In situ
    - Vadose zone treatment with electric heating elements (e.g., source area treatment)
- Potential waste streams include but are not limited to soils, GAC, biosolids



Thermal Conductive Heating (FlexHeater®)

Vapors captured and treated ex situ

Coiled wire in steel heater well (900ºC)

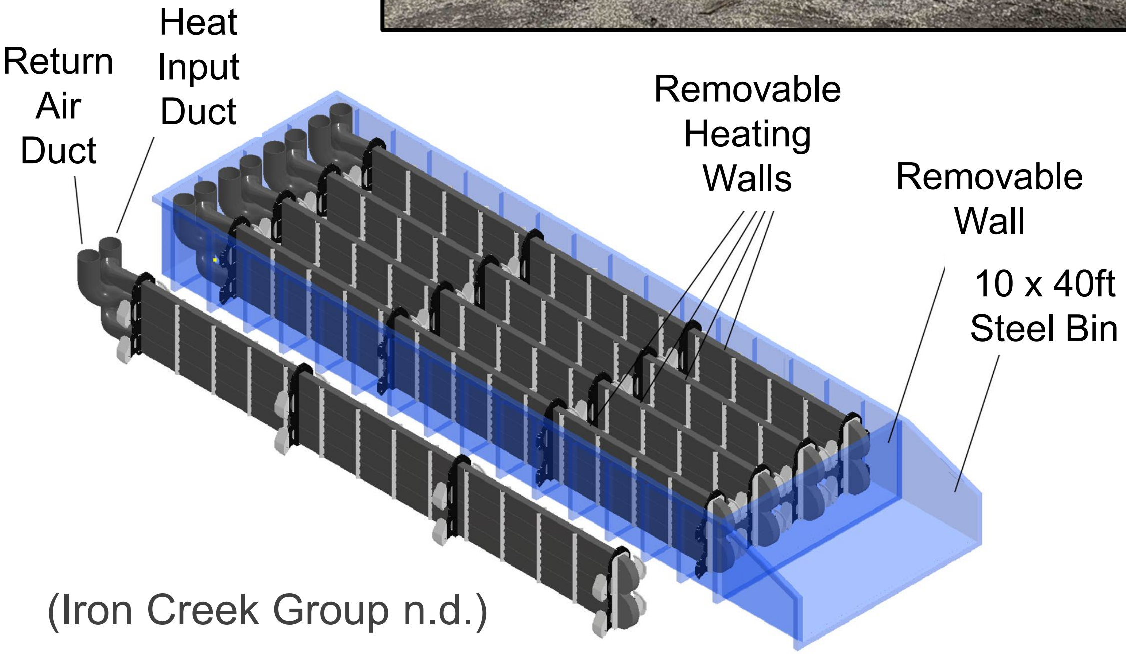
Soil heated to 350-400ºC

Heats, desorbs and volatilizes PFAS and volatile co-contaminants

(TRS 2024)

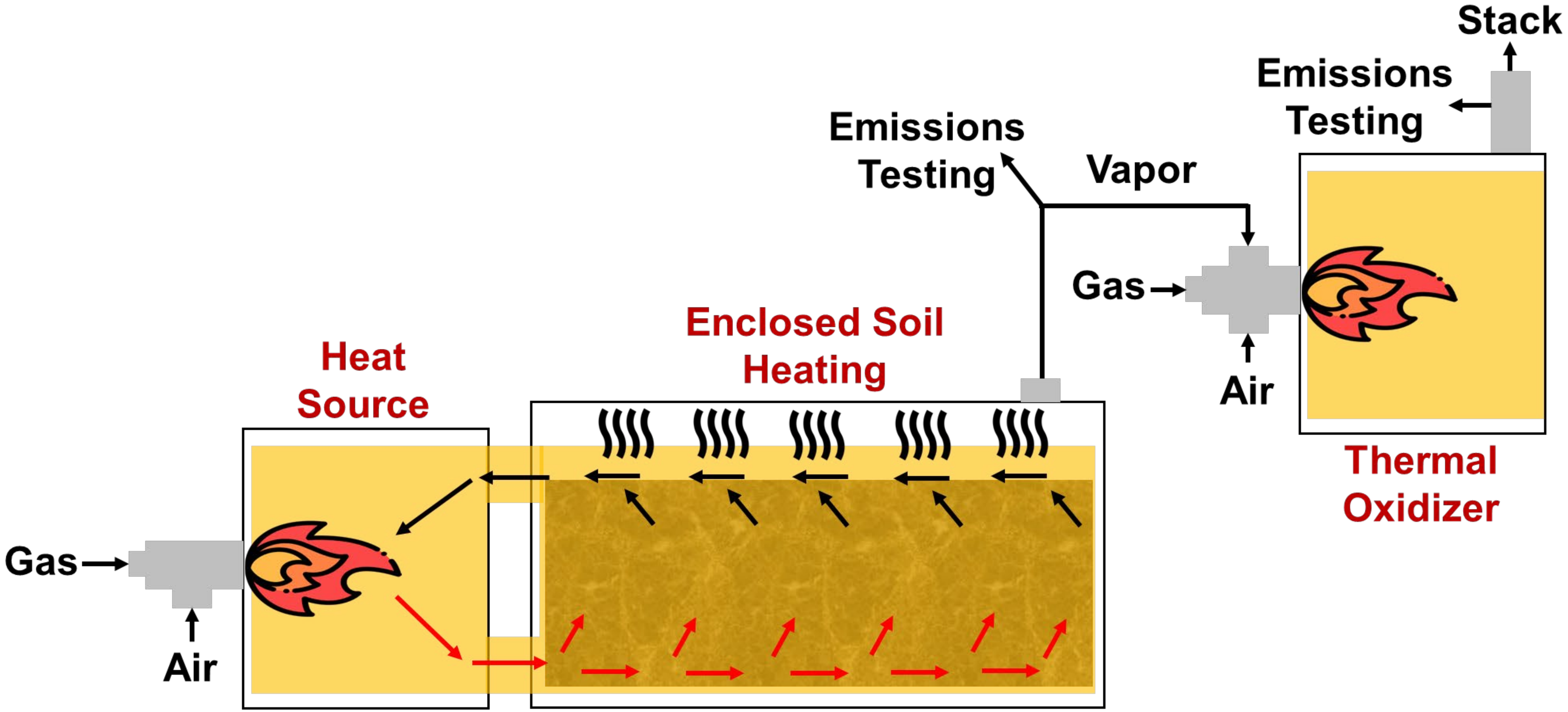
Thermal Desorption – Containerized Example

- Treats impacted material in an enclosed environment by heating a gas and pulling heated gas through rigid, hollow heating walls traversing the interior of heating chamber
- Bin is filled with impacted material, and bin is covered with an airtight seal
- Heated gas flows through heating walls, separate from impacted material, and returns to air heater to be reheated and recirculated
- 10 ft (width) x 40 ft (length) x 4 ft (height)
- Each bin has a capacity of approximately 47 cubic yards (36 cubic meters)



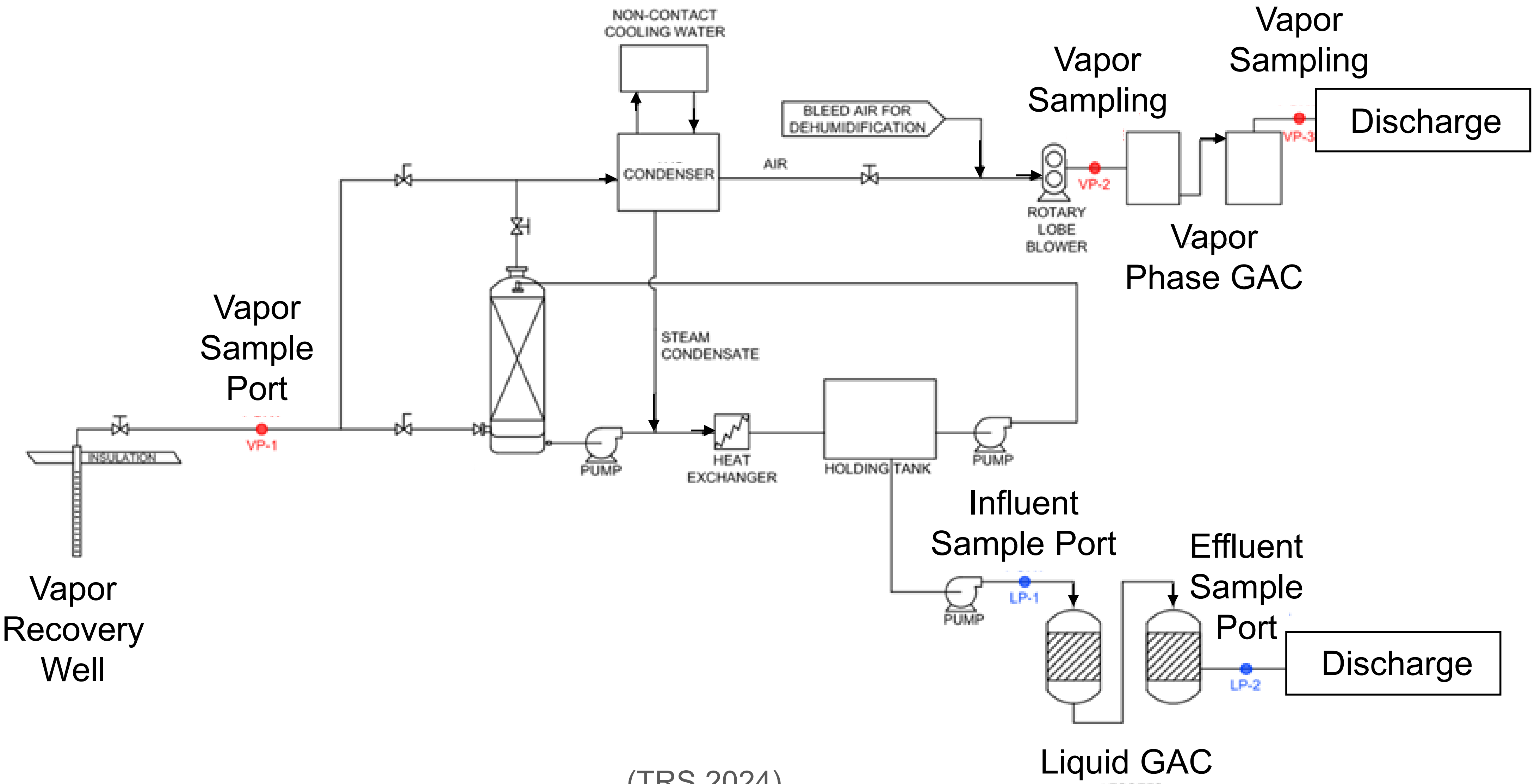
(Iron Creek Group n.d.)

Thermal Desorption – Containerized Example



(Modified from Iron Creek Group 2025)

Thermal Desorption – Example of In Situ Treatment Process Flow



(TRS 2024)

Thermal Desorption

- General factors affecting performance
  - Moisture content
  - Heat distribution
  - Natural PFAS retention in soils, GAC
- Other limitations
  - High energy requirements; increased requirements for media containing high moisture content
  - Unintentional generation of PICs/PIDs

Example of in situ thermal desorption application – Beale AFB
(TRS 2024)

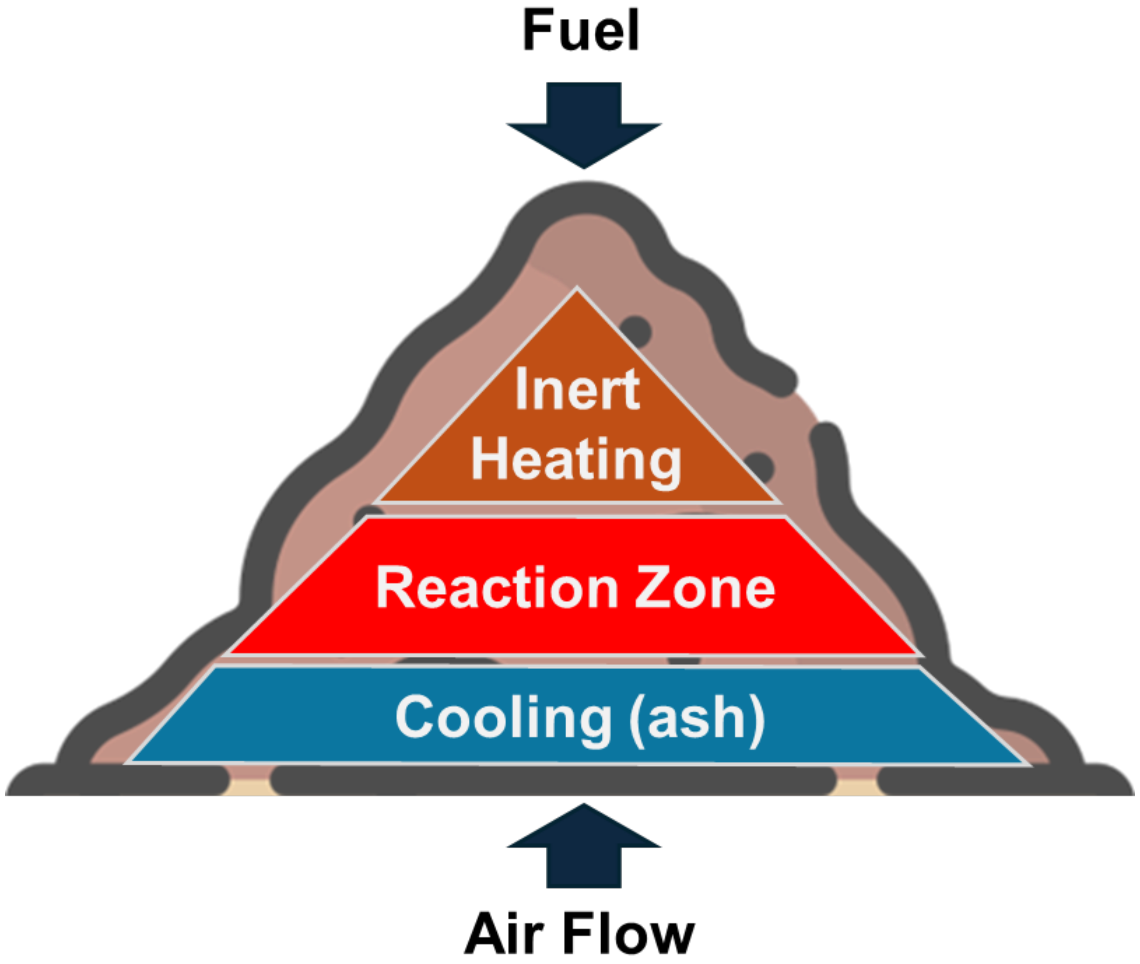
AFB: Air Force Base

Smoldering

- Thermal oxidation process that uses solid or liquid fuel, an oxidant, inert porous media (e.g., silica sand)
- Temperature ranges from ~500-1,200˚C, but maintaining >900˚C desirable for mineralization
- Potential waste streams: spent GAC, soils, wastewater solids
- Ex situ batch systems tested to date for PFAS-impacted materials; has been conducted in situ for other chemicals
  - Ex situ may allow for better mixing and optimization of treatment mixture

Smoldering

- Key zones in smoldering systems: inert heating, reaction, and cooling zones
  - Inert heating zone: endothermic, reaction-free region characterized by phase change processes
  - Reaction zone: oxidation, pyrolysis, gasification
  - Cooling zone: buffer against extinction
- GAC generally considered excellent fuel source for smoldering, but can be costly
- Sand and/or soils for better air flow/increasing smoldering front



Smoldering

- General factors affecting performance
  - Air flux
  - Fuel quantity and distribution in soil
  - Oxygen content
  - Fuel energy content
  - Heat losses

- Other limitations
  - Emissions
    - HF
      - Limestone may be added as emission control
    - PICs/PIDs
  - Potential for zones of uneven heating
  - Hazards associated with high temperature processes

HF: Hydrofluoric acid
PIC/PID: Products of incomplete combustion/destruction

Soil Washing

- Media transfer technology that separates PFAS from soils and transfers it to a liquid stream; liquid undergoes secondary treatment
- Surfactant and/or solvent may be used to increase desorption
- May be used as a strategy to reduce soil volume requiring offsite disposal
- Fine- and coarse-grained materials need to be separated and managed individually
    - PFAS affinity for clays, organics, silts in fines
    - Easier to desorb PFAS from gravel and sands

Soil Washing

- Key parameters
  - Soil characterization
    - Organic carbon content
    - Particle size distribution
      - 0.25–2 millimeters or < 25% silt and clay content is ideal
    - Cation exchange capacity
  - Soil washing throughput/retention time
  - Soil dewatering post-wash

(Denning n.d.)

Soil Washing

- General limitations affecting performance
  - High clay and moisture content
  - High silt
  - Soil heterogeneity and inconsistent feed
  - Difficulty separating coarse and fine soil particles
- Other limitations
  - High energy requirements
  - Large volumes of liquids requiring treatment
  - Fines will likely require offsite disposal

Stabilization

- Immobilization strategy to reduce PFAS leaching from soils using adsorbent amendment
  - Activated carbon (granular, powdered, colloidal), organoclays, ion exchange resins, polymers
- Electrostatic and/or hydrophobic interactions imparted by adsorbent bind to PFAS, similar to liquids treatment process with filtration media

- May be applied ex situ or in situ
  - Ex situ
    - Mixing adsorbent with soil piles to limit leaching
  - In situ
    - Injection (e.g., CAC, PAC)
    - Soil mixing
    - Trenching
- Solidification agent may be used in conjunction with stabilizers to create a “monolith,” further reducing leaching potential by limiting soil permeability
  - Offsite disposal
  - In situ soil mixing

CAC: colloidal activated carbon
PAC: powdered activated carbon

Stabilization

- Performance evaluations and amendment dose optimization should be conducted at bench and pilot scales prior to full-scale implementation
    - Bench scale
        - Leachability testing to determine appropriate amendments and doses using site-derived media
    - Potential approaches for field pilot performance monitoring of in situ stabilization amendments
        - Porewater concentrations via lysimeters
        - Time integrated/passive samplers
        - Groundwater monitoring
        - “Radius of influence” determination for in situ injections
            - Soil cores and TOC for colloidal activated carbon distribution

TOC: total organic carbon

Stabilization

- General limitations affecting performance
  - Soil constituents competing for sorption sites
  - Uncertainties with amendment distribution, especially for in situ injection into complex formations, may affect effective treatment radius
- Other limitations
  - Uncertainties with long-term stability
  - Increased solids volume

Knowledge Check

Which property has the most deleterious effect on thermal desorption process performance?

A. Coarse grain size
B. Inert Porous Media (IPM)
C. Moisture

Knowledge Check

Which property has the most deleterious effect on thermal desorption process performance?

A. Coarse grain size

B. Inert Porous Media (IPM)

C. Moisture

Knowledge Check

The smoldering combustion process is comprised of inert heating, reaction, and __________ zones

Knowledge Check

The smoldering combustion process is comprised of inert heating, reaction, and ***cooling*** *zones*

Summary of Solids Treatment Technologies

	Thermal Desorption	Smoldering Combustion	Soil Washing	Stabilization/ Solidification
Technology Readiness Level (TRL) for PFAS-Impacted Solids	**~8**; Multiple pilot projects completed	**~8**; Multiple pilot projects completed	**~7**; System prototypes tested domestically	**9**; Broad application to impacted solids
Availability	- Multiple vendors with commercially available or pilot-scale units	- Vendor with commercially available or pilot-scale units	- Vendor with commercially available or pilot-scale units	- Multiple US vendors
Advantages	- Removes PFAS from solids	- Removes PFAS from solids and may promote mineralization	- Transfers PFAS from solids to liquid phase	- Generally low mass of stabilizer required - Many stabilizer choices
Summary of Limitations	- High energy requirements, exacerbated by soil moisture - Uneven heating or reaction zones may result in untreated areas - Potential for PIC/PID and HF formation (emissions) - Vapor phase capture and treatment requirement	- Uneven heating or reaction zones may result in untreated areas - May require amendment of fuel and inert porous material - Potential for PIC/PID and HF formation - Vapor phase capture and treatment requirement	- Large process infrastructure - May only be effective for reducing PFAS in coarse materials; disposal of fines - Large volumes of PFAS-impacted water generated & associated treatment - May require addition of co-solvent or surfactant - Efficacy/utility still not fully understood	- Does not remove or destroy PFAS - Long-term stability uncertain - May require reapplication - Increases disposal volumes

Summary of Solids Treatment Technologies

	Thermal Desorption	Smoldering Combustion	Soil Washing	Stabilization/ Solidification
Cost Estimate*	~\$500 per ton (variable; TRS, 2023)	~\$260-330 per ton (2016 estimate; Vidonish et al. 2016)	~\$100-\$200 per ton, excluding residuals treatment and disposal (ESTCP ER20-5258)	~\$100-150 per ton, assuming 2% (w/w) amendment

* Costs vary depending on site conditions, technology related factors, and soil volume treated. More accurate cost estimates should be developed on a project-by-project basis.

Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Break

Presentation Overview

- Introduction
- Technologies for Solids Treatment or Disposal
  - Established Technologies for PFAS-Impacted Solids
  - On-Base Pilot Study Testing for PFAS Technologies
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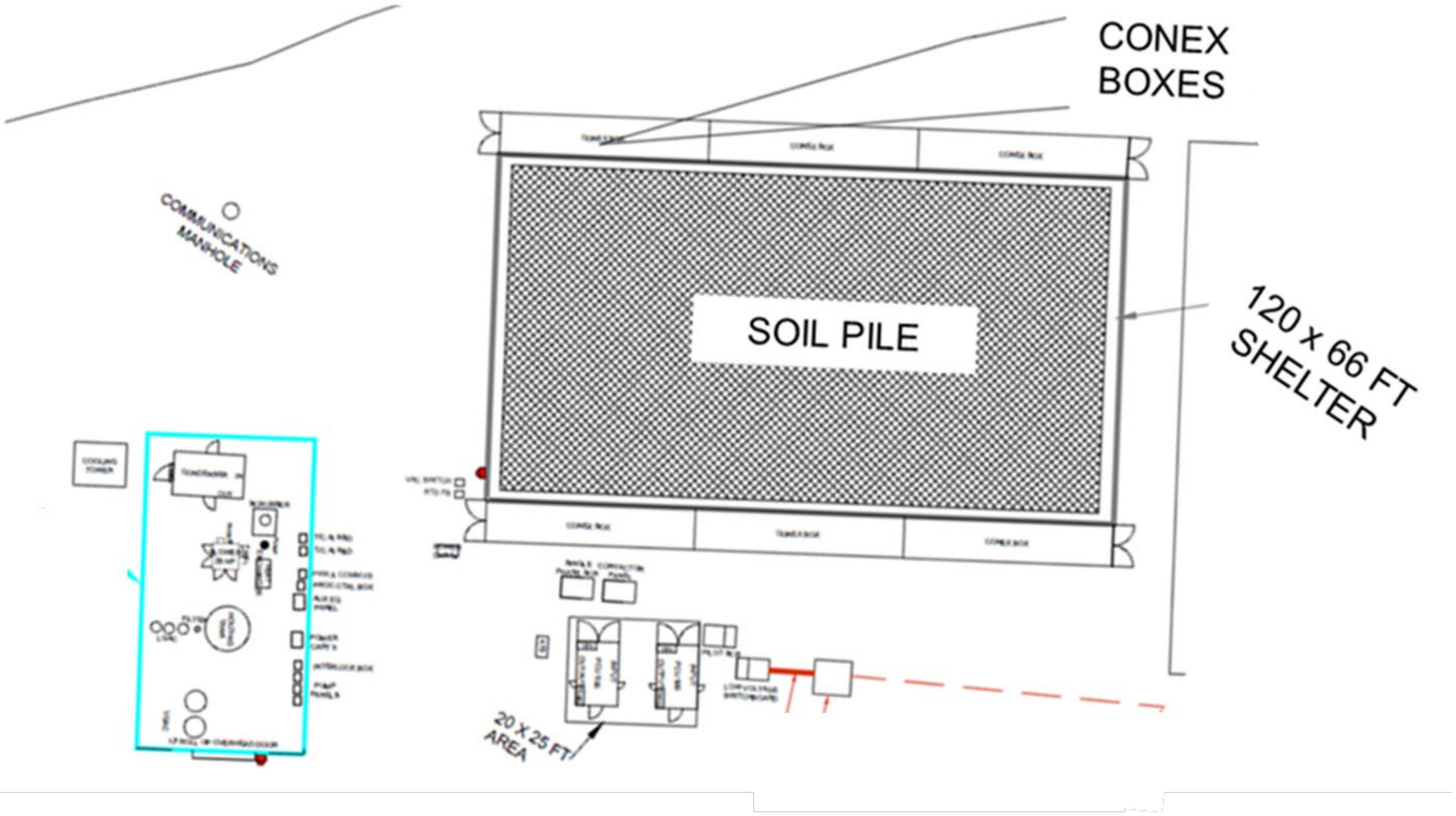
- Summary/Key Takeaways

Thermal Desorption

- Conducted under ESTCP ER23-8369 (Ongoing)
  - Joint Base Elmendorf-Richardson (JBER)
- Demonstrate ex situ thermal treatment of PFAS applying thermal conduction heating
- Objectives
  - PFAS removal in soil to below EPA Residential and ADEC RSLs
  - Treatment of PFAS in extracted vapors and process water

ADEC: Alaska Department of Environmental Conservation
ESTCP: Environmental Security Technology Certification Program
RSL: Regional Screening Level

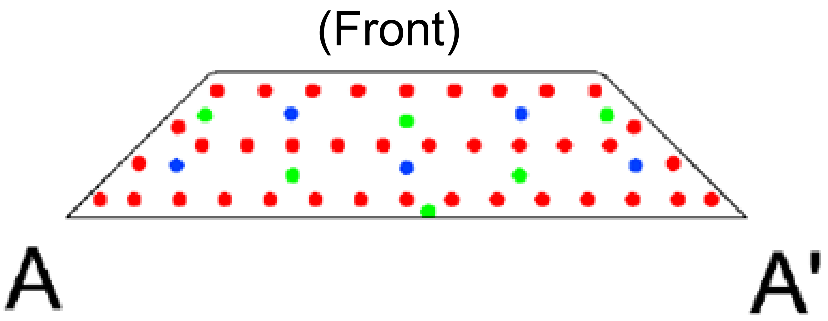
Equipment Layout (Top View)

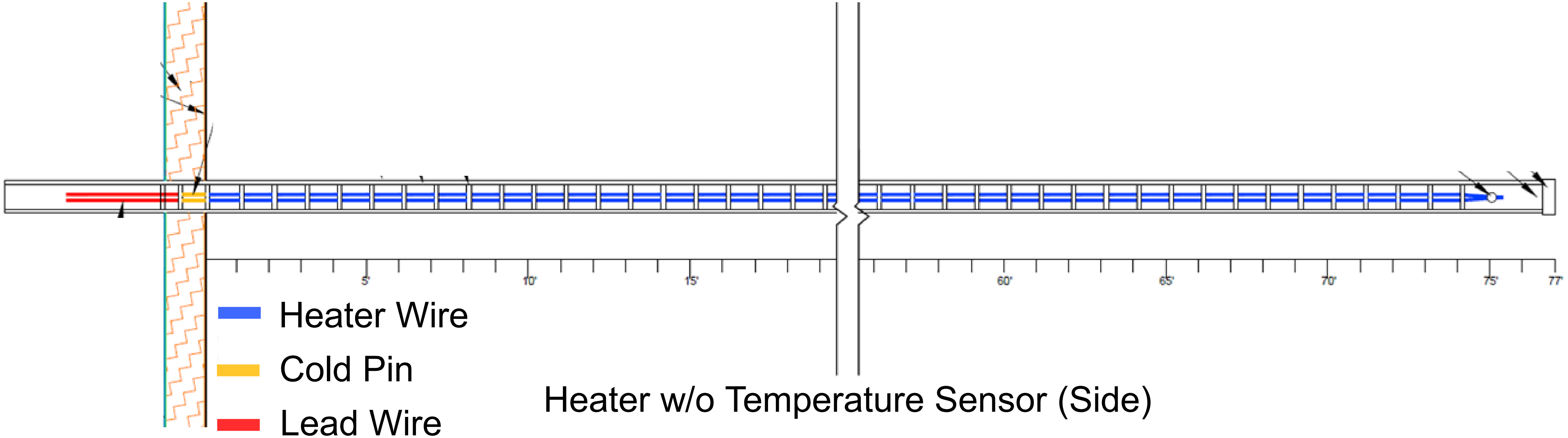


(TRS 2024)

Horizontal Heater Layout

- 🔴 Heater
- 🔵 Sampling and Temp Monitoring
- 🟢 Soil Vapor Extraction Point


(Front)



- 🟦 Heater Wire
- 🟨 Cold Pin
- 🟥 Lead Wire

Heater w/o Temperature Sensor (Side)

(TRS 2024)

Soil Stockpile Treatment Cell Construction

(TRS 2024)

Completed Soil Stockpile Treatment Cell

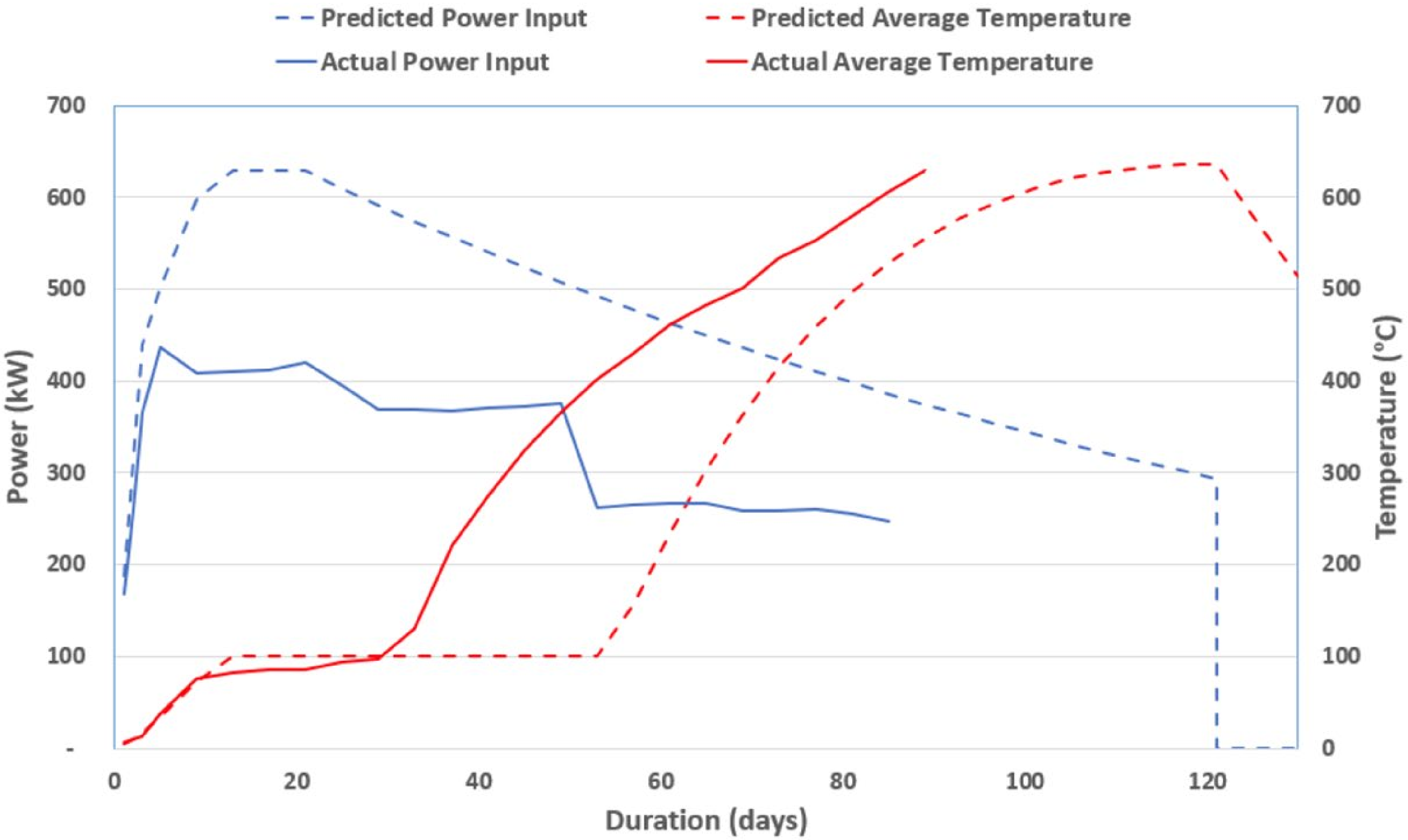
(TRS 2024)

Summary of Test Conditions

Title	Ex Situ JBER
Max Total PFAS Concentration (µg/kg)	50
Volume soil treated (yd^3)	2,000
Heated Zone Thickness/Height (ft)	13
Heater Orientation	Horizontal
Linear Heater Length (ft)	5,230
Linear Vapor Recovery Screen Length (ft)	360
Temperature Monitoring Sensors	30

yd^3: cubic yards

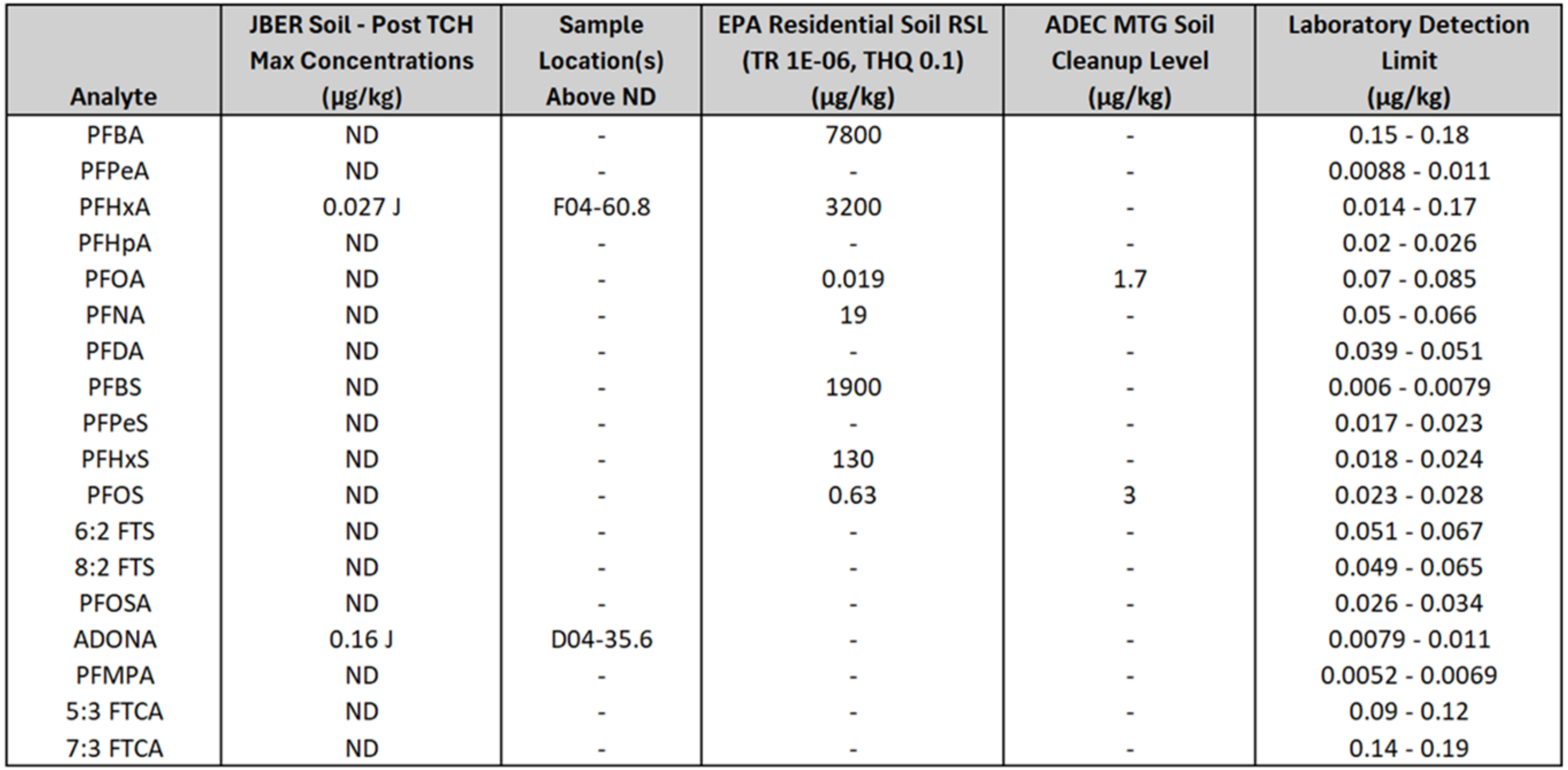
Thermal Desorption Results



kW: kilowatt

(TRS 2024)

Thermal Desorption Results



Analyte	JBER Soil - Post TCH Max Concentrations (µg/kg)	Sample Location(s) Above ND	EPA Residential Soil RSL (TR 1E-06, THQ 0.1) (µg/kg)	ADEC MTG Soil Cleanup Level (µg/kg)	Laboratory Detection Limit (µg/kg)
PFBA	ND	-	7800	-	0.15 - 0.18
PFPeA	ND	-	-	-	0.0088 - 0.011
PFHxA	0.027 J	F04-60.8	3200	-	0.014 - 0.17
PFHpA	ND	-	-	-	0.02 - 0.026
PFOA	ND	-	0.019	1.7	0.07 - 0.085
PFNA	ND	-	19	-	0.05 - 0.066
PFDA	ND	-	-	-	0.039 - 0.051
PFBS	ND	-	1900	-	0.006 - 0.0079
PFPeS	ND	-	-	-	0.017 - 0.023
PFHxS	ND	-	130	-	0.018 - 0.024
PFOS	ND	-	0.63	3	0.023 - 0.028
6:2 FTS	ND	-	-	-	0.051 - 0.067
8:2 FTS	ND	-	-	-	0.049 - 0.065
PFOSA	ND	-	-	-	0.026 - 0.034
ADONA	0.16 J	D04-35.6	-	-	0.0079 - 0.011
PFMPA	ND	-	-	-	0.0052 - 0.0069
5:3 FTCA	ND	-	-	-	0.09 - 0.12
7:3 FTCA	ND	-	-	-	0.14 - 0.19

(TRS 2024)

MTG: migration to groundwater
ND: nondetect
TCH: thermal conduction heating
THQ: target hazard quotient
TR: target risk

KEY POINT

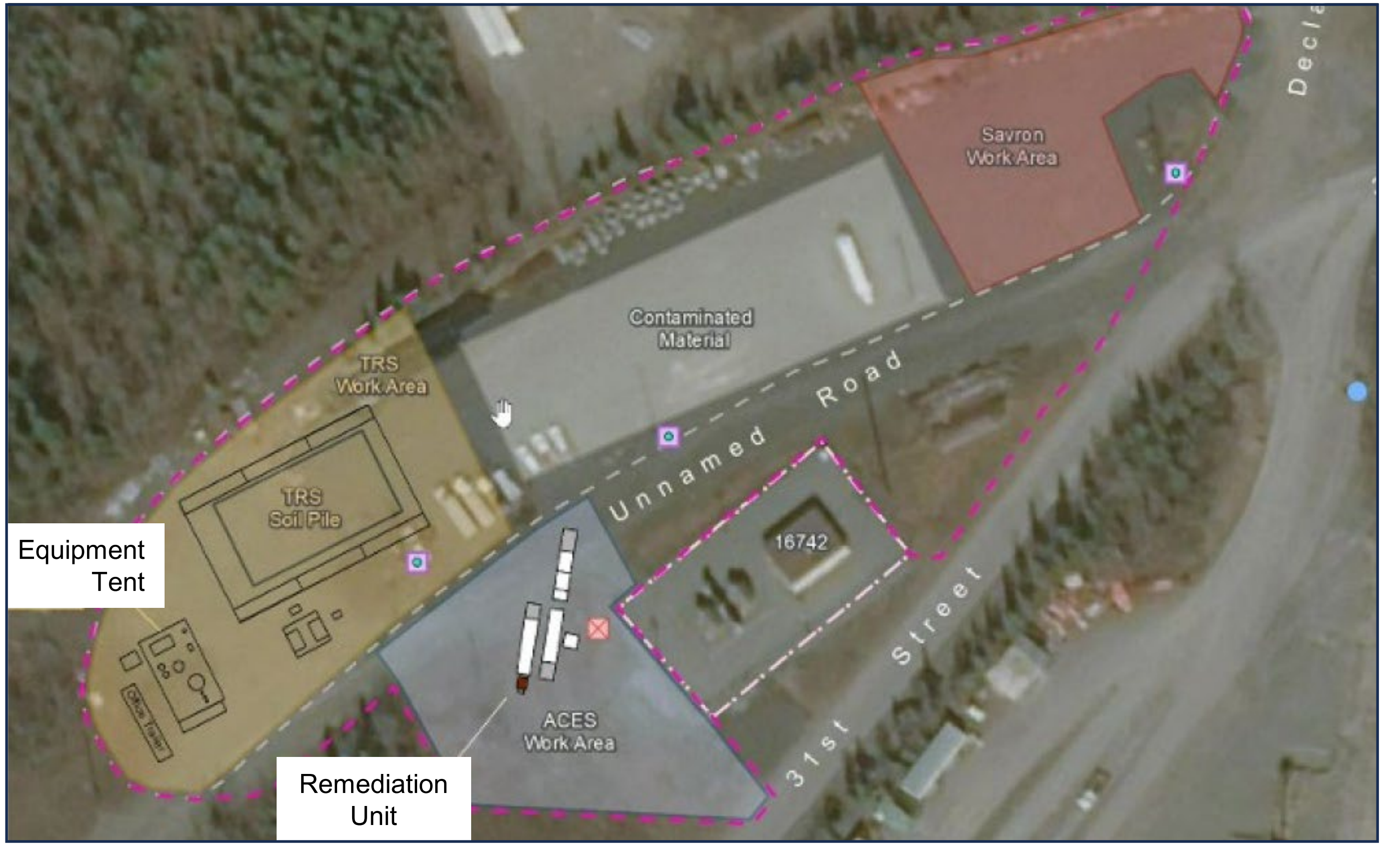
All locations tested below Alaska DEC standards and EPA Residential RSLs.

Thermal Desorption Summary

- Highly scalable and adaptable technology to handle variable treatment scenarios
  - May be operated both in situ and ex situ
  - Large soil volumes may be easily addressed through additional electrode placement
- Soil treated to below Alaska DEC soil cleanup levels and EPA Residential RSLs
- Combined PFOA and PFOS concentrations in discharge process water below 4 ng/L

ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

Smoldering Combustion Conducted at JBER



(Savron 2024)

- Design/fabricate system consisting of two 35-cubic-meter treatment vessels
- Demonstrate treatment of PFAS-impacted soil to below ADEC MTG criteria for PFOS and PFOA
- Generate technology performance data

System Fabrication

(Savron 2024)

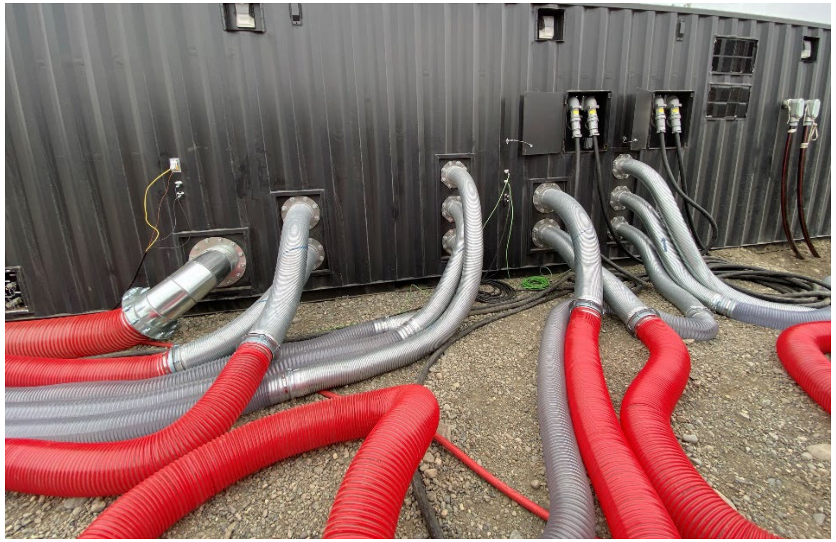
System Fabrication

(Savron 2024)

Smoldering Combustion Field Implementation

(Savron 2024)

Smoldering Combustion Field Implementation



(Savron 2024)

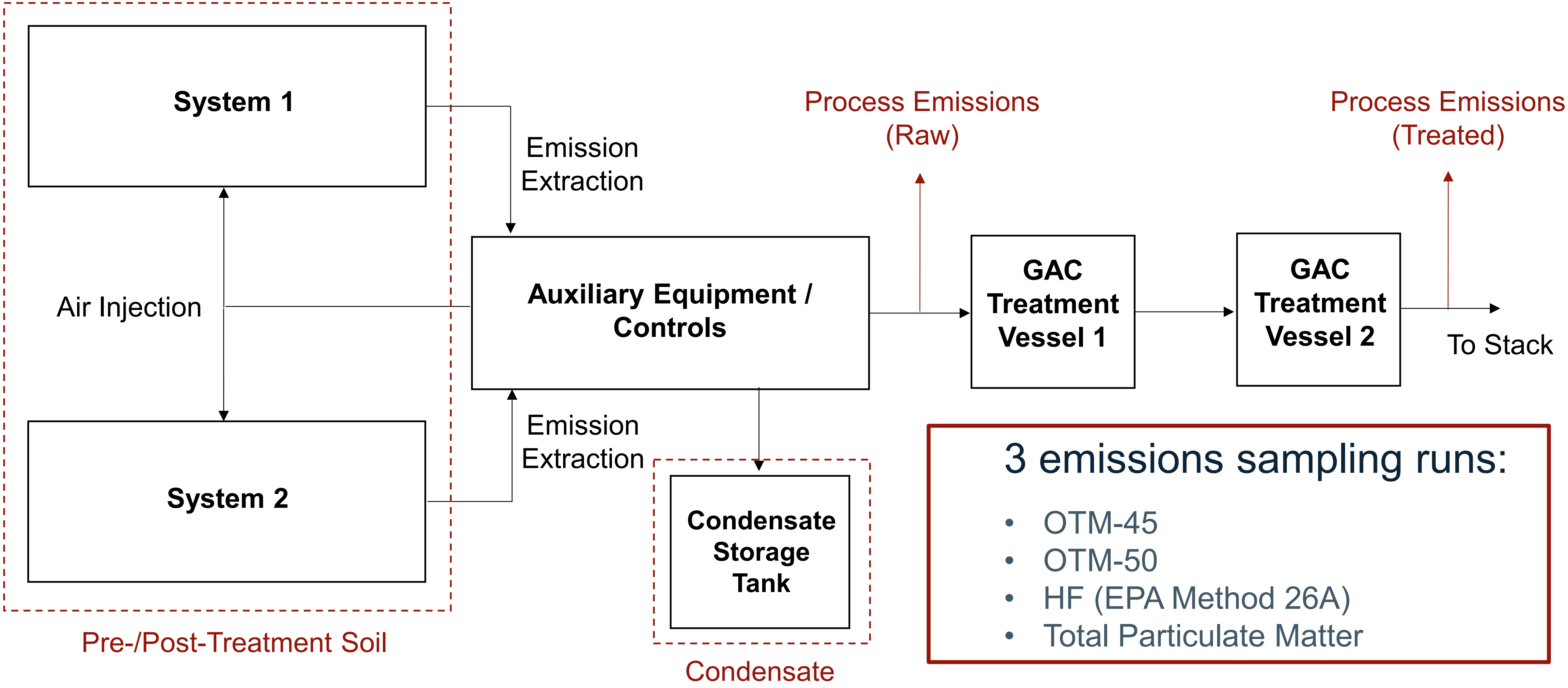
Smoldering Combustion Field Implementation

(Savron 2024)

Smoldering Combustion Field Implementation

(Savron 2024)

Smoldering Combustion Sampling



3 emissions sampling runs:

- OTM-45
- OTM-50
- HF (EPA Method 26A)
- Total Particulate Matter

(Deeb et al. 2023)

Smoldering Combustion Results Summary

(Savron 2024)

Soil Results

- > 99.9% reduction of PFAS (to near or below detection limits)
- Fluorine primarily retained as calcium fluoride (CaF_2)

Emissions Results

- < 0.2% of total fluorine emitted as PFAS
- < 2% of total fluorine emitted as HF
- Fluorinated breakdown products can be captured via vapor-phase GAC

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Guidelines for Selecting/Implementing Technologies

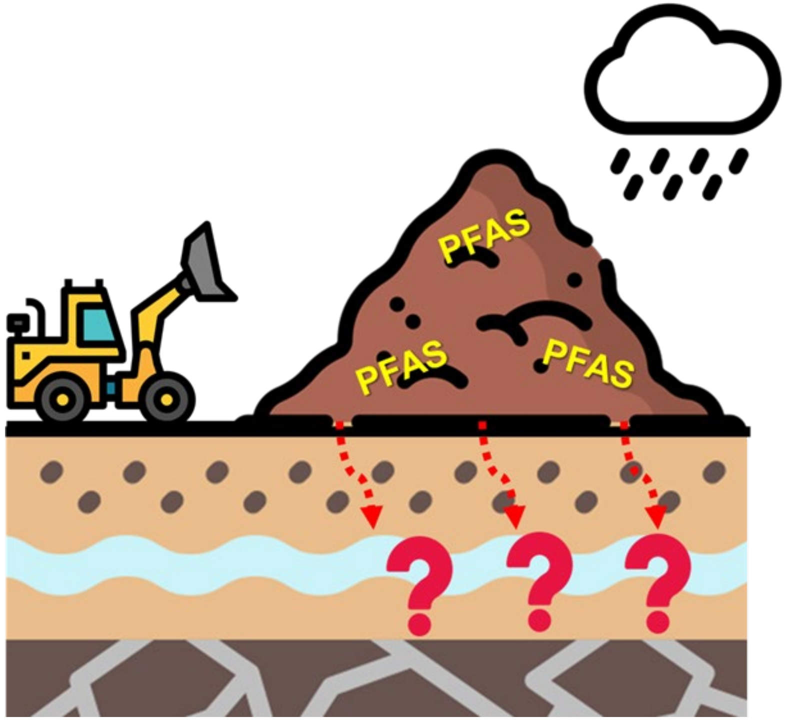
- Ensure remedy can achieve protectiveness of human health and environment through eliminating exposure pathways or preventing contact with receptors
  - Understand that containment, institutional controls, etc., may be only technically practicable strategy
- Leverage historical data from treatability studies and past implementation at the installation (or under similar conditions)

ERP: Environmental Restoration Program
FS: feasibility study
Navy: Department of the Navy

- Conduct bench-scale and on-site pilot treatability studies if sufficient information for technology cost and performance is not available for conditions specific to your site
  - May be conducted under FS, remedial design/remedial action phases
- Perform alternatives analysis (Chapter 8; Navy ERP Manual)
- Collaborate with baselevel management offices
  - Technology footprint and setup may require additional permissions
- Develop contingencies (alternative handling or disposal methods and costs) of managing the treated soil, if it does not meet applicable screening criteria for unrestricted or planned use

Preliminary Considerations for Excavated Soils Management

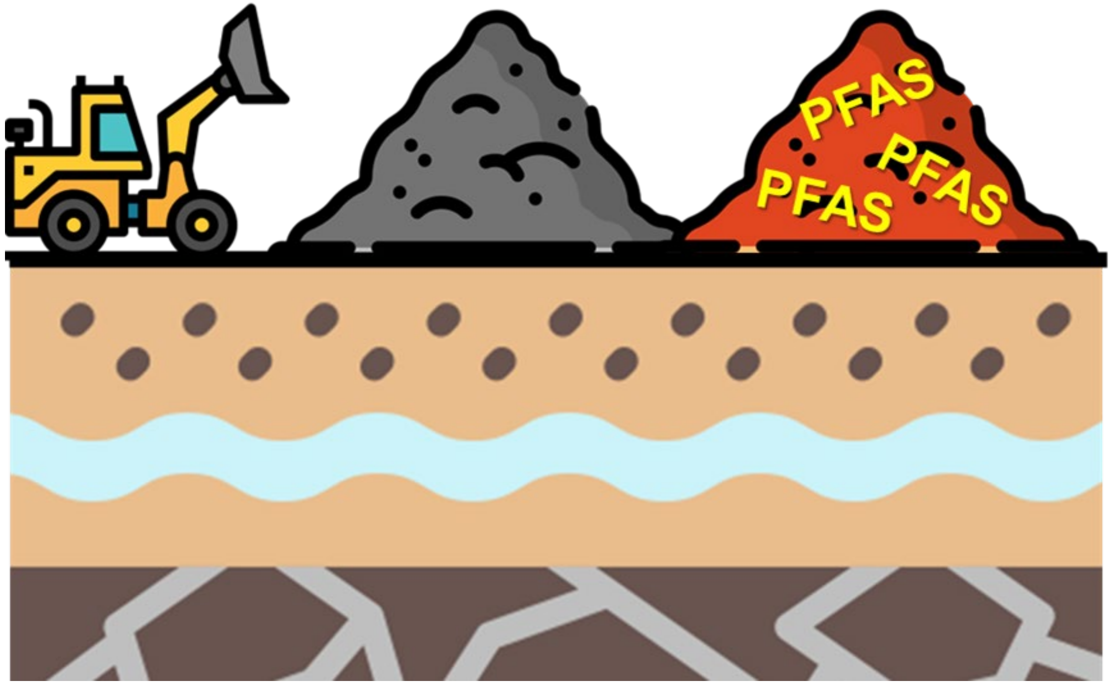
- Prior to Excavation
  - If available, leverage data from previous investigations (e.g., PA/SI, RI, etc.) to inform potential impacts to soils prior to excavation
  - If no data are available but there is suspected PFAS release in targeted excavation area, explore possibility for screening or characterization of excavated area
  - If excavated soil is to be stockpiled away from excavation site, identify whether any potential receiving groundwater and surface waters may be affected
    - Consider alternative storage areas
  - Maintenance of impermeable coverings and underlining



PA/SI: Preliminary Assessment/Site Inspection

Preliminary Considerations for Excavated Soils Management

- During & Post-Excavation
  - If available, use characterization data to segregate soils based on high vs low concentrations/non-detect to promote more cost-effective management
  - Keep other construction debris (e.g., asphalt or concrete) separate from soils



Presentation Overview

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Summary and Key Takeaways

- Management of PFAS-impacted soils and other impacted materials (e.g., aggregate) are an ongoing issue at multiple installations
  - To date: Limited availability of effective technologies for removing PFAS from soils; some strategies show promise and have more advanced Technology Readiness Levels (TRLs)
- Presented existing and developing strategies for PFAS-impacted solids management
  - Mature
    - Landfilling (off-site)
  - Developing
    - Thermal (on-site)
      - Desorption
      - Smoldering Combustion
    - Soil washing (on-site; likely requires off-site disposal for some components)
    - Stabilization

Summary and Key Takeaways

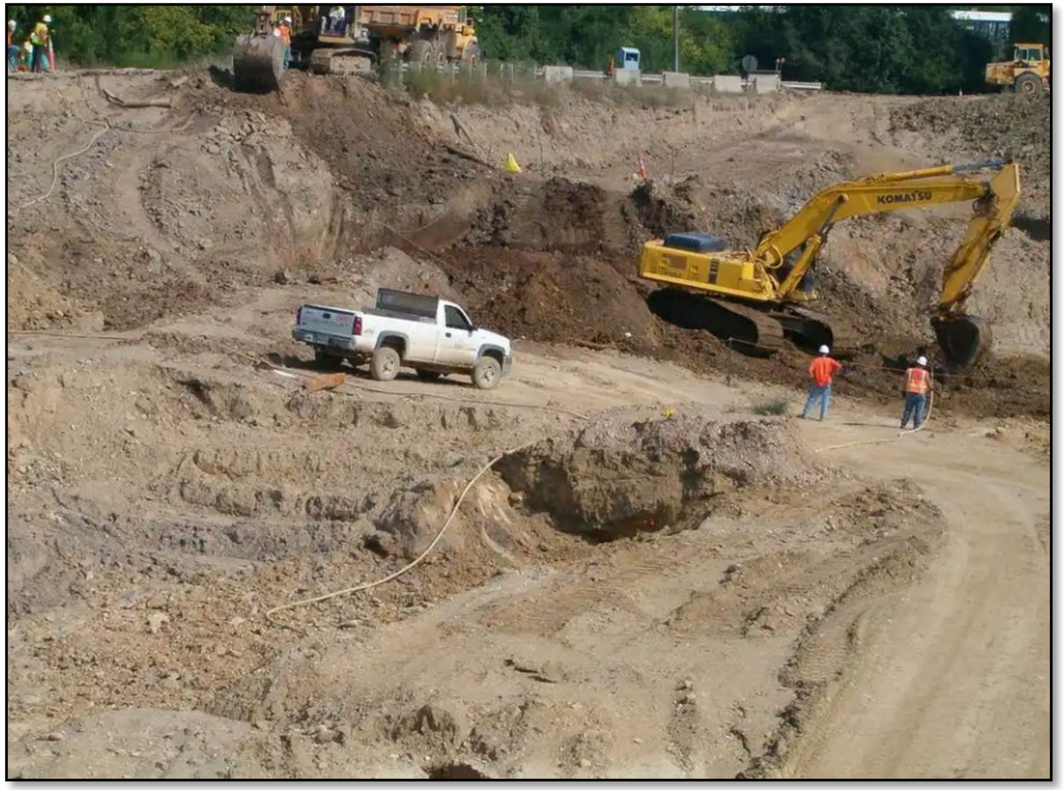
- Both Thermal Desorption and Smoldering Combustion processes demonstrated considerable removal performance with PFAS-impacted JBER soils
  - PFAS removal to non-detect for most target analytes in treated soils*
- Described process limitations, emissions considerations

(National Archives 1988)

*Target analyte list could grow in the future, as analytical methods improve

Summary and Key Takeaways

- Landfilling: Make early contact with disposal facilities to determine requirements and availability
- Coordinate technology use with regulators prior to demonstration or implementation at your site
- OSD plans to update relevant disposal guidance; RPMs should always follow Navy and OSD PFAS policy
- Develop applicable screening criteria and alternative handling or disposal methods for treated soil before project starts



(National Archives 2010)

OSD: Office of the Secretary of Defense
RPM: remedial project manager

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Naval Facilities Engineering Systems Command
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Questions

Naval Facilities Engineering Systems Command
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Optimization Tools and Strategies Implemented at Sites with Long-Term Remediation Systems

Mike Perlmutter, PE, Jacobs

RITS 2025

Disclaimer

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Information in this presentation is current as of 9 May 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Mike Perlmutter, PE
Senior Environmental Engineer

- Bachelor of Science from Georgia Tech
- Master of Science from University of Texas at Austin
- Senior environmental engineer with more than 25 years of experience evaluating and designing a wide range of remediation systems to address contaminated soil and groundwater at numerous federal and commercial project sites
- Experience includes conducting feasibility and corrective measures studies; designing, implementing, and operating a wide range of cost-effective in situ and ex situ remedial systems for impacted soil and groundwater sites; and interpreting analytical and field data from environmental investigations and bench-, pilot-, and full-scale remedy applications

Presentation Overview

- Introduction
- Optimization Basics
- Case Study #1: JBPHH Former Aiea Laundry Facility
- Case Study #2: Camp Lejeune Site 78
- Case Study #3: NAPR SWMUs 7 and 8
- Case Study #4: ABL Site 10
- Key Takeaways

ABL: Allegany Ballistics Laboratory
JBPHH: Joint Base Pearl Harbor-Hickam
NAPR: Naval Activity Puerto Rico
SWMU: solid waste management unit

What is Optimization and its Objectives?

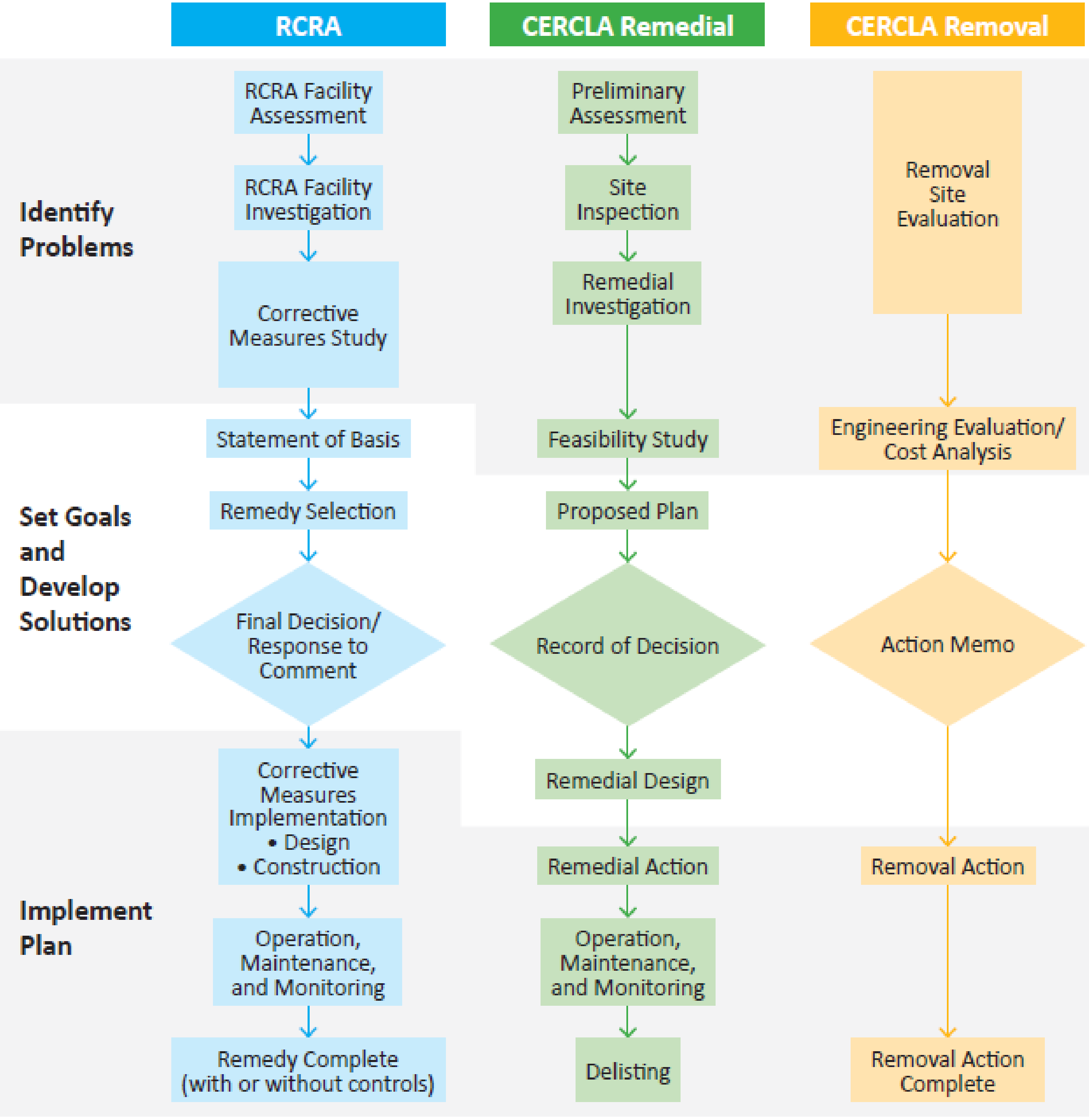
- Systematic review process with goal to achieve RC and ultimately SC in shortest amount of time and with least possible remedy footprint and expenditure (NAVFAC EXWC 2012)
- Specific objectives
  - Improve system performance
  - Reduce time to achieve response complete and site closeout
  - Reduce LCCs
  - Minimize impacts to mission and community
  - Maintain protectiveness of human health and the environment

LCCs: life-cycle costs
RC: response complete
SC: site closeout

When is Optimization Applied?

- Applicable to range of regulatory programs (e.g., CERCLA, RCRA, state programs)
- Applicable throughout lifecycle of a site

(NAVFAC n.d.)



Identify Problems

Set Goals and Develop Solutions

Implement Plan

RCRA

RCRA Facility Assessment
RCRA Facility Investigation
Corrective Measures Study
Statement of Basis
Remedy Selection
Final Decision/ Response to Comment
Corrective Measures Implementation
• Design
• Construction
Operation, Maintenance, and Monitoring
Remedy Complete (with or without controls)

CERCLA Remedial

Preliminary Assessment
Site Inspection
Remedial Investigation
Feasibility Study
Proposed Plan
Record of Decision
Remedial Design
Remedial Action
Operation, Maintenance, and Monitoring
Delisting

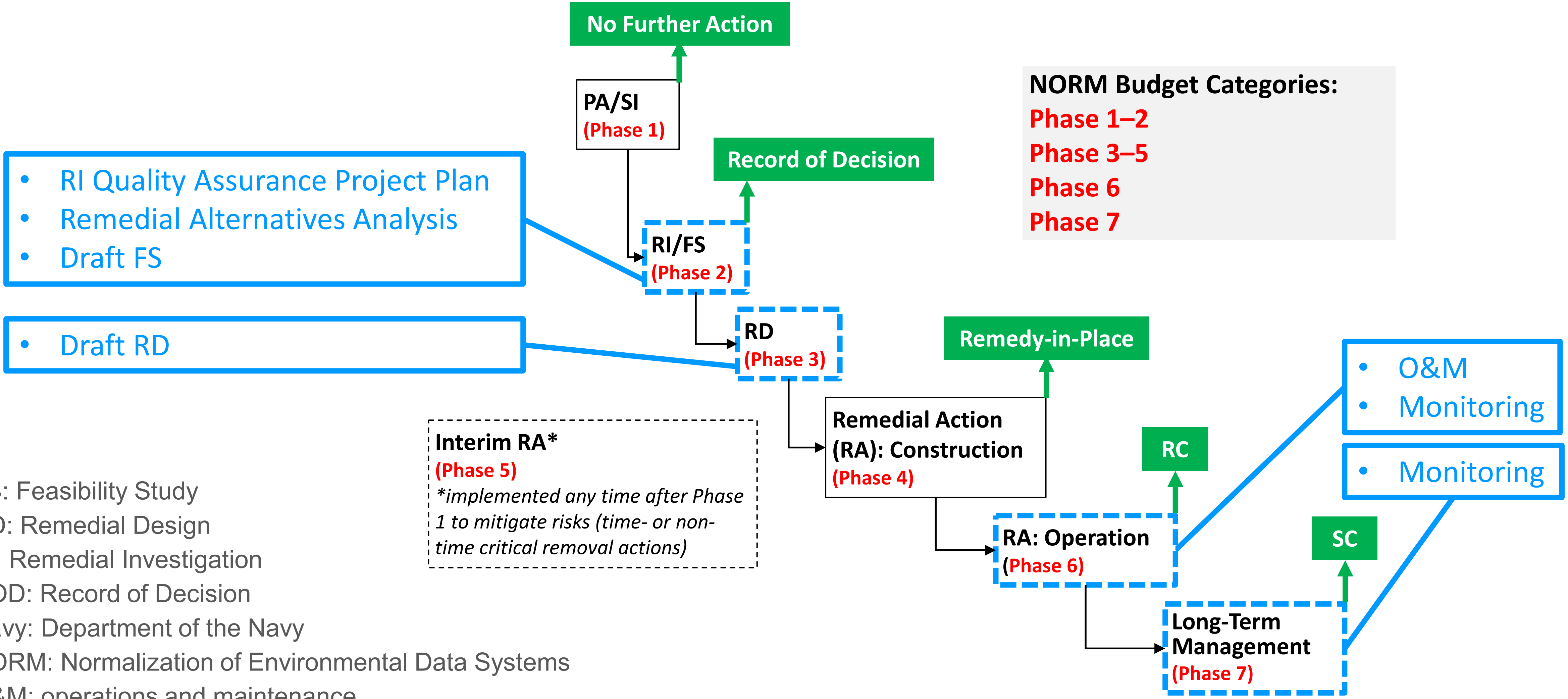
CERCLA Removal

Removal Site Evaluation
Engineering Evaluation/ Cost Analysis
Action Memo
Removal Action
Removal Action Complete

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act

RCRA: Resource Conservation and Recovery Act

When and How is Optimization Commonly Applied at Navy CERCLA Sites?



No Further Action

PA/SI
(Phase 1)

Record of Decision

- RI Quality Assurance Project Plan
- Remedial Alternatives Analysis
- Draft FS

RI/FS
(Phase 2)

- Draft RD

RD
(Phase 3)

Remedy-in-Place

Remedial Action (RA): Construction
(Phase 4)

Interim RA*
(Phase 5)
**implemented any time after Phase 1 to mitigate risks (time- or non-time critical removal actions)*

RC

RA: Operation
(Phase 6)

- O&M
- Monitoring

SC

- Monitoring

Long-Term Management
(Phase 7)

NORM Budget Categories:
Phase 1–2
Phase 3–5
Phase 6
Phase 7

FS: Feasibility Study
RD: Remedial Design
RI: Remedial Investigation
ROD: Record of Decision
Navy: Department of the Navy
NORM: Normalization of Environmental Data Systems
O&M: operations and maintenance
PA/SI: Preliminary Assessment Site Inspection

What are Common Triggers for Optimization?

- O&M and/or sampling data are consistent and predictable
- Contaminant mass recovery has become asymptotic
- Mechanical system repairs are required more frequently
- Costs per pound of contaminant removed are significantly increasing
- Contaminant concentrations in impacted site media are not decreasing according to the planned remediation timeframe
- Remedy not expected to meet RAOs

RAO: Remedial Action Objective

Relevant Guidance Documents and Support

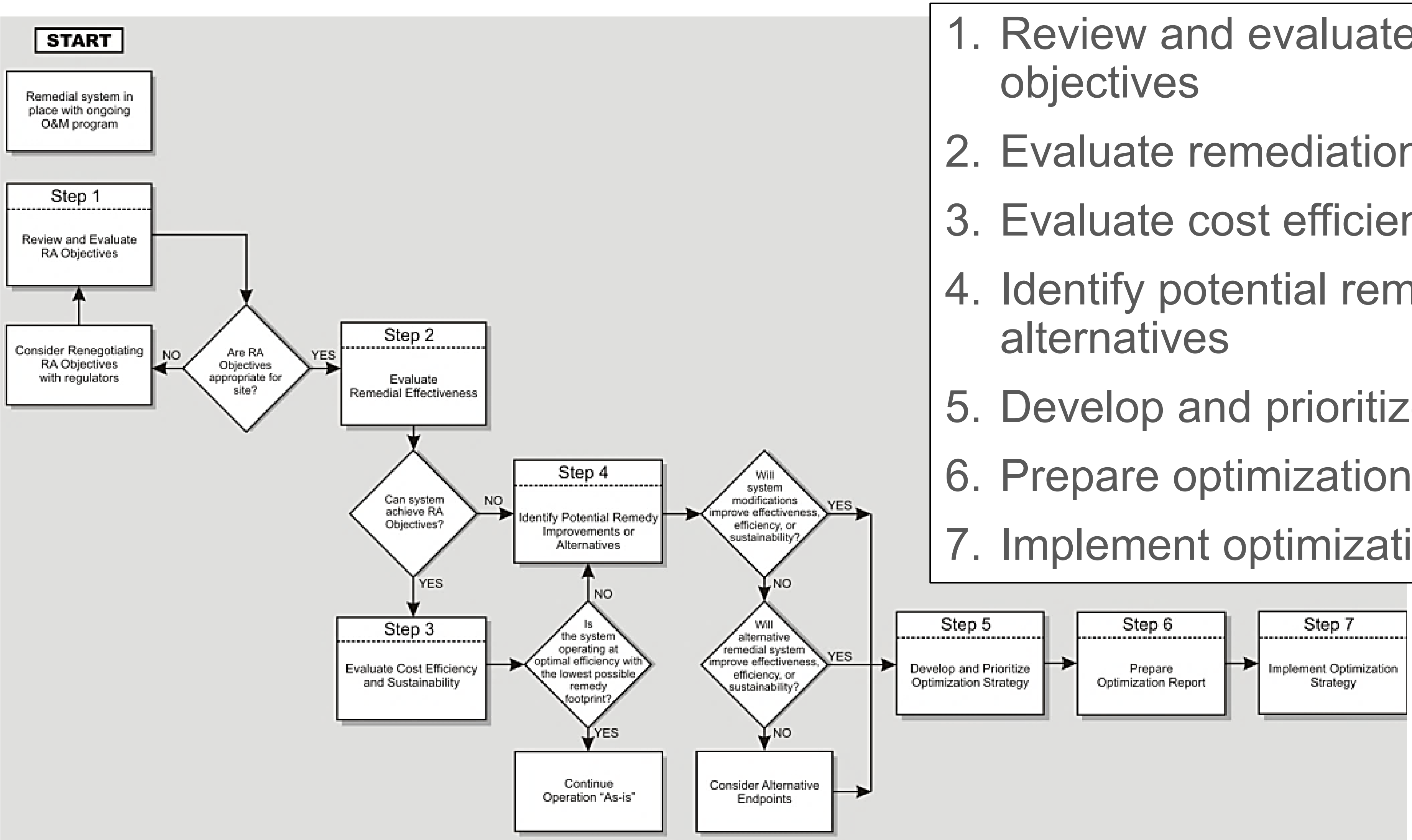
- Optimizing Remedy Selection and the Site Closeout Process – Naval Civil Engineer Corps Officers School Environmental Training **(current)**
  - Provides instruction on making technically sound and cost-effective remedial action decisions for Navy and Marine Corps ERP sites in a manner consistent with regulatory and Navy/Marine Corps policy requirements
- NAVFAC Optimizing Remediation Technologies (NAVFAC EXWC) **(2022)**
  - Provides technology-specific guidance for optimization of 15 commonly applied remediation technologies
- Case Study Review of Optimization Practices and Navy Petroleum Sites (NAVFAC EXWC) **(2021)**
  - Provides an overview of optimization concepts as applied to the cleanup of petroleum sites
- Guidance for Optimizing Remedial Action Operation (NAVFAC EXWC) **(2012)**
  - Focuses on ways to design and optimize remedial action operations to maximize cost efficiency and minimize the remedy footprint while maintaining effectiveness

ERP: Environmental Restoration Program

Relevant Guidance Documents and Support

- Five Year Review Guidance (NAVFAC EXWC n.d.) **(2011 and later)**
  - Clearinghouse of federal guidance documents for preparing Five-Year Reviews to assess whether the remedies selected for a site are functioning as intended and continue to be protective of human health and the environment
- NAVFAC Tiered Approach for Developing Sampling and Analysis Plan (Navy) **(2011)**
  - Provides guidance for the use and development of sampling and analysis plans using a tiered approach and employing a systematic planning process for ERP sites
- Policy for Optimizing Remedial and Removal Actions under the ERPs (Navy) **(2004)**
  - Establishes procedures for optimizing the screening, evaluation, selection, design, and implementation for long-term operation and management of response actions conducted under the ERP
- Optimization checklists for 22 processes (USACE n.d.) **(1999 and later)**
  - Provides process-specific checklists to guide optimization of 22 mechanical processes associated with commonly-applied remediation approaches

Guidance for Optimizing Remedial Action Operation



1. Review and evaluate remedial action objectives
2. Evaluate remediation effectiveness
3. Evaluate cost efficiency and sustainability
4. Identify potential remedy improvements or alternatives
5. Develop and prioritize optimization strategy
6. Prepare optimization report
7. Implement optimizations recommendations

(NAVFAC EXWC 2012)

Common Tools or Methods for Optimization

- Desktop tools
  - Statistical
  - Sustainability
  - Groundwater modeling
  - Value engineering
- MBTs + treatability testing
- Site characterization
  - High resolution
  - Conventional
- Other approaches
  - Risk assessment, regulatory/partnering, and system O&M

MBTs: molecular biological tools

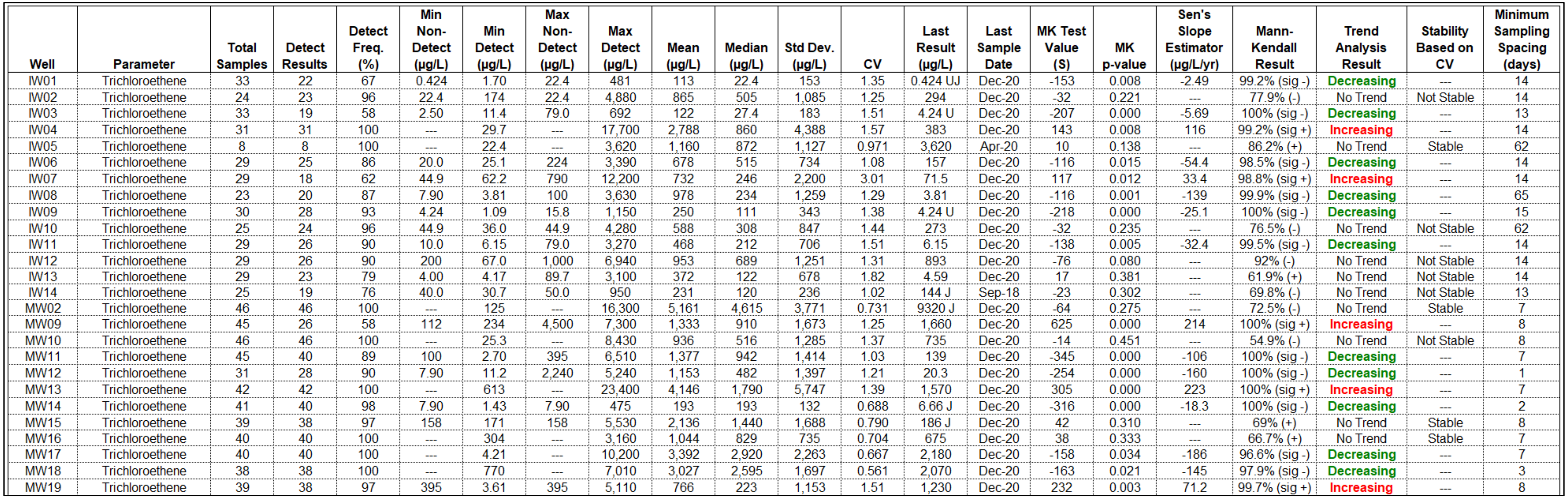
Desktop Tools

Example Tool	Description	Why use?	Typical Phase
Statistical Tools			
MAROS	Evaluates optimal number of sampling locations and frequency, and laboratory analytes; plume stability conditions and remedy performance	Optimize monitoring program to reduce LCCs	6,7
Mann-Kendall and regression analyses *(Case Studies 1 and 4)*	Nonparametric method used to identify whether there is a statistically significant trend over a period of monitoring and various methods to calculate slope of a series of concentration data	Estimate remediation timeframes at specific sampling locations and optimize monitoring program to reduce LCCs	6,7
Plume mass and center-of-mass analysis	Uses a consistent set of monitoring wells to calculate the total contaminant dissolved-phase mass and location of the center-of-mass over time	Provides a measure of overall plume behavior	6,7
SERDP TA^2 tool *(Case Study 4)*	Provides a sound framework to guide site management decisions about transitioning to MNA	Determine whether MNA can be used to meet site objectives within a reasonable timeframe	6,7

MAROS: Monitoring and Remediation Optimization System
MNA: monitored natural attenuation

SERDP: Strategic Environmental Research and Development Program
TA^2: Transition Assessment Teaching Assistant

Desktop Tools



Well	Parameter	Total Samples	Detect Results	Detect Freq. (%)	Min Non-Detect (µg/L)	Min Detect (µg/L)	Max Non-Detect (µg/L)	Max Detect (µg/L)	Mean (µg/L)	Median (µg/L)	Std Dev. (µg/L)	CV	Last Result (µg/L)	Last Sample Date	MK Test Value (S)	MK p-value	Sen's Slope Estimator (µg/L/yr)	Mann-Kendall Result	Trend Analysis Result	Stability Based on CV	Minimum Sampling Spacing (days)
IW01	Trichloroethene	33	22	67	0.424	1.70	22.4	481	113	22.4	153	1.35	0.424 UJ	Dec-20	-153	0.008	-2.49	99.2% (sig -)	Decreasing	---	14
IW02	Trichloroethene	24	23	96	22.4	174	22.4	4,880	865	505	1,085	1.25	294	Dec-20	-32	0.221	---	77.9% (-)	No Trend	Not Stable	14
IW03	Trichloroethene	33	19	58	2.50	11.4	79.0	692	122	27.4	183	1.51	4.24 U	Dec-20	-207	0.000	-5.69	100% (sig -)	Decreasing	---	13
IW04	Trichloroethene	31	31	100	---	29.7	---	17,700	2,788	860	4,388	1.57	383	Dec-20	143	0.008	116	99.2% (sig +)	Increasing	---	14
IW05	Trichloroethene	8	8	100	---	22.4	---	3,620	1,160	872	1,127	0.971	3,620	Apr-20	10	0.138	---	86.2% (+)	No Trend	Stable	62
IW06	Trichloroethene	29	25	86	20.0	25.1	224	3,390	678	515	734	1.08	157	Dec-20	-116	0.015	-54.4	98.5% (sig -)	Decreasing	---	14
IW07	Trichloroethene	29	18	62	44.9	62.2	790	12,200	732	246	2,200	3.01	71.5	Dec-20	117	0.012	33.4	98.8% (sig +)	Increasing	---	14
IW08	Trichloroethene	23	20	87	7.90	3.81	100	3,630	978	234	1,259	1.29	3.81	Dec-20	-116	0.001	-139	99.9% (sig -)	Decreasing	---	65
IW09	Trichloroethene	30	28	93	4.24	1.09	15.8	1,150	250	111	343	1.38	4.24 U	Dec-20	-218	0.000	-25.1	100% (sig -)	Decreasing	---	15
IW10	Trichloroethene	25	24	96	44.9	36.0	44.9	4,280	588	308	847	1.44	273	Dec-20	-32	0.235	---	76.5% (-)	No Trend	Not Stable	62
IW11	Trichloroethene	29	26	90	10.0	6.15	79.0	3,270	468	212	706	1.51	6.15	Dec-20	-138	0.005	-32.4	99.5% (sig -)	Decreasing	---	14
IW12	Trichloroethene	29	26	90	200	67.0	1,000	6,940	953	689	1,251	1.31	893	Dec-20	-76	0.080	---	92% (-)	No Trend	Not Stable	14
IW13	Trichloroethene	29	23	79	4.00	4.17	89.7	3,100	372	122	678	1.82	4.59	Dec-20	17	0.381	---	61.9% (+)	No Trend	Not Stable	14
IW14	Trichloroethene	25	19	76	40.0	30.7	50.0	950	231	120	236	1.02	144 J	Sep-18	-23	0.302	---	69.8% (-)	No Trend	Not Stable	13
MW02	Trichloroethene	46	46	100	---	125	---	16,300	5,161	4,615	3,771	0.731	9320 J	Dec-20	-64	0.275	---	72.5% (-)	No Trend	Stable	7
MW09	Trichloroethene	45	26	58	112	234	4,500	7,300	1,333	910	1,673	1.25	1,660	Dec-20	625	0.000	214	100% (sig +)	Increasing	---	8
MW10	Trichloroethene	46	46	100	---	25.3	---	8,430	936	516	1,285	1.37	735	Dec-20	-14	0.451	---	54.9% (-)	No Trend	Not Stable	8
MW11	Trichloroethene	45	40	89	100	2.70	395	6,510	1,377	942	1,414	1.03	139	Dec-20	-345	0.000	-106	100% (sig -)	Decreasing	---	7
MW12	Trichloroethene	31	28	90	7.90	11.2	2,240	5,240	1,153	482	1,397	1.21	20.3	Dec-20	-254	0.000	-160	100% (sig -)	Decreasing	---	1
MW13	Trichloroethene	42	42	100	---	613	---	23,400	4,146	1,790	5,747	1.39	1,570	Dec-20	305	0.000	223	100% (sig +)	Increasing	---	7
MW14	Trichloroethene	41	40	98	7.90	1.43	7.90	475	193	193	132	0.688	6.66 J	Dec-20	-316	0.000	-18.3	100% (sig -)	Decreasing	---	2
MW15	Trichloroethene	39	38	97	158	171	158	5,530	2,136	1,440	1,688	0.790	186 J	Dec-20	42	0.310	---	69% (+)	No Trend	Stable	8
MW16	Trichloroethene	40	40	100	---	304	---	3,160	1,044	829	735	0.704	675	Dec-20	38	0.333	---	66.7% (+)	No Trend	Stable	7
MW17	Trichloroethene	40	40	100	---	4.21	---	10,200	3,392	2,920	2,263	0.667	2,180	Dec-20	-158	0.034	-186	96.6% (sig -)	Decreasing	---	7
MW18	Trichloroethene	38	38	100	---	770	---	7,010	3,027	2,595	1,697	0.561	2,070	Dec-20	-163	0.021	-145	97.9% (sig -)	Decreasing	---	3
MW19	Trichloroethene	39	38	97	395	3.61	395	5,110	766	223	1,153	1.51	1,230	Dec-20	232	0.003	71.2	99.7% (sig +)	Increasing	---	8

Typical Mann-Kendall tabular output
(Jacobs 2021)

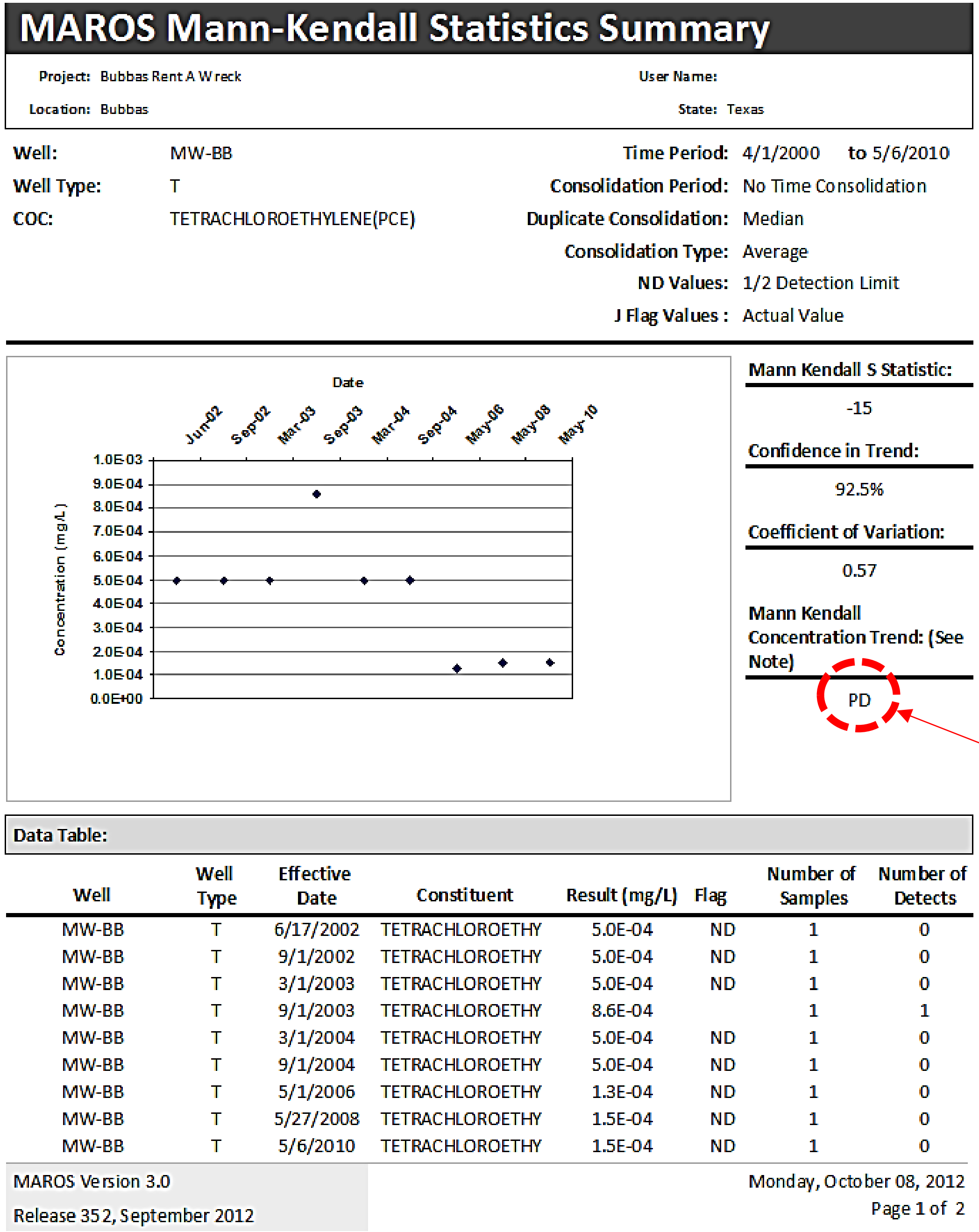
KEY POINT

Mann-Kendall provides statistically defensible trend analysis results that can be used to predict remediation timeframes or optimize the monitoring program.

Desktop Tools

KEY POINT

MAROS provides Statistics Summary Output for a well.



MAROS Mann-Kendall Statistics Summary

Project: Bubbas Rent A Wreck
User Name:
Location: Bubbas
State: Texas

Well: MW-BB
Well Type: T
COC: TETRACHLOROETHYLENE(PCE)

Time Period: 4/1/2000 to 5/6/2010
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Mann Kendall S Statistic:
-15

Confidence in Trend:
92.5%

Coefficient of Variation:
0.57

Mann Kendall Concentration Trend: (See Note)
PD

Probably decreasing

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
MW-BB	T	6/17/2002	TETRACHLOROETHY	5.0E-04	ND	1	0
MW-BB	T	9/1/2002	TETRACHLOROETHY	5.0E-04	ND	1	0
MW-BB	T	3/1/2003	TETRACHLOROETHY	5.0E-04	ND	1	0
MW-BB	T	9/1/2003	TETRACHLOROETHY	8.6E-04		1	1
MW-BB	T	3/1/2004	TETRACHLOROETHY	5.0E-04	ND	1	0
MW-BB	T	9/1/2004	TETRACHLOROETHY	5.0E-04	ND	1	0
MW-BB	T	5/1/2006	TETRACHLOROETHY	1.3E-04	ND	1	0
MW-BB	T	5/27/2008	TETRACHLOROETHY	1.5E-04	ND	1	0
MW-BB	T	5/6/2010	TETRACHLOROETHY	1.5E-04	ND	1	0

MAROS Version 3.0
Release 352, September 2012

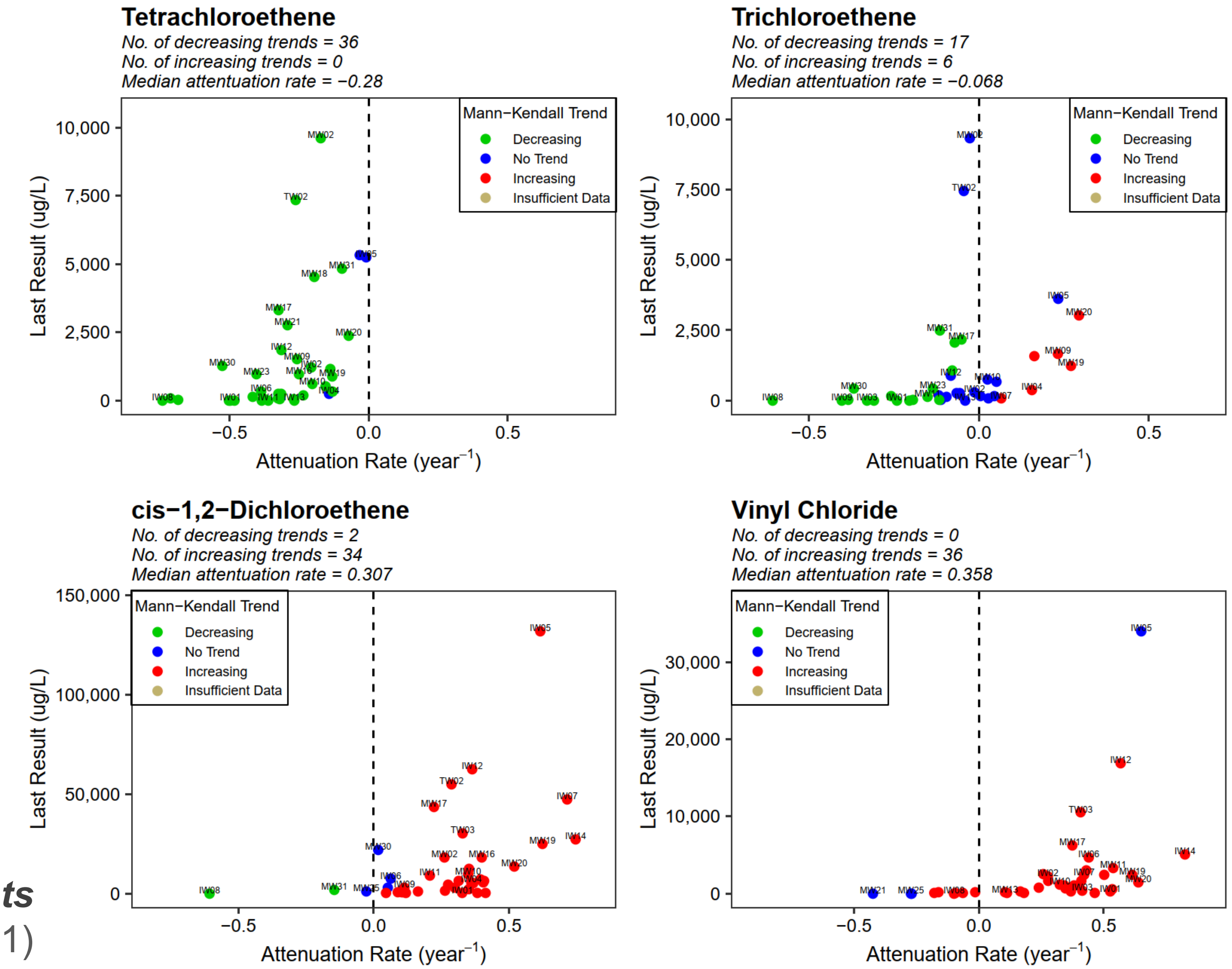
Monday, October 08, 2012
Page 1 of 2

Typical MAROS Well Summary
(GSI 2013)

Desktop Tools

KEY POINT

Combination plots consolidate trend data and attenuation rates from an entire monitoring network.

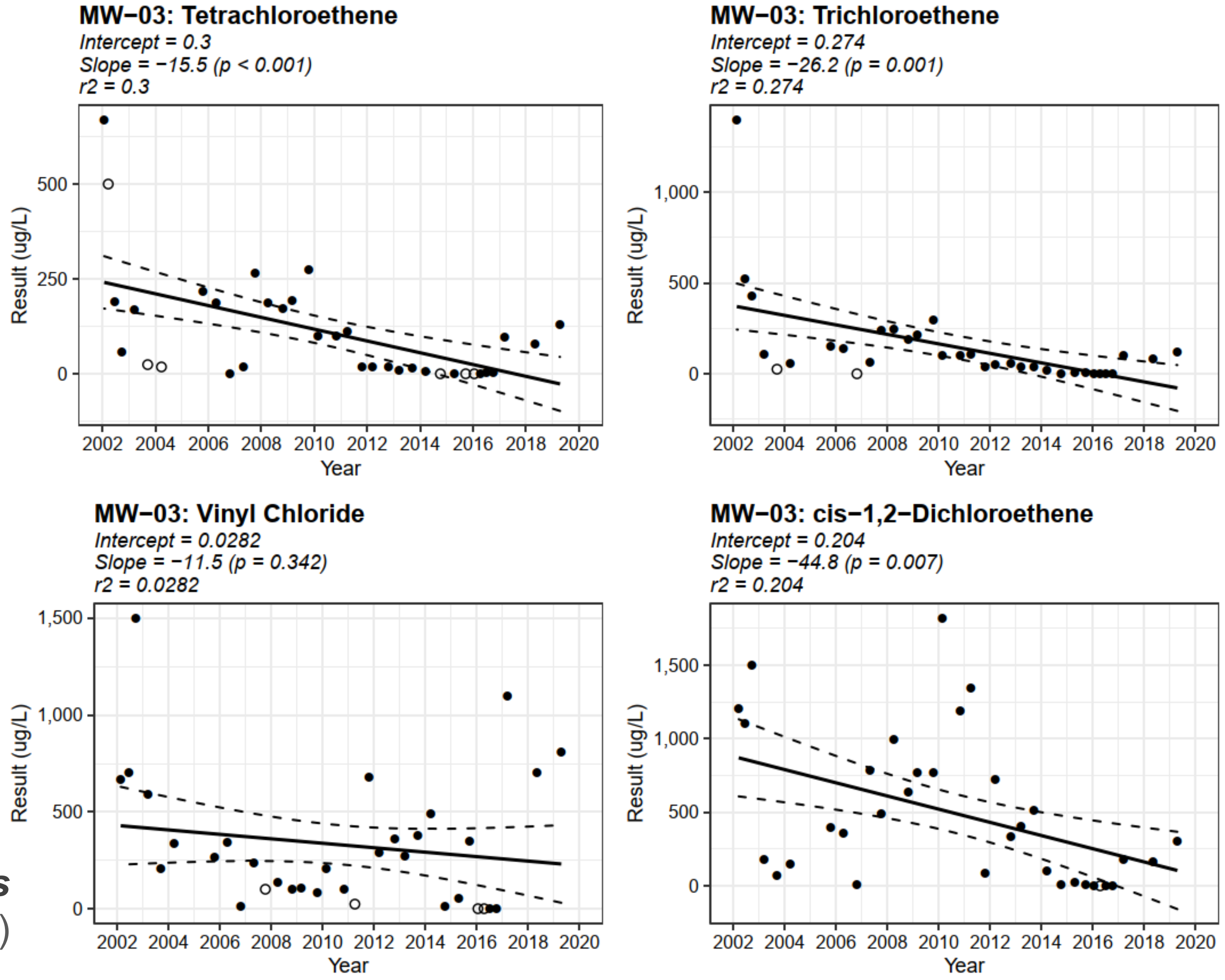


Combination Plots
(Jacobs 2021)

Desktop Tools

KEY POINT

Regression plots visualize concentration trends and their uncertainty.

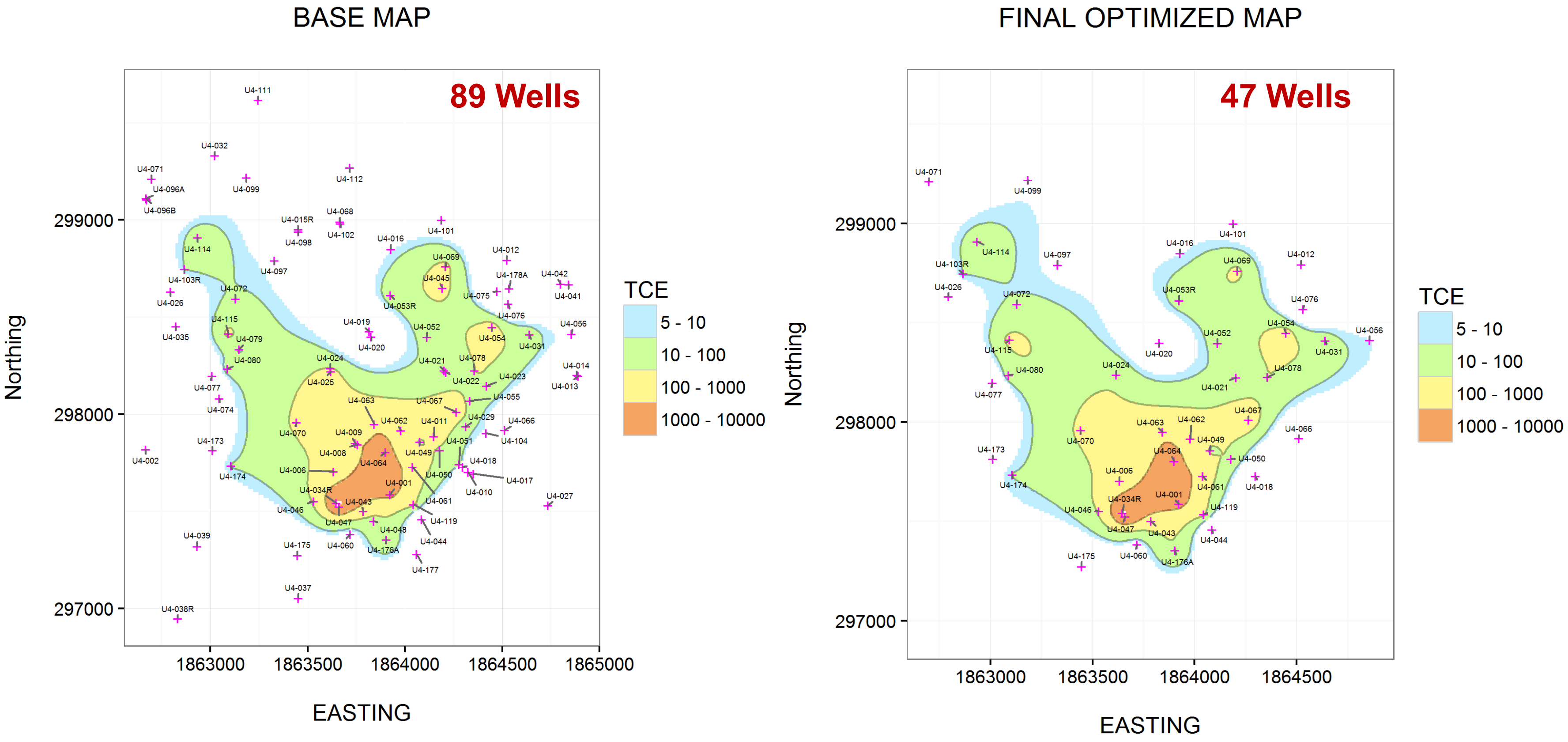


Regression Plots
(Jacobs 2021)

Desktop Tools

KEY POINT

Visualizes how optimized network has minimal affect on plume geometry.



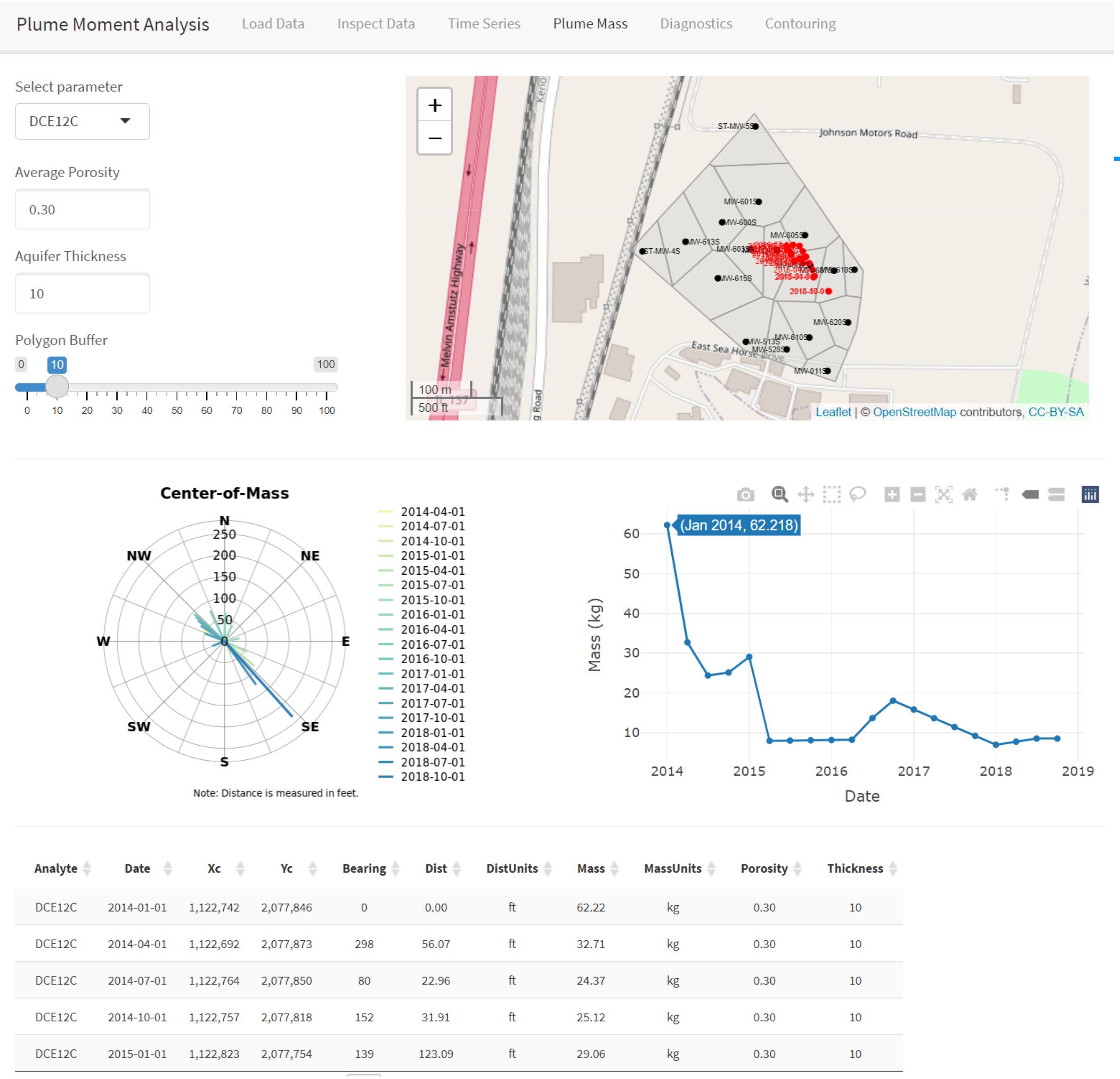
Optimization Plume Map Output

(Jacobs 2021)

Desktop Tools

KEY POINT

Plume moment analysis indicates whether a plume is shrinking, stable, or expanding, which informs an MNA evaluation.



Select parameter: DCE12C

Average Porosity: 0.30

Aquifer Thickness: 10

Polygon Buffer: 10 (range 0–100)

Analyte	Date	Xc	Yc	Bearing	Dist	DistUnits	Mass	MassUnits	Porosity	Thickness
DCE12C	2014-01-01	1,122,742	2,077,846	0	0.00	ft	62.22	kg	0.30	10
DCE12C	2014-04-01	1,122,692	2,077,873	298	56.07	ft	32.71	kg	0.30	10
DCE12C	2014-07-01	1,122,764	2,077,850	80	22.96	ft	24.37	kg	0.30	10
DCE12C	2014-10-01	1,122,757	2,077,818	152	31.91	ft	25.12	kg	0.30	10
DCE12C	2015-01-01	1,122,823	2,077,754	139	123.09	ft	29.06	kg	0.30	10

Plume Moment Analysis
(Jacobs 2021)

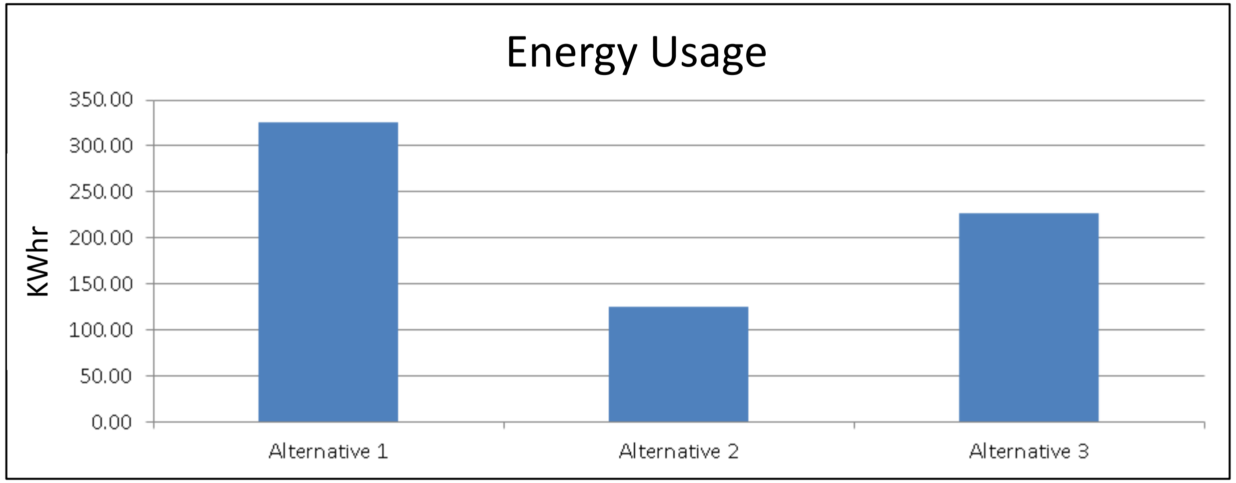
Desktop Tools

Example Tool	Description	Why use?	Typical Phase
Sustainability Tools			
SiteWise or Sustainable Remediation Tool	Assesses the environmental impact of remedial alternatives and technologies	Optimize operation of existing remediation systems to reduce environmental impact and LCCs	2,3,5,6

KEY POINT

Discuss with NAVFAC HQ prior to using SiteWise or other Sustainable Remediation Tool.

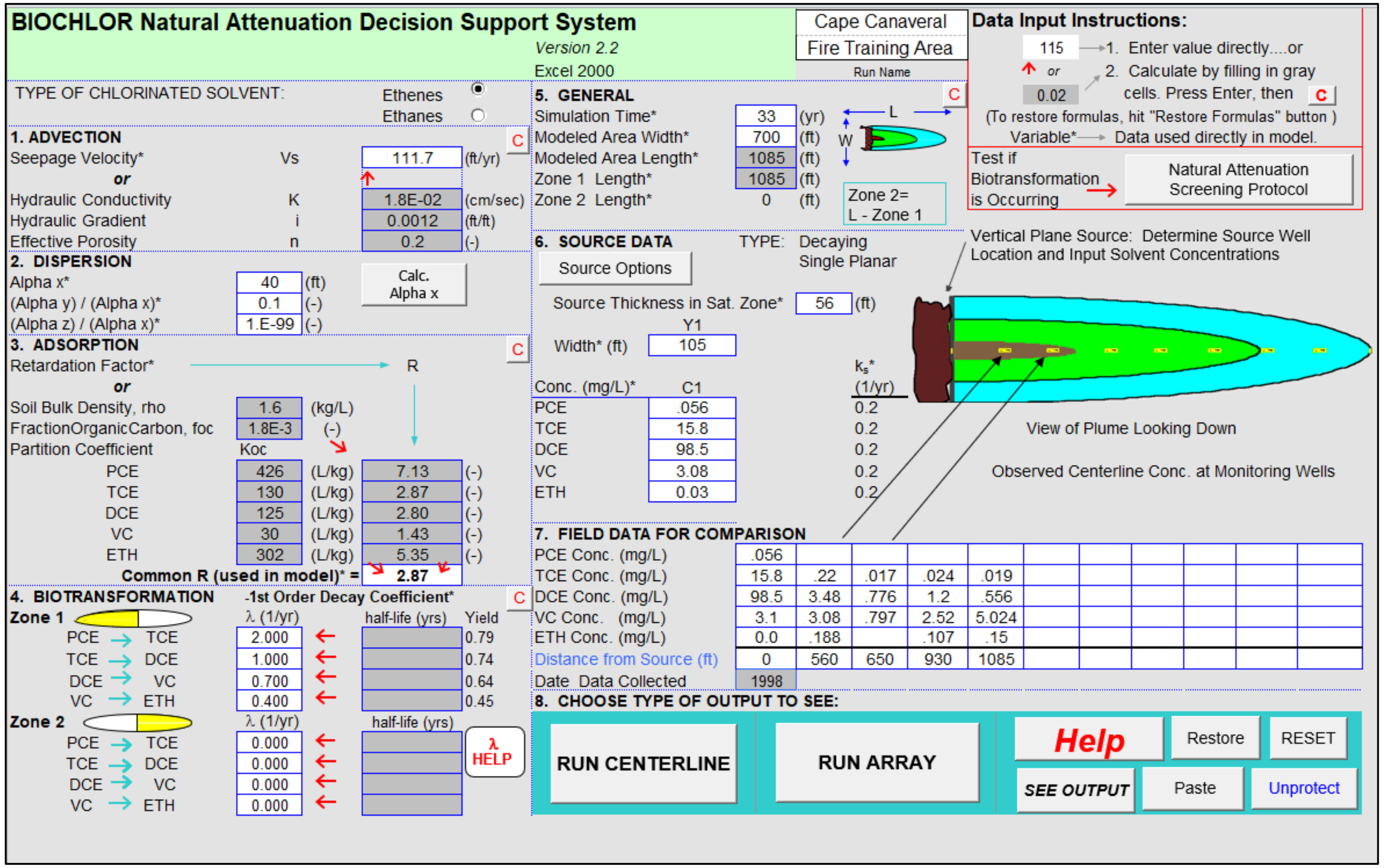
Example Output (Jacobs 2024)



Desktop Tools

Example Tool	Description	Why use?	Typical Phase
Groundwater Modeling Tools			
BIOCHLOR, BIOPLUME, or BIOSCREEN	One-dimensional screening models that simulate remediation by natural attenuation of chlorinated solvents and petroleum hydrocarbons	Simple spreadsheet-based models to estimate decay rates and assess whether MNA can be used to meet site objectives within a reasonable timeframe	2,6
REMChlor or REMChlor-Matrix Diffusion *(Case Study 2)*	Two-dimensional analytical solution for simulating transient effects of groundwater source and plume remediation	Integrates site-specific characteristics to estimate influence of various remediation scenarios, including source and plume treatment, and MNA, on remediation timeframes	2,3,5,6
MODFLOW-MT3D	Three-dimensional modular finite-difference flow model used to simulate flow of groundwater through aquifers and fate and transport of contaminants	Same as above, but with greater site characterization granularity plus the ability to simulate the hydraulic influence of remedial alternatives	2,3,5,6
Value Engineering			
Value Engineering	Systematic problem-solving technique involving thorough analysis of project functions using team dynamics to creatively consider design options	Reduce LCCs while meeting intended functions, and/or to maximize functionality for roughly the same cost	3,5

Desktop Tools



BIOCHLOR Natural Attenuation Decision Support System
Version 2.2
Excel 2000

Cape Canaveral
Fire Training Area
Run Name

Data Input Instructions:
115 → 1. Enter value directly....or
or
0.02 ↗ 2. Calculate by filling in gray cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: ● Ethenes ○ Ethanes

1. ADVECTION
Seepage Velocity* Vs 111.7 (ft/yr)
or
Hydraulic Conductivity K 1.8E-02 (cm/sec)
Hydraulic Gradient i 0.0012 (ft/ft)
Effective Porosity n 0.2 (-)

2. DISPERSION
Alpha x* 40 (ft)
(Alpha y) / (Alpha x)* 0.1 (-)
(Alpha z) / (Alpha x)* 1.E-99 (-)
Calc. Alpha x

3. ADSORPTION
Retardation Factor* R
or
Soil Bulk Density, rho 1.6 (kg/L)
FractionOrganicCarbon, foc 1.8E-3 (-)
Partition Coefficient Koc

	Koc		R	
PCE	426	(L/kg)	7.13	(-)
TCE	130	(L/kg)	2.87	(-)
DCE	125	(L/kg)	2.80	(-)
VC	30	(L/kg)	1.43	(-)
ETH	302	(L/kg)	5.35	(-)

Common R (used in model)* = 2.87

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	2.000		0.79
TCE → DCE	1.000		0.74
DCE → VC	0.700		0.64
VC → ETH	0.400		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

5. GENERAL
Simulation Time* 33 (yr)
Modeled Area Width* 700 (ft)
Modeled Area Length* 1085 (ft)
Zone 1 Length* 1085 (ft)
Zone 2 Length* 0 (ft)
Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar
Source Options
Source Thickness in Sat. Zone* 56 (ft)
Y1
Width* (ft) 105

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.056	0.2
TCE	15.8	0.2
DCE	98.5	0.2
VC	3.08	0.2
ETH	0.03	0.2

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations
View of Plume Looking Down
Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

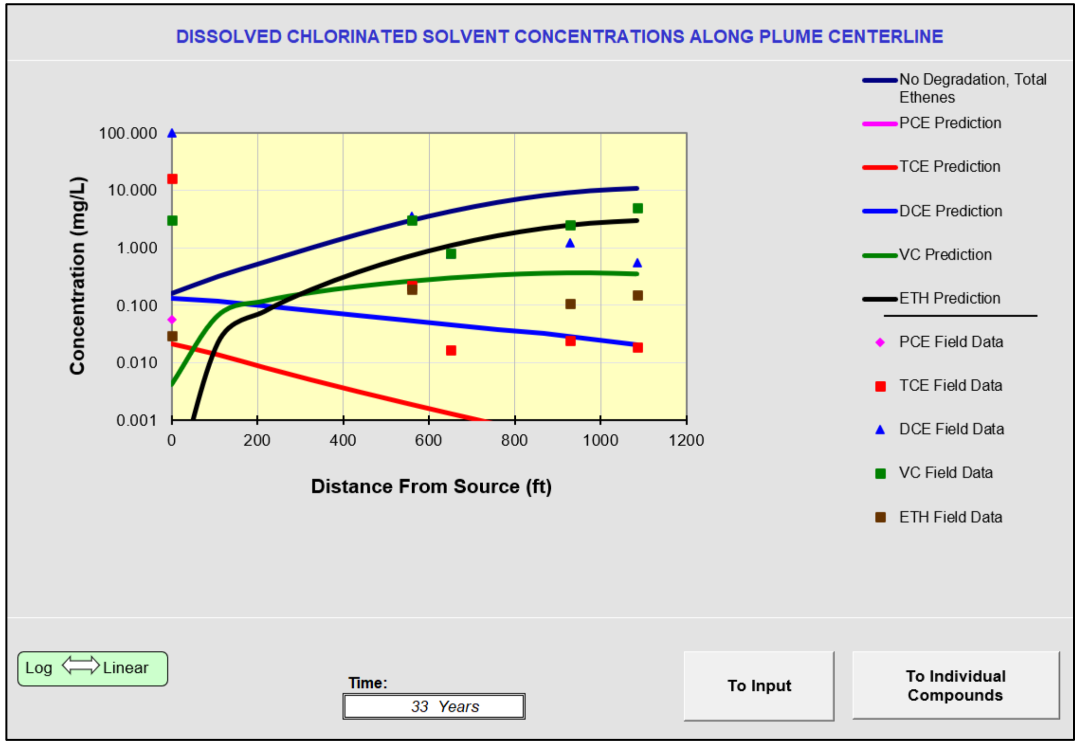
PCE Conc. (mg/L)	.056				
TCE Conc. (mg/L)	15.8	.22	.017	.024	.019
DCE Conc. (mg/L)	98.5	3.48	.776	1.2	.556
VC Conc. (mg/L)	3.1	3.08	.797	2.52	5.024
ETH Conc. (mg/L)	0.0	.188		.107	.15
Distance from Source (ft)	0	560	650	930	1085
Date Data Collected	1998				

8. CHOOSE TYPE OF OUTPUT TO SEE:

Example BIOCHLOR Data Entry
(Aziz et al., 2012)

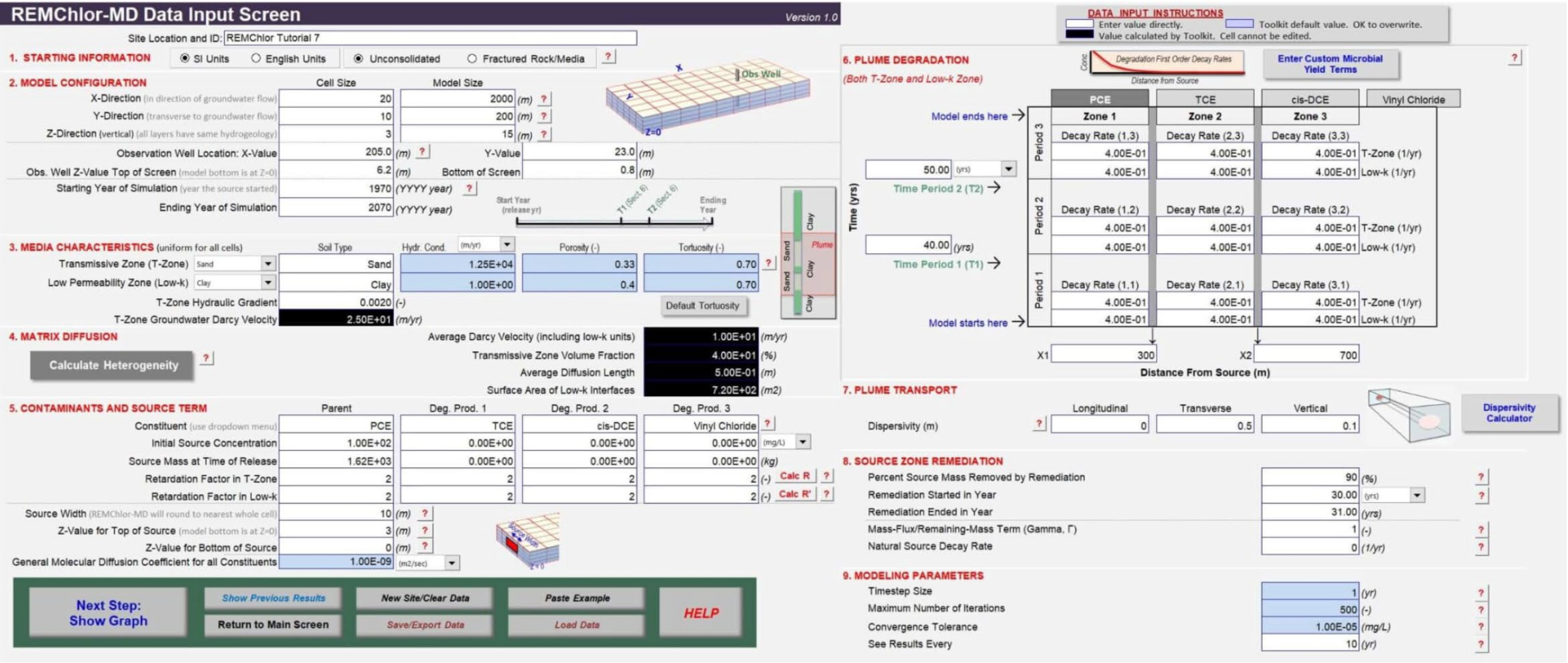
KEY POINT

BIOCHLOR is a simple desktop tool that can be used to quickly generate screening level remedial timeframe estimates



Example BIOCHLOR Output
(Aziz et al. 2012)

Desktop Tools



REMChlor-MD Data Input Screen

Version 1.0

Site Location and ID: REMChlor Tutorial 7

DATA INPUT INSTRUCTIONS
☐ Enter value directly.
🟦 Toolkit default value. OK to overwrite.
■ Value calculated by Toolkit. Cell cannot be edited.

1. STARTING INFORMATION ● SI Units ○ English Units ● Unconsolidated ○ Fractured Rock/Media

2. MODEL CONFIGURATION

	Cell Size	Model Size	
X-Direction (in direction of groundwater flow)	20	2000	(m)
Y-Direction (transverse to groundwater flow)	10	200	(m)
Z-Direction (vertical) (all layers have same hydrogeology)	3	15	(m)

Observation Well Location: X-Value 205.0 (m) Y-Value 23.0 (m)

Obs. Well Z-Value Top of Screen (model bottom is at Z=0) 6.2 (m) Bottom of Screen 0.8 (m)

Starting Year of Simulation (year the source started) 1970 (YYYY year)

Ending Year of Simulation 2070 (YYYY year)

3. MEDIA CHARACTERISTICS (uniform for all cells)

		Soil Type	Hydr. Cond. (m/yr)	Porosity (-)	Tortuosity (-)
Transmissive Zone (T-Zone)	Sand	Sand	1.25E+04	0.33	0.70
Low Permeability Zone (Low-k)	Clay	Clay	1.00E+00	0.4	0.70

T-Zone Hydraulic Gradient 0.0020 (-)

T-Zone Groundwater Darcy Velocity 2.50E+01 (m/yr)

Default Tortuosity

4. MATRIX DIFFUSION

Calculate Heterogeneity

Average Darcy Velocity (including low-k units) 1.00E+01 (m/yr)

Transmissive Zone Volume Fraction 4.00E+01 (%)

Average Diffusion Length 5.00E-01 (m)

Surface Area of Low-k Interfaces 7.20E+02 (m2)

5. CONTAMINANTS AND SOURCE TERM

	Parent	Deg. Prod. 1	Deg. Prod. 2	Deg. Prod. 3	
Constituent (use dropdown menu)	PCE	TCE	cis-DCE	Vinyl Chloride	
Initial Source Concentration	1.00E+02	0.00E+00	0.00E+00	0.00E+00	(mg/L)
Source Mass at Time of Release	1.62E+03	0.00E+00	0.00E+00	0.00E+00	(kg)
Retardation Factor in T-Zone	2	2	2	2	(-) Calc R
Retardation Factor in Low-k	2	2	2	2	(-) Calc R'

Source Width (REMChlor-MD will round to nearest whole cell) 10 (m)

Z-Value for Top of Source (model bottom is at Z=0) 3 (m)

Z-Value for Bottom of Source 0 (m)

General Molecular Diffusion Coefficient for all Constituents 1.00E-09 (m2/sec)

Next Step: Show Graph | Show Previous Results | Return to Main Screen | New Site/Clear Data | Save/Export Data | Paste Example | Load Data | HELP

6. PLUME DEGRADATION

(Both T-Zone and Low-k Zone)

Enter Custom Microbial Yield Terms

Time Period 2 (T2): 50.00 (yrs)

Time Period 1 (T1): 40.00 (yrs)

Model ends here → / Model starts here →

		PCE Zone 1	TCE Zone 2	cis-DCE Zone 3	
Period 3		Decay Rate (1,3)	Decay Rate (2,3)	Decay Rate (3,3)	
		4.00E-01	4.00E-01	4.00E-01	T-Zone (1/yr)
		4.00E-01	4.00E-01	4.00E-01	Low-k (1/yr)
Period 2		Decay Rate (1,2)	Decay Rate (2,2)	Decay Rate (3,2)	
		4.00E-01	4.00E-01	4.00E-01	T-Zone (1/yr)
		4.00E-01	4.00E-01	4.00E-01	Low-k (1/yr)
Period 1		Decay Rate (1,1)	Decay Rate (2,1)	Decay Rate (3,1)	
		4.00E-01	4.00E-01	4.00E-01	T-Zone (1/yr)
		4.00E-01	4.00E-01	4.00E-01	Low-k (1/yr)

Vinyl Chloride

X1 300 X2 700

Distance From Source (m)

7. PLUME TRANSPORT

	Longitudinal	Transverse	Vertical
Dispersivity (m)	0	0.5	0.1

Dispersivity Calculator

8. SOURCE ZONE REMEDIATION

Percent Source Mass Removed by Remediation 90 (%)

Remediation Started in Year 30.00 (yrs)

Remediation Ended in Year 31.00 (yrs)

Mass-Flux/Remaining-Mass Term (Gamma, Γ) 1 (-)

Natural Source Decay Rate 0 (1/yr)

9. MODELING PARAMETERS

Timestep Size 1 (yr)

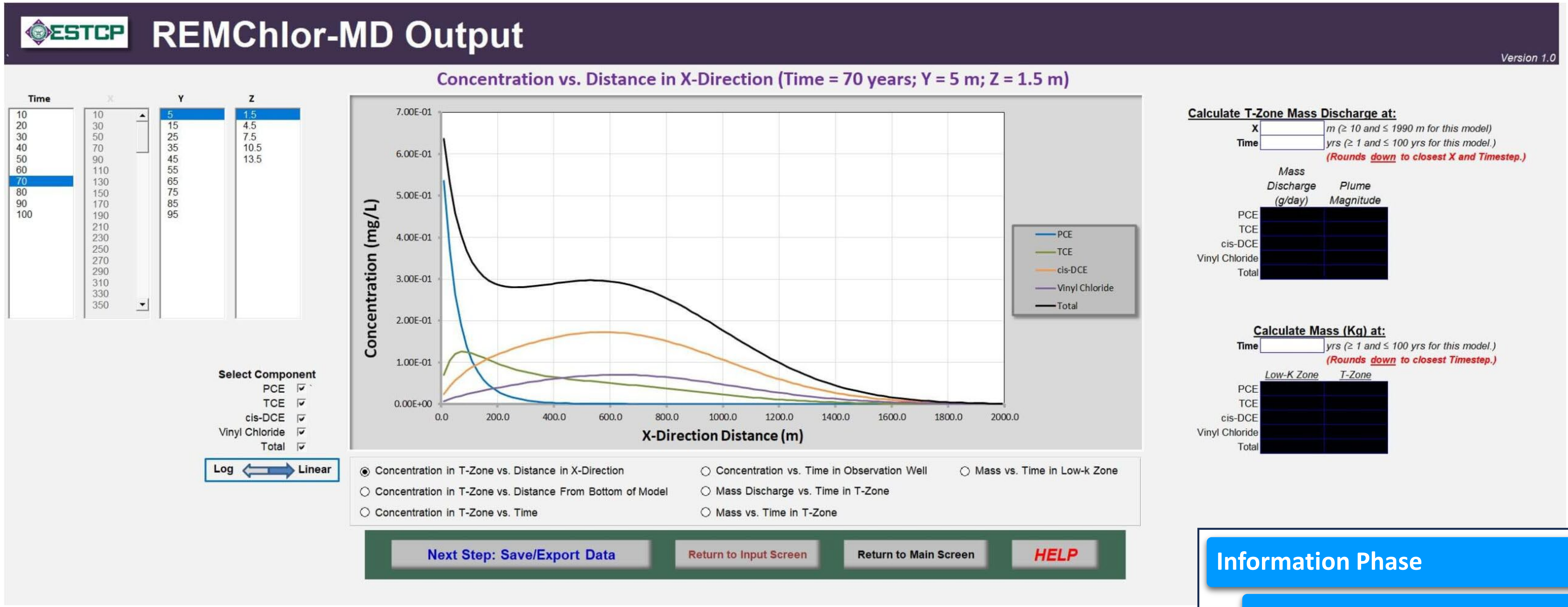
Maximum Number of Iterations 500 (-)

Convergence Tolerance 1.00E-05 (mg/L)

See Results Every 10 (yr)

Typical REMChlor Data Entry (GSI n.d.)

Desktop Tools



REMChlor-MD Output

Version 1.0

Concentration vs. Distance in X-Direction (Time = 70 years; Y = 5 m; Z = 1.5 m)

Time	X	Y	Z
10 20 30 40 50 60 **70** 80 90 100	10 30 50 70 90 110 130 150 170 190 210 230 250 270 290 310 330 350	**5** 15 25 35 45 55 65 75 85 95	**1.5** 4.5 7.5 10.5 13.5

Select Component
- PCE ☑
- TCE ☑
- cis-DCE ☑
- Vinyl Chloride ☑
- Total ☑

Log ⟺ Linear

- ● Concentration in T-Zone vs. Distance in X-Direction
- ○ Concentration in T-Zone vs. Distance From Bottom of Model
- ○ Concentration in T-Zone vs. Time
- ○ Concentration vs. Time in Observation Well
- ○ Mass Discharge vs. Time in T-Zone
- ○ Mass vs. Time in T-Zone
- ○ Mass vs. Time in Low-k Zone

Calculate T-Zone Mass Discharge at:

X m (≥ 10 and ≤ 1990 m for this model)

Time yrs (≥ 1 and ≤ 100 yrs for this model.)

(Rounds down to closest X and Timestep.)

	Mass Discharge (g/day)	Plume Magnitude
PCE		
TCE		
cis-DCE		
Vinyl Chloride		
Total		

Calculate Mass (Kg) at:

Time yrs (≥ 1 and ≤ 100 yrs for this model.)

(Rounds down to closest Timestep.)

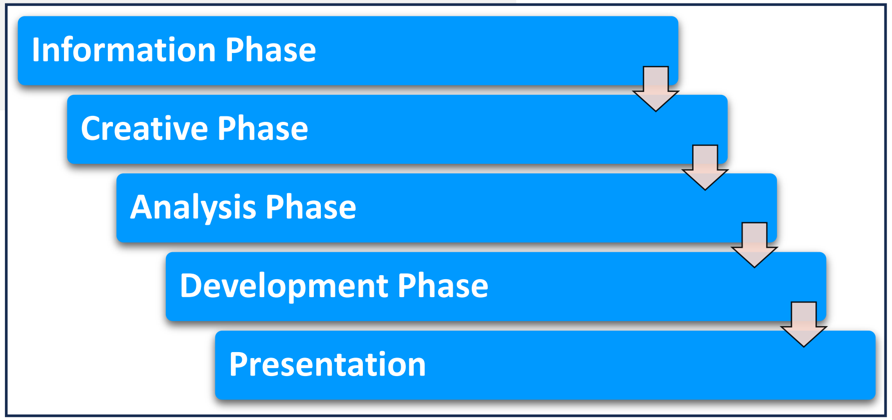
	Low-K Zone	T-Zone
PCE		
TCE		
cis-DCE		
Vinyl Chloride		
Total		

Typical REMChlor Output
(GSI n.d.)

KEY POINT

REMChlor-MD can provide a more robust remediation timeframe estimate inclusive of active remediation.

Value Engineering Process



- Information Phase
- Creative Phase
- Analysis Phase
- Development Phase
- Presentation

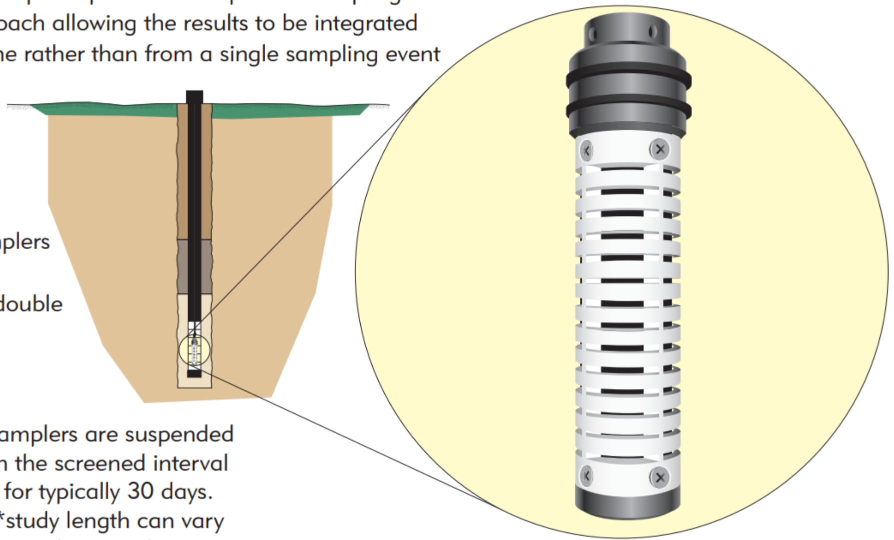
MBTs + Treatability Testing

Example Tool	Description	Why use?	Typical Phase
Laboratory Molecular Biological Tools			
Quantitative polymerase chain reaction	Nucleic acid-targeted quantitative tool to quantify specific microorganisms and functional genes responsible for biodegradation of contaminants	Identifies whether specific microorganisms that can biodegrade the site contaminants are present; and whether bioaugmentation might be productive	2, 6, and 7
Metagenomics and metabolomics	Study of the collection of all genomes and genes from all microorganisms present in a sample and their metabolic processes	Provides more comprehensive profile and health of microbial community so biodegradation processes may be optimized	2, 6, and 7
Compound specific isotope analysis	Analytical method that measures ratio of stable isotopes of a contaminant	Can provide direct evidence of degradation (rather than dilution) to support use of MNA as optimized remedial strategy	2, 6, and 7
Magnetic susceptibility	Provides an estimate of the quantity of magnetite present in environmental samples	Can provide support for abiotic degradation to support use of MNA as optimized remedial strategy	2, 6, and 7
Acid volatile sulfides	Estimates presence of iron sulfide minerals in sediment or soil samples	Can provide support for abiotic degradation to support use of MNA as optimized remedial strategy	2, 6, and 7

MBTs + Treatability Testing

Example Tool	Description	Why use?	Typical Phase
Field Molecular Biological Tools			
BioTraps	Passive samplers that provide a substrate to facilitate microbial growth in a monitoring well for laboratory analysis	Identifies whether specific microorganisms that can biodegrade the site contaminants are present in situ, and whether bioaugmentation might be productive	2, 6, and 7
MinTraps	Passive samplers that collect mineralogic data in a monitoring well for laboratory analysis	Can provide support for abiotic degradation to support use of MNA as optimized remedial strategy	2, 6, and 7
Laboratory or Field Treatability Testing			
Bench- or pilot-scale testing *(Case Studies 2, 3, and 4)*	Laboratory or field-scale simulations of various remedial technologies to evaluate effectiveness and optimize designs	Cost-effective methods to evaluate technologies to replace existing approaches	2 and 6

MBTs + Treatability Testing

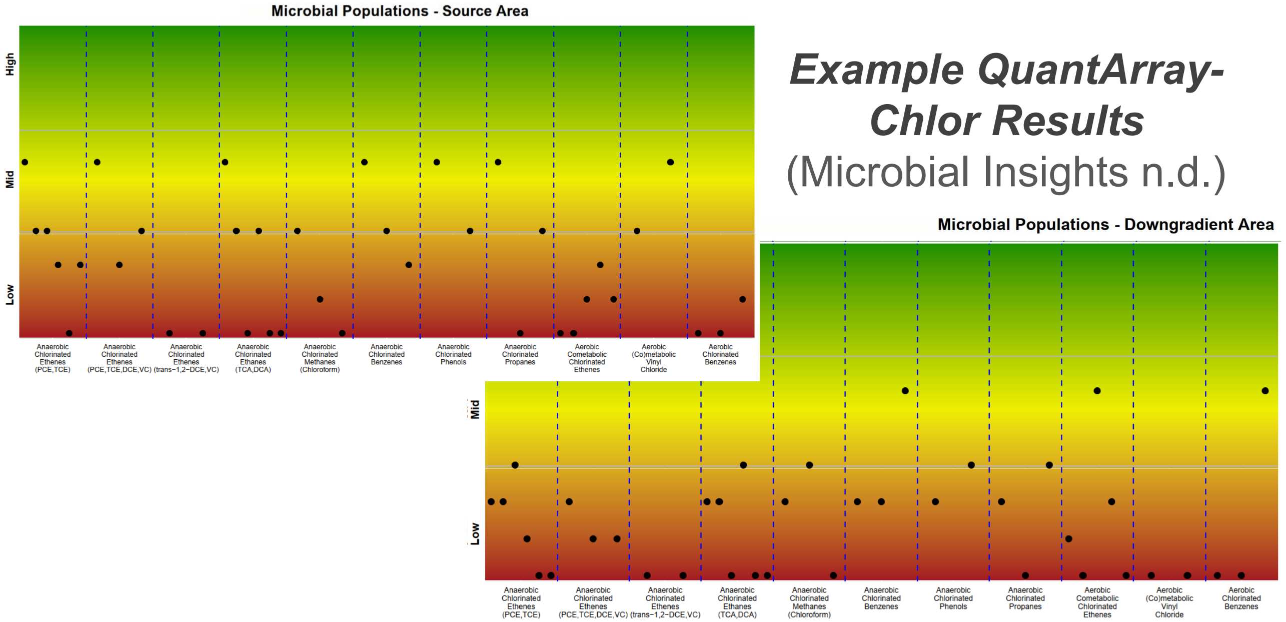


Bio-Trap samplers utilize a passive sampling approach allowing the results to be integrated over time rather than from a single sampling event

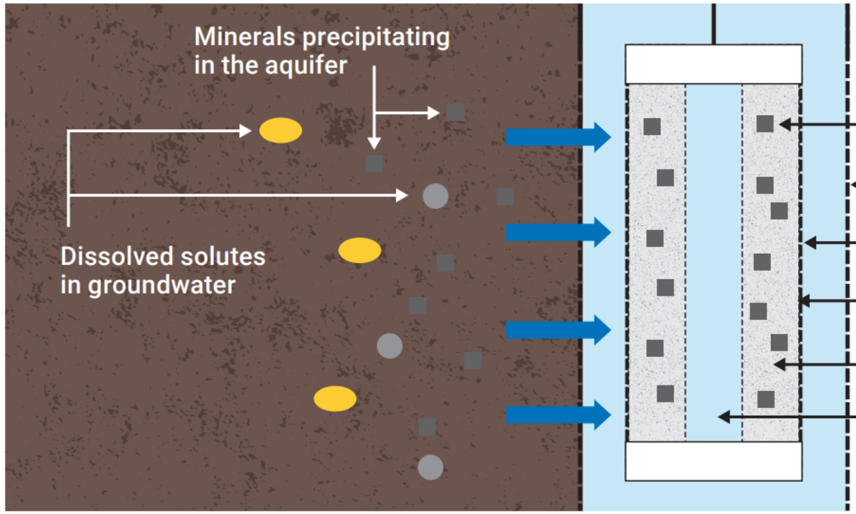
Multiple Bio-Trap samplers can be isolated from one another using a double seal cap assembly

Samplers are suspended in the screened interval for typically 30 days.
*study length can vary depending on objectives

Bio-Trap Sampler
(Microbial Insights n.d.)



Example QuantArray-Chlor Results
(Microbial Insights n.d.)



Mineral precipitates captured in Min-Trap™ matrix

Monitoring Well Screened Interval

Slotted PVC Housing

Permeable mesh

Non-reactive sand matrix (or reactive media, or site soil)

Open interior facilitates groundwater flux through Min-Trap™

Min-Trap Sampler
(Microbial Insights n.d.)

PVC: polyvinyl chloride

Characterization

Example Tool	Description	Why use?	Typical Phase
HRSC			
Passive soil gas sampling	Use of adsorbent samplers emplaced just below ground surface to adsorb VOCs and semivolatile organic compounds in soil gas; often installed in a grid pattern	Cost-effective method to refine extent of soil and groundwater impacts in two dimensions and optimize more intrusive sampling approaches	2 and 6
MiHPT (membrane interface hydraulic profiling tool)	DPT-based logging tool that measures relative VOC concentrations in soil and groundwater, and provides lithology characterization	Cost-effective methods to identify residual source materials, refine the extent of soil and groundwater impacts in three dimensions, and optimize more intrusive sampling approaches	2 and 6
Discrete soil and groundwater grab sampling	Collection of a relatively high density of soil and groundwater samples typically using DPT	Verification of semi-quantitative characterization tools to refine extent of soil and groundwater impacts in three dimensions	2 and 6
Downhole geophysical testing	Use of temperature/conductivity, caliper, natural gamma, and optical/acoustic televiewer geophysical logging; and borehole dynamic flowmeter and nuclear magnetic resonance hydrophysical tools	Improves understanding of conceptual site model, especially with respect to preferential flow pathways that might be targeted during remedy optimization	2 and 6

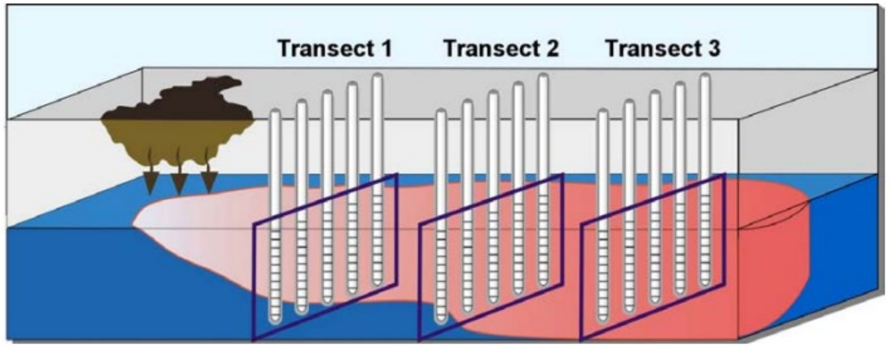
DPT: direct-push technology

HRSC: high resolution site characterization

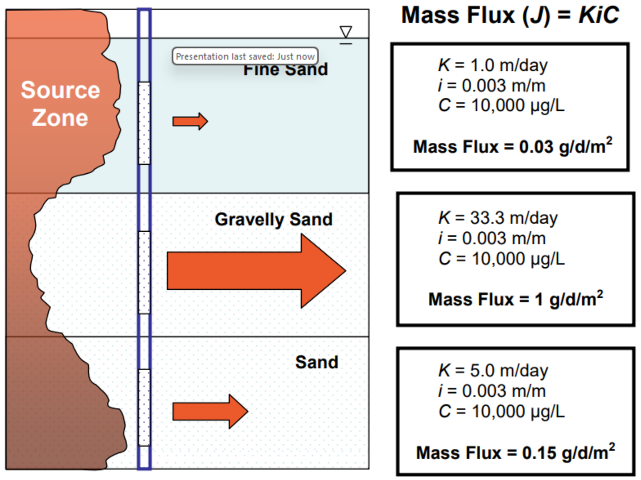
VOC: volatile organic compound

Characterization

Example Tool	Description	Why use?	Typical Phase
HRSC			
NSZD *(Case Study 3)*	Collective naturally occurring processes of dissolution, volatilization, and biodegradation that result in mass losses of LNAPL petroleum hydrocarbon constituents from the subsurface (CRC CARE 2018)	Evaluates whether natural attenuation processes are removing more LNAPL mass than physical removal methods	2 and 6
Mass flux	Combines contaminant concentration data with groundwater velocity to estimate contaminant mass migration through a specific area	Can be used to identify cross-sectional areas of the site where most of the contaminant mass is migrating so that remediation strategies can be optimized to maximize contaminant removal	2 and 6



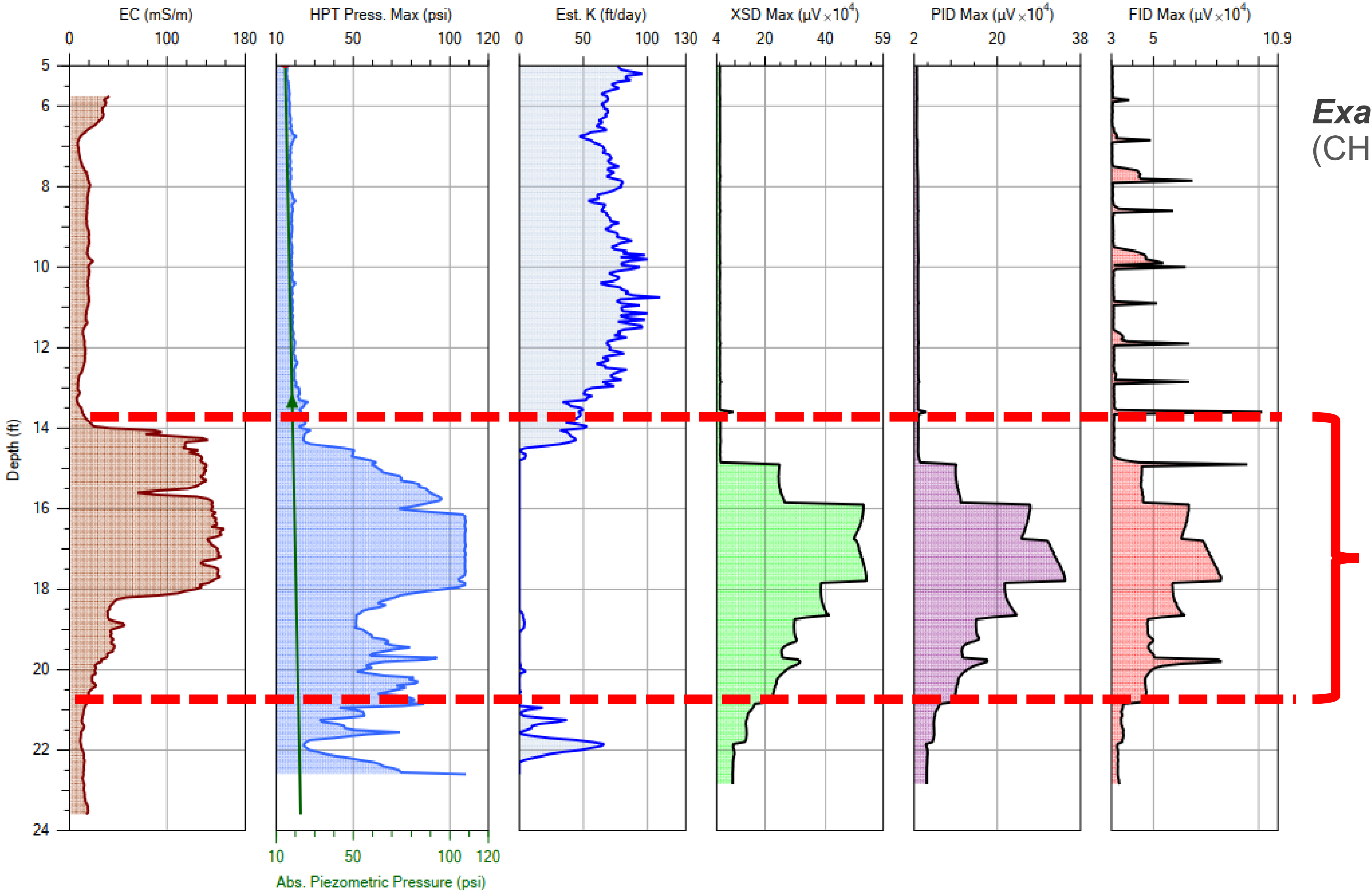
(ITRC 2010 [Adapted from Einarson and Mackay 2001])



(ITRC 2010)

LNAPL: light nonaqueous-phase liquid
NSZD: Natural Source Zone Depletion

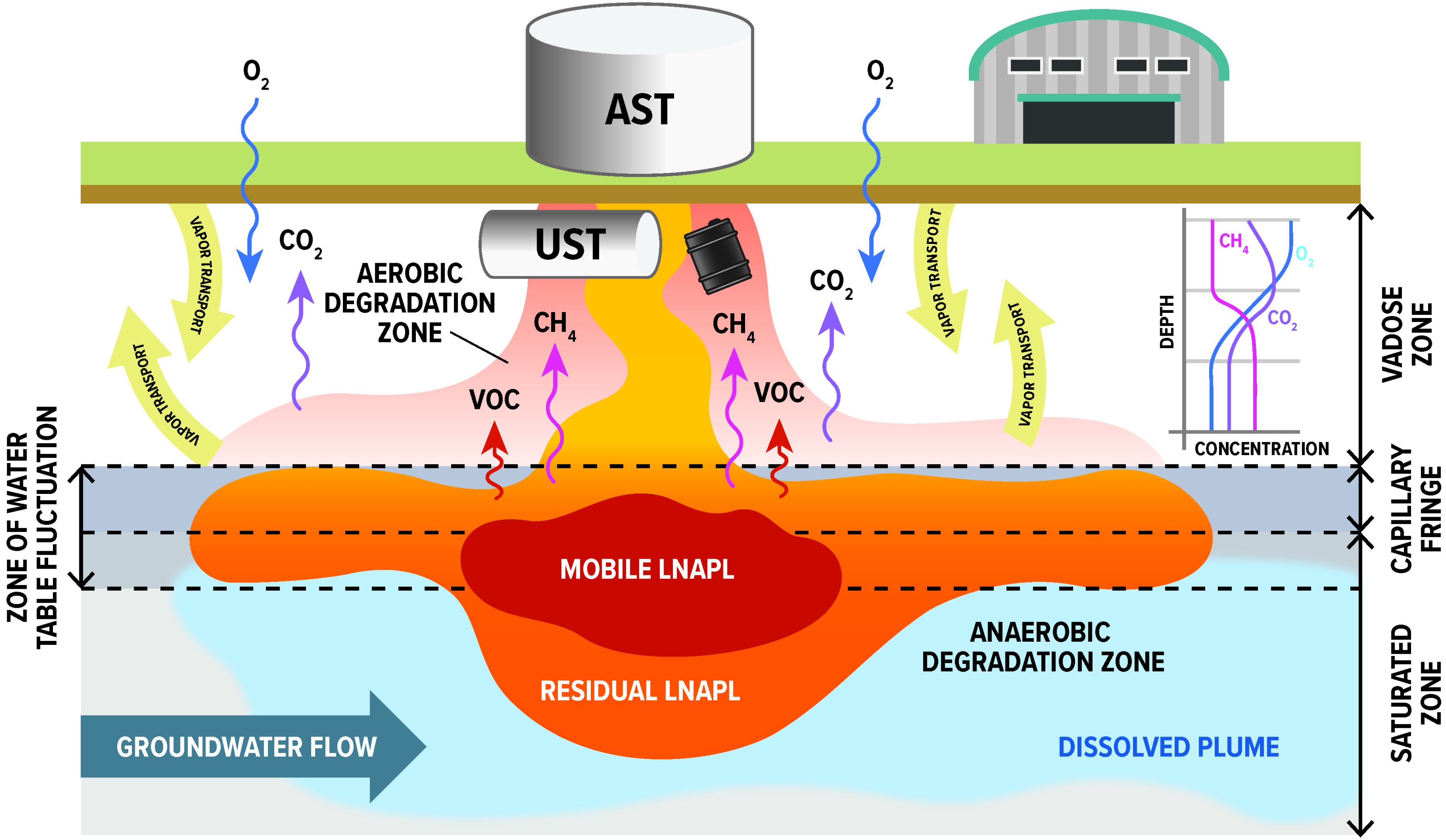
Characterization



Example MiHPT Output
(CH2M 2023)

Low permeability with residual source mass that could be addressed with targeted remediation to optimize overall remedy

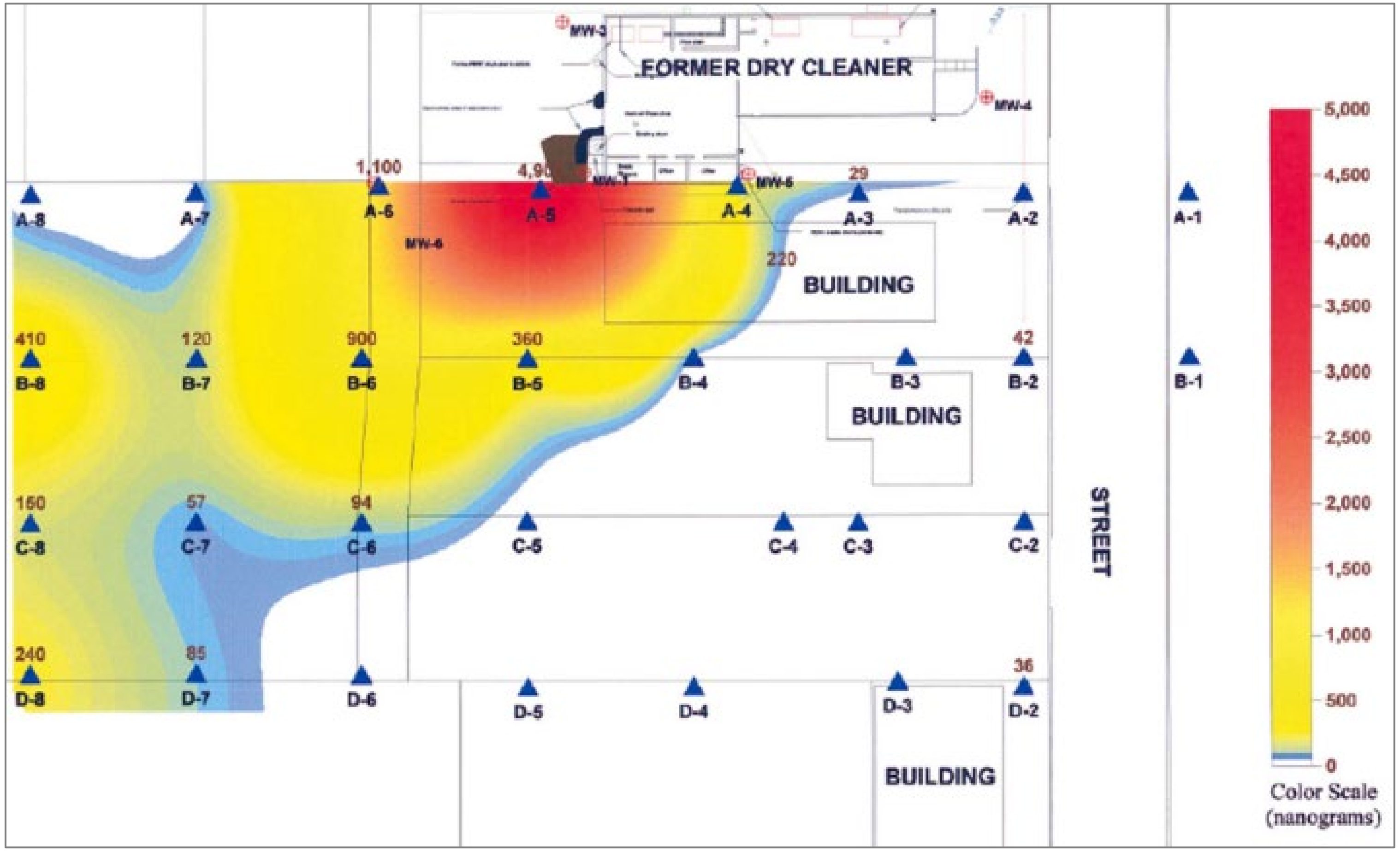
Characterization

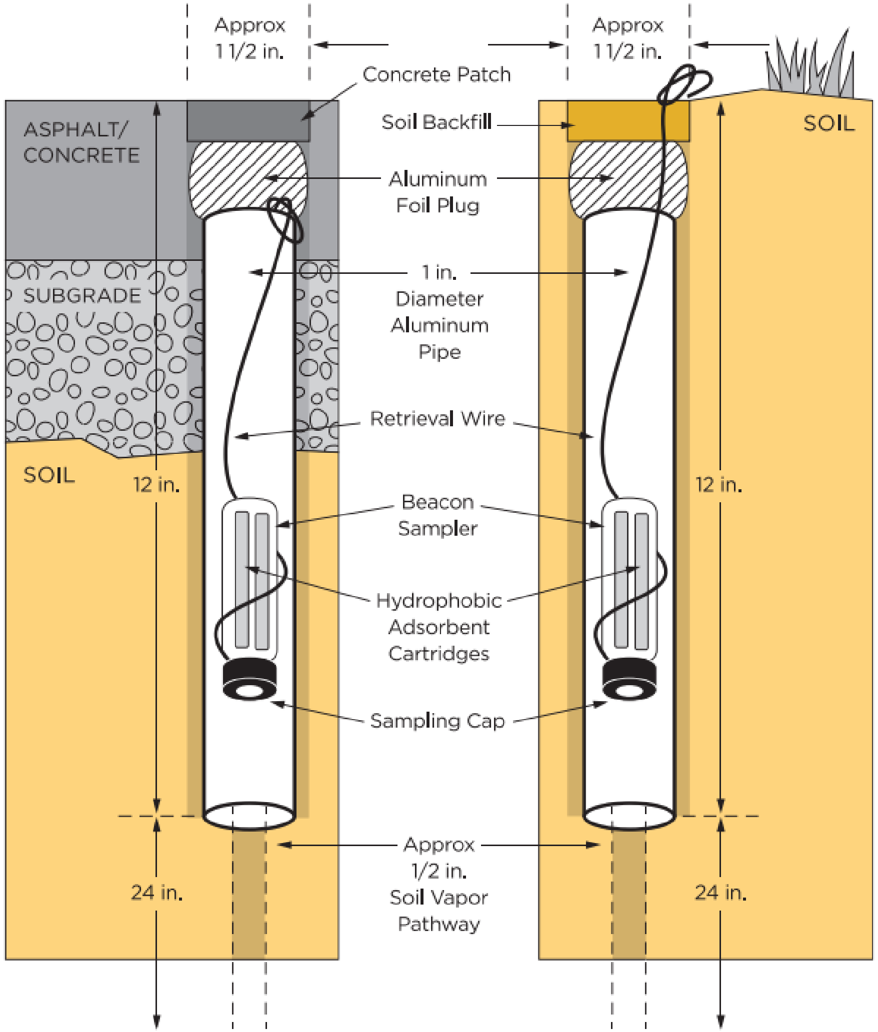


AST: above-ground storage tank
UST: underground storage tank

NSZD Schematic
(Jacobs 2025)

Characterization

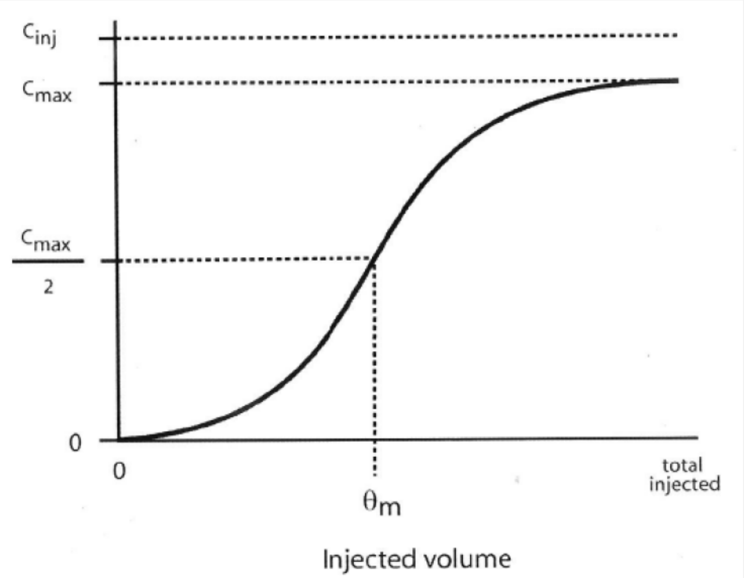




Example Isopleth (l) and Sampler (r)
(Beacon 2024)

Characterization

Example Tool	Description	Why use?	Typical Phase
Conventional Characterization Tools			
New monitoring wells	Installation of new monitoring wells via DPT or other drilling methods	Verification of grab groundwater sampling to refine extent of groundwater impacts in three dimensions	2 and 6
Tracer testing	Injection and monitoring of conservative compound (e.g., dye or bromide) to assess hydrogeologic properties of aquifer	Improves understanding of groundwater flow direction and velocity and improve in situ remedy design	2 and 6



Tracer Test Process
(USACE 2023)

KEY POINT

Tracer studies can be used to evaluate radius of influence and pore volume to optimize injections.

Other Approaches

- Risk assessment
  - Updates to receptors, exposure pathways, contaminants of concern, and conceptual site model
- Regulatory/partnering
  - **Flexible decision documents with defined exit strategies (Case Study 2)**
  - **Defined exit strategies (Case Study 2)**
  - **Partnering process (Case Study 2)**
  - **Regulation and clean-up goal updates (Case Study 2)**
  - Five-Year Review process
  - State risk-based closure programs (especially useful for UST and RCRA sites)
- System O&M
  - Troubleshooting
  - Replace old equipment with updated technology

Presentation Overview

- Introduction
- Optimization Basics
- **Case Study #1: JBPHH Former Aiea Laundry Facility**
- Case Study #2: Camp Lejeune Site 78
- Case Study #3: NAPR SWMUs 7 and 8
- Case Study #4: ABL Site 10
- Key Takeaways

NORM Phase(s)	2 (but with elements of 6)
Optimization trigger(s)	Sampling data are consistent and predictable and contaminant mass recovery has become asymptotic
Key tools or concepts	• Vapor concentration trend analysis • Monitoring program optimization
Key constraint(s)	Sensitive receptors adjacent to site

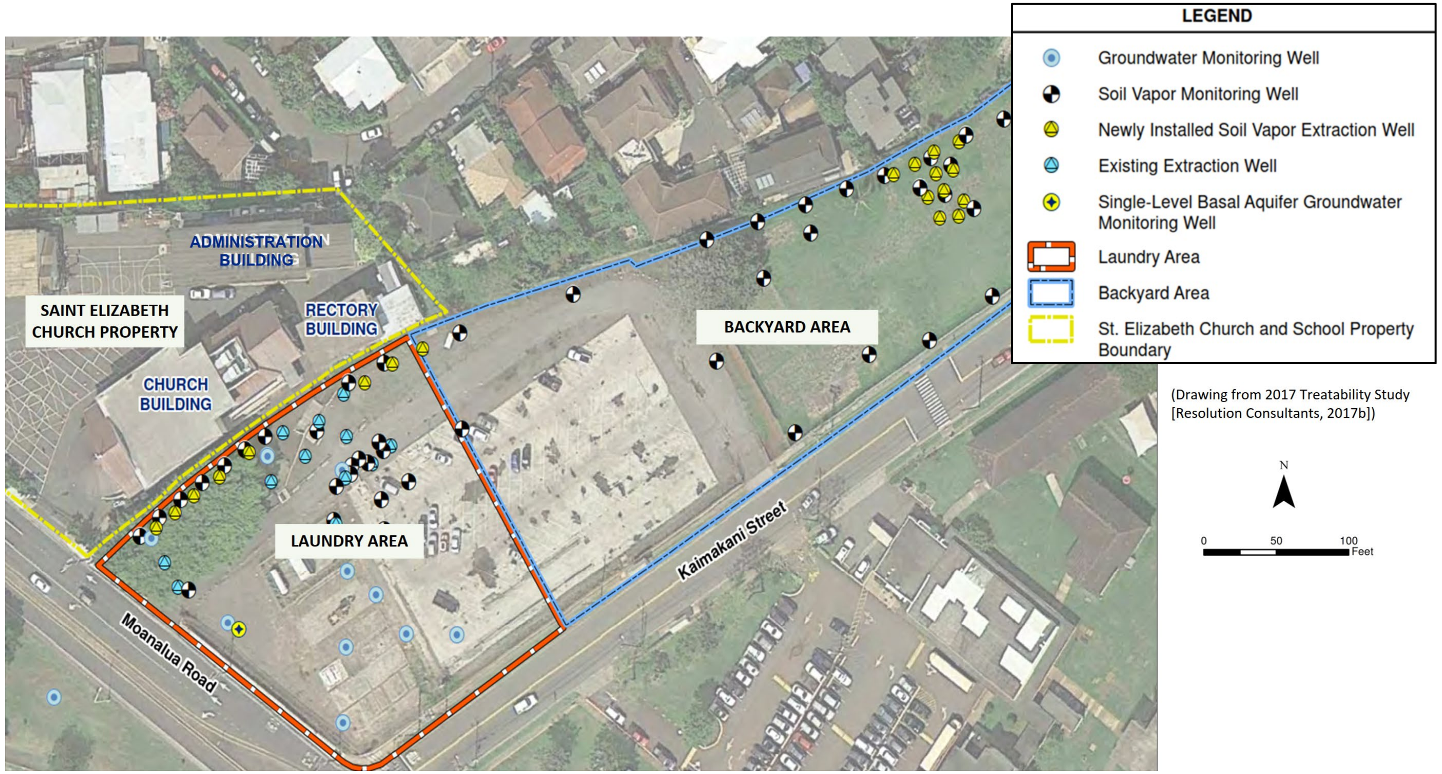
Site Location

- 3.2-acre site
- Located approximately 0.3 mile east of the shoreline of Aiea Bay
- Bordered by
  - Saint Elizabeth Church
  - Residential housing
  - Aiea Elementary School and Kaimakani Street
  - Moanalua Road and Aloha Stadium

(AECOM 2023a)

Site Background

- Divided into two areas based on historical use and sources
  - **Laundry Area**
    - Currently used as a parking lot by Saint Elizabeth Church and School
    - Saint Elizabeth Church property consists of Church Building, Rectory Building, and Administration Building
  - **Backyard Area**
    - Currently an unused grassy area



(Drawing from 2017 Treatability Study [Resolution Consultants, 2017b])

(Resolution Consultants 2017b)

Site Background

- Operated as a laundry and dry-cleaning facility
  - PCE was stored in four USTs (considered the primary CVOC source)
  - One AST stored diesel fuel; a potential source of LNAPL
- Investigations conducted from 1993 to 1997 indicated CVOCs in soil, soil vapor, and groundwater at the Laundry Area and Saint Elizabeth Church

Early to Mid-1940s: Begin Laundry Facility Operations

1952: Begin Dry-cleaning Activities

1962 to 1969: Facility Demolition and Church Construction

1993: Time Critical Removal Action to Remove Drain Lines, USTs, and the AST

1993 to 1997: Additional Investigation

1998: Laundry Area Buildings Demolished

CVOC: chlorinated volatile organic compound
PCE: tetrachloroethene

Site Background

- Additional investigations included human health and ecological risk assessments
  - **Human health risk:** Potential to future receptors due to migration of dissolved caprock-aquifer contaminants to the basal aquifer
    - COCs: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC
  - **Ecological:** None from impacted soil or groundwater
- SVE system installed in 1996 to remediate and prevent potential offsite migration of COCs in soil and soil vapor and operated intermittently
  - Deactivated in 2007 based on reductions of CVOC concentrations
- Field monitoring activities conducted in support of the RI and FS in 2011 and 2012, respectively
  - PCE concentrations in soil gas exceeded the PSLs in both Laundry and Backyard areas

COC: chemicals of concern

DCE: dichloroethane

EPA: United States Environmental Protection Agency

PSL: project screening levels

RI: Remedial Investigation

TCE: trichloroethene

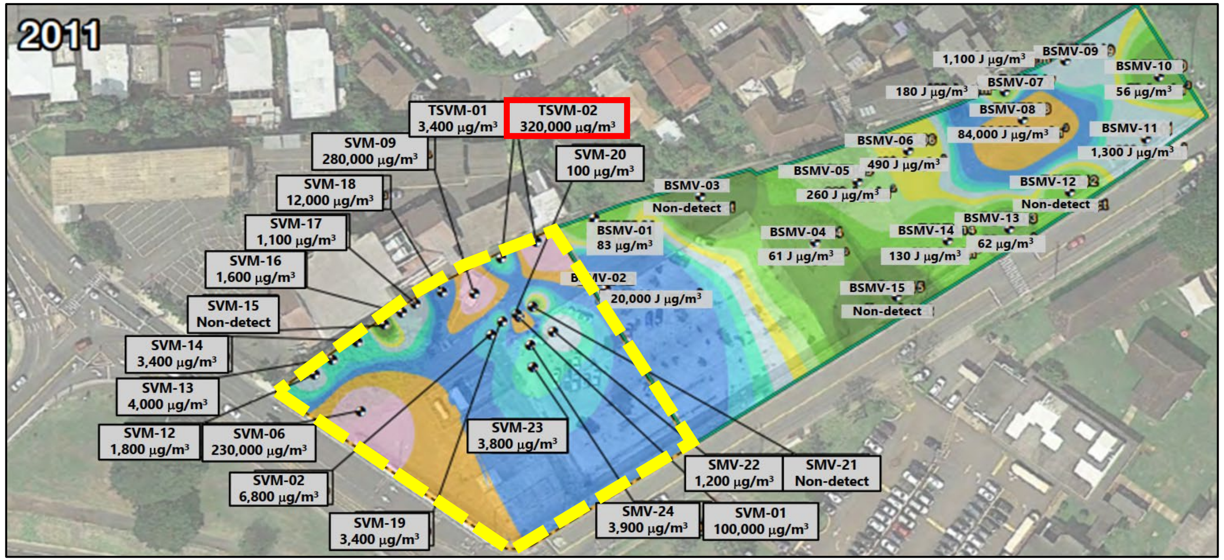
VC: vinyl chloride

SVE: soil vapor extraction

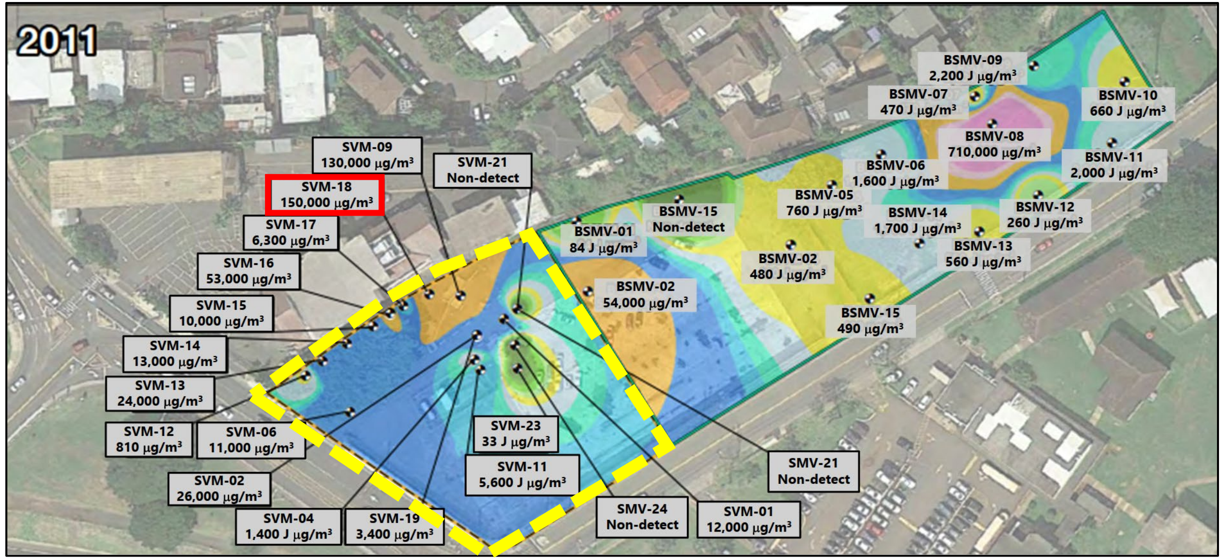
Note: *PSLs are based on lowest screening residential criteria from EPA and the Hawaii State Department of Health.*

Site Background

- Laundry Area soil vapor concentrations before optimization
  - **Shallow:** up to 320,000 µg/m^3 (TSVM-02)
  - **Deep:** up to 150,000 µg/m^3 (SVM-18)



Laundry Area Shallow Soil Vapor Results (2011)



Laundry Area Deep Soil Vapor Results (2011)

(Resolution Consultants 2017b)

LEGEND

● Soil Vapor Monitoring Well

▭ Laundry Area Boundary

▭ Backyard Area Boundary

Interpolated PCE Soil Vapor Concentration (µg/m³)

🟩	0 - 41	🟦	2,060 - 4,120
🟩	41 - 82	🟦	4,120 - 8,240
🟩	82 - 206	🟦	8,240 - 41,200
🟩	206 - 412	🟧	41,200 - 206,000
🟨	412 - 824	🟪	206,000 - 412,000
🟦	824 - 2,060	🟪	412,000 - 710,000

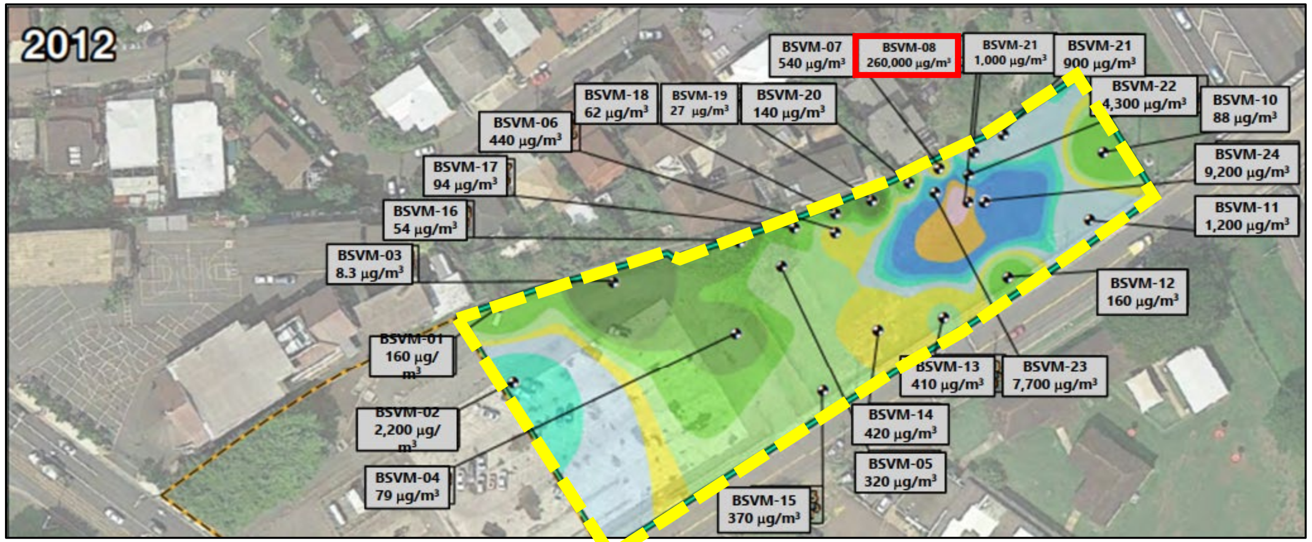
µg/m^3: microgram(s) per cubic meter

SVM: soil vapor monitoring probe

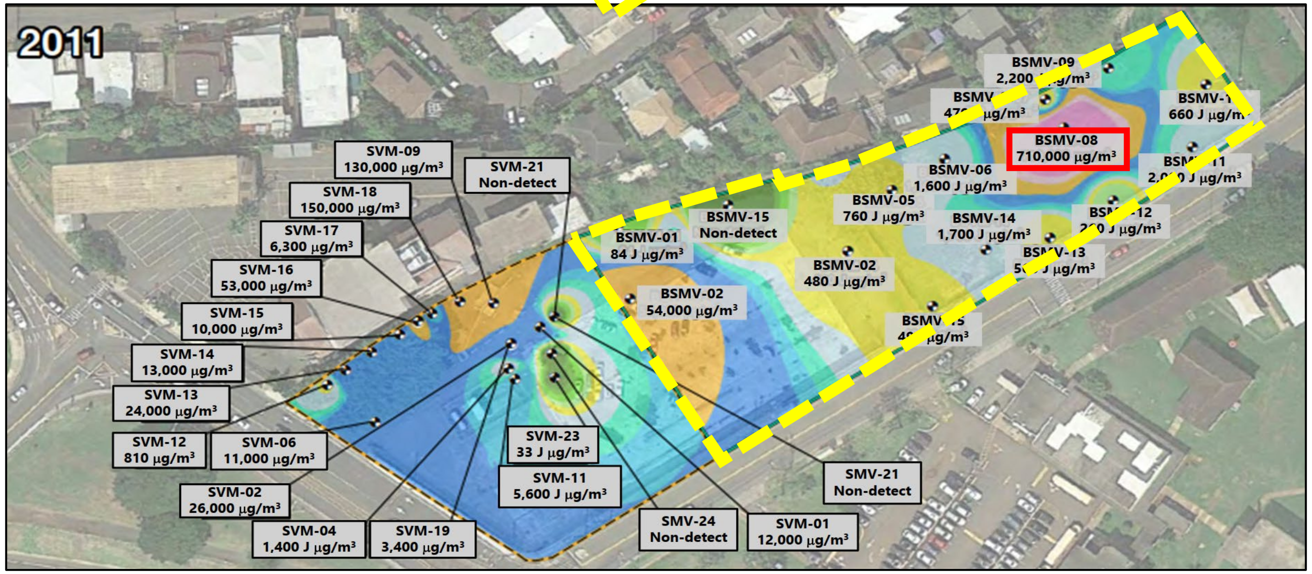
TSVM: temporary soil vapor monitoring probe

Site Background

- Backyard Area soil vapor concentrations prior to optimization
    - **Shallow:** up to 260,000 µg/m^3 (BSVM-08)
    - **Deep:** up to 710,000 µg/m^3 (BSVM-08)



Backyard Area Shallow Soil Vapor Results (2012)



Backyard Area Deep Soil Vapor Results (2011)

LEGEND

● Soil Vapor Monitoring Well

▭ Laundry Area Boundary

▭ Backyard Area Boundary

Interpolated PCE Soil Vapor Concentration (µg/m^3)

🟩	0 - 41	🟦	2,060 - 4,120
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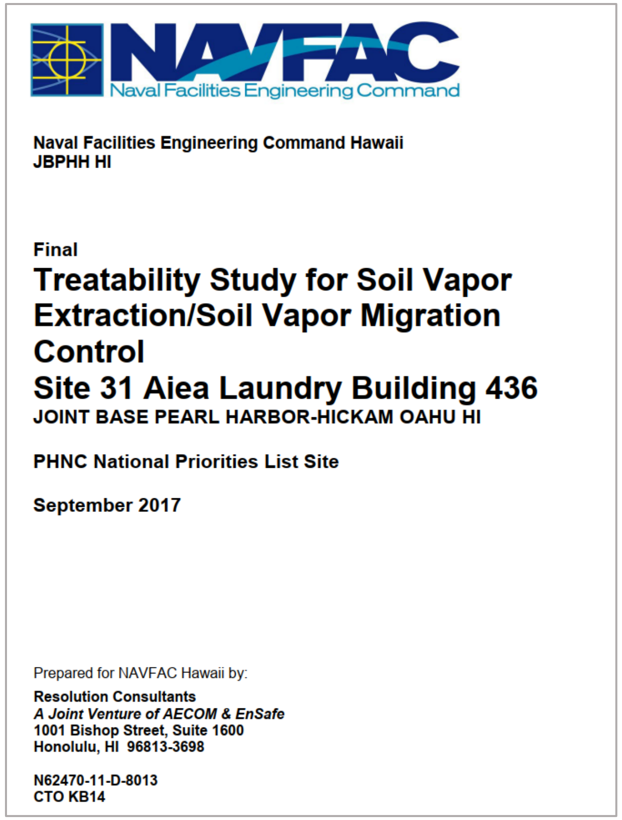
🟩	206 - 412	🟧	41,200 - 206,000
🟨	412 - 824	🟪	206,000 - 412,000
🟦	824 - 2,060	🟪	412,000 - 710,000

(Resolution Consultants 2017b)

BSVM: Backyard Area soil vapor monitoring probe

Site Background

- Second SVE/SVMC system was installed and began operation in October 2013 to:
  - Mitigate potential migration of soil vapors from site to neighboring receptors including the Priest residence and preschool in Saint Elizabeth Church
  - Reduce soil vapor mass around hotspot area near BSVM-08
- Second SVE/SVMC system operations are ongoing
  - Soil vapor and indoor air monitoring performed as part of SVE/SVMC system operation, maintenance, and monitoring program



NAVFAC Naval Facilities Engineering Command

Naval Facilities Engineering Command Hawaii
JBPHH HI

Final
Treatability Study for Soil Vapor Extraction/Soil Vapor Migration Control
Site 31 Aiea Laundry Building 436
JOINT BASE PEARL HARBOR-HICKAM OAHU HI

PHNC National Priorities List Site

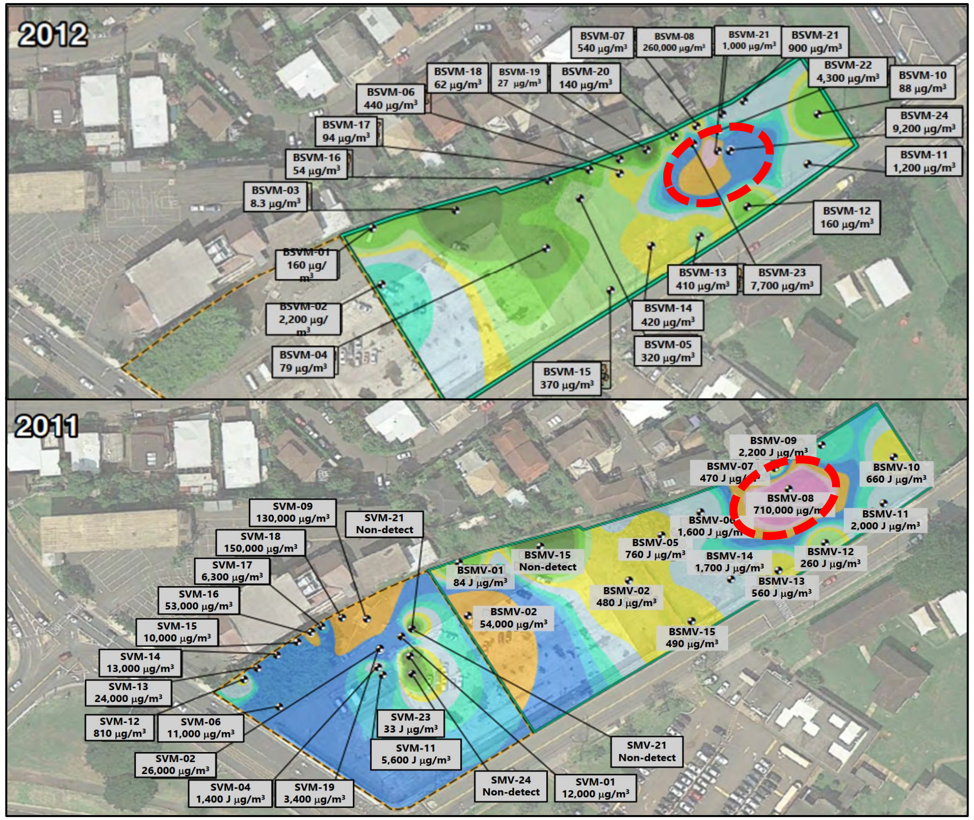
September 2017

Prepared for NAVFAC Hawaii by:
Resolution Consultants
A Joint Venture of AECOM & EnSafe
1001 Bishop Street, Suite 1600
Honolulu, HI 96813-3698

N62470-11-D-8013
CTO KB14

(NAVFAC 2017)

Targeted Hot Spots



(Resolution Consultants 2017b)

SVMC: soil vapor migration control

Optimization Study: Objectives

- Second SVE/SVMC operations optimization study conducted in 2024
- Objectives
  - Evaluate second SVE/SVMC system performance based on main objectives to mitigate migration and decrease source mass
  - **Assess the potential for current VI impacts** to neighboring property (Saint Elizabeth Church)
  - **Optimize the current monitoring program**
  - Determine next steps for second SVE/SVMC system operation
  - Identify exit strategies to be included in Proposed Plan/ROD

VI: vapor intrusion

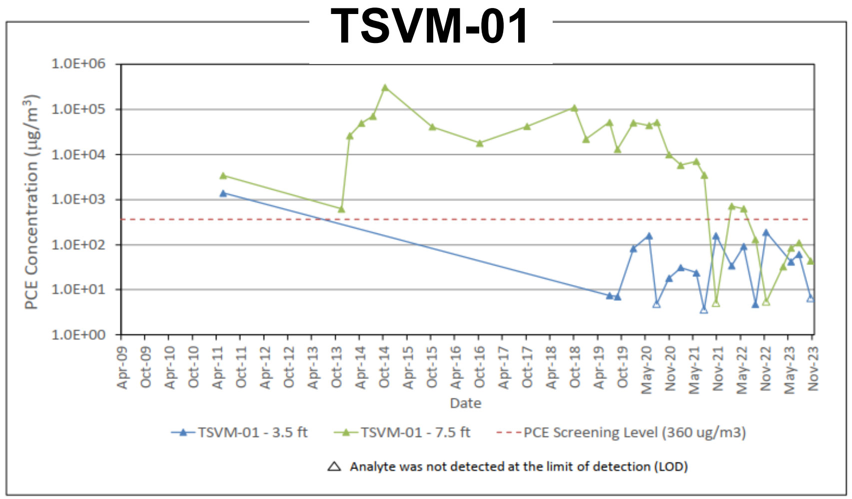
Optimization Study: Data Summary

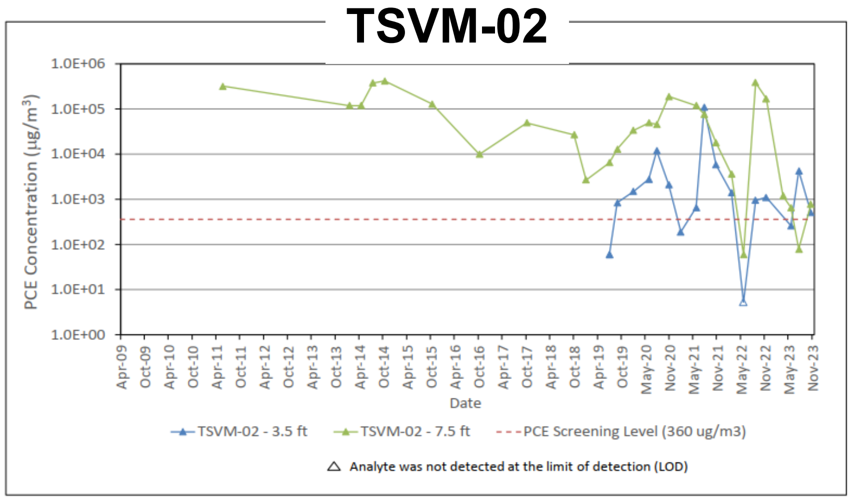
KEY POINTS

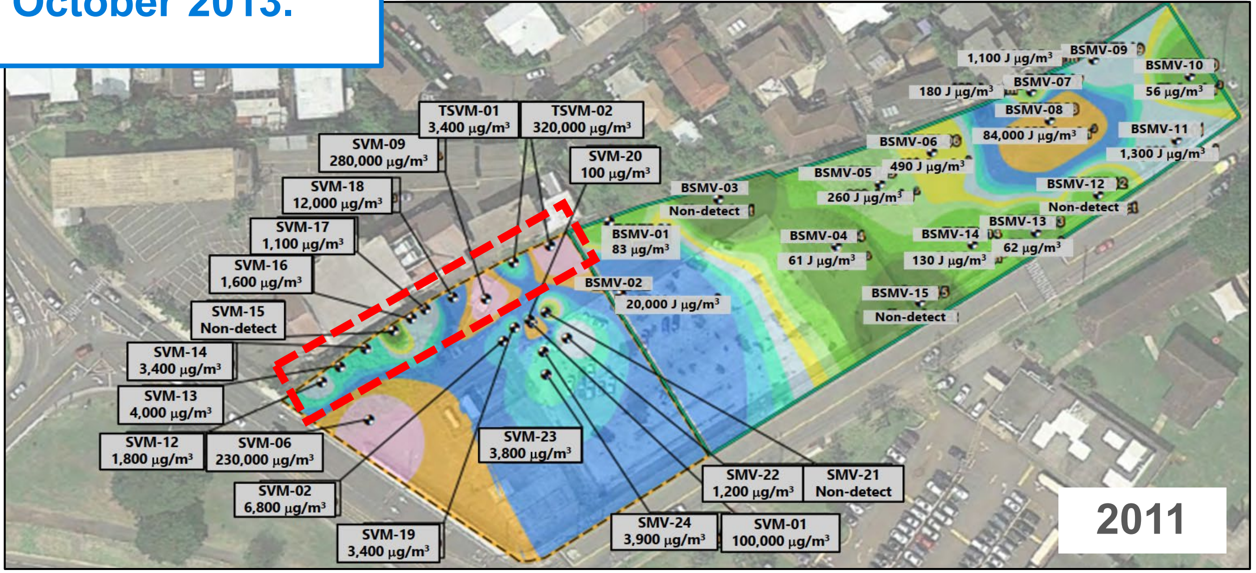
Second SVE/SVMC system effectively mitigated lateral migration from Laundry Area into Saint Elizabeth Church buildings.

CVOC concentrations have reduced by 1 to 3 OOM since SVE/SVMC system startup in October 2013.

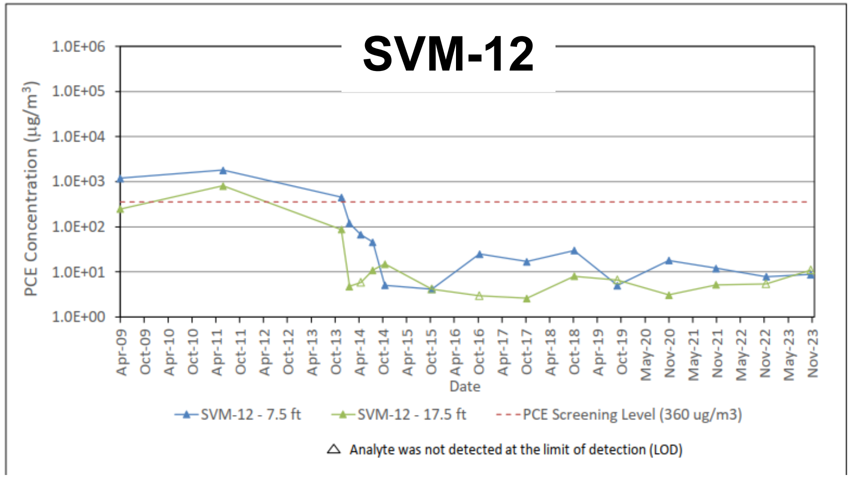
OOM: order(s) of magnitude







(NAVFAC 2017)



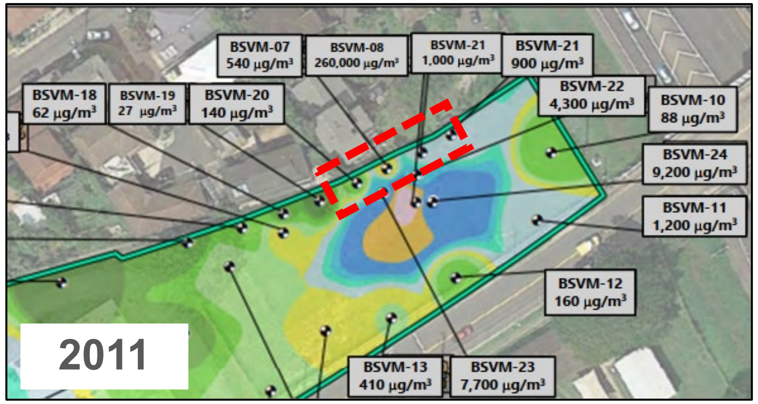
Select Laundry Area Soil Vapor Analytical Results

Optimization Study: Data Summary

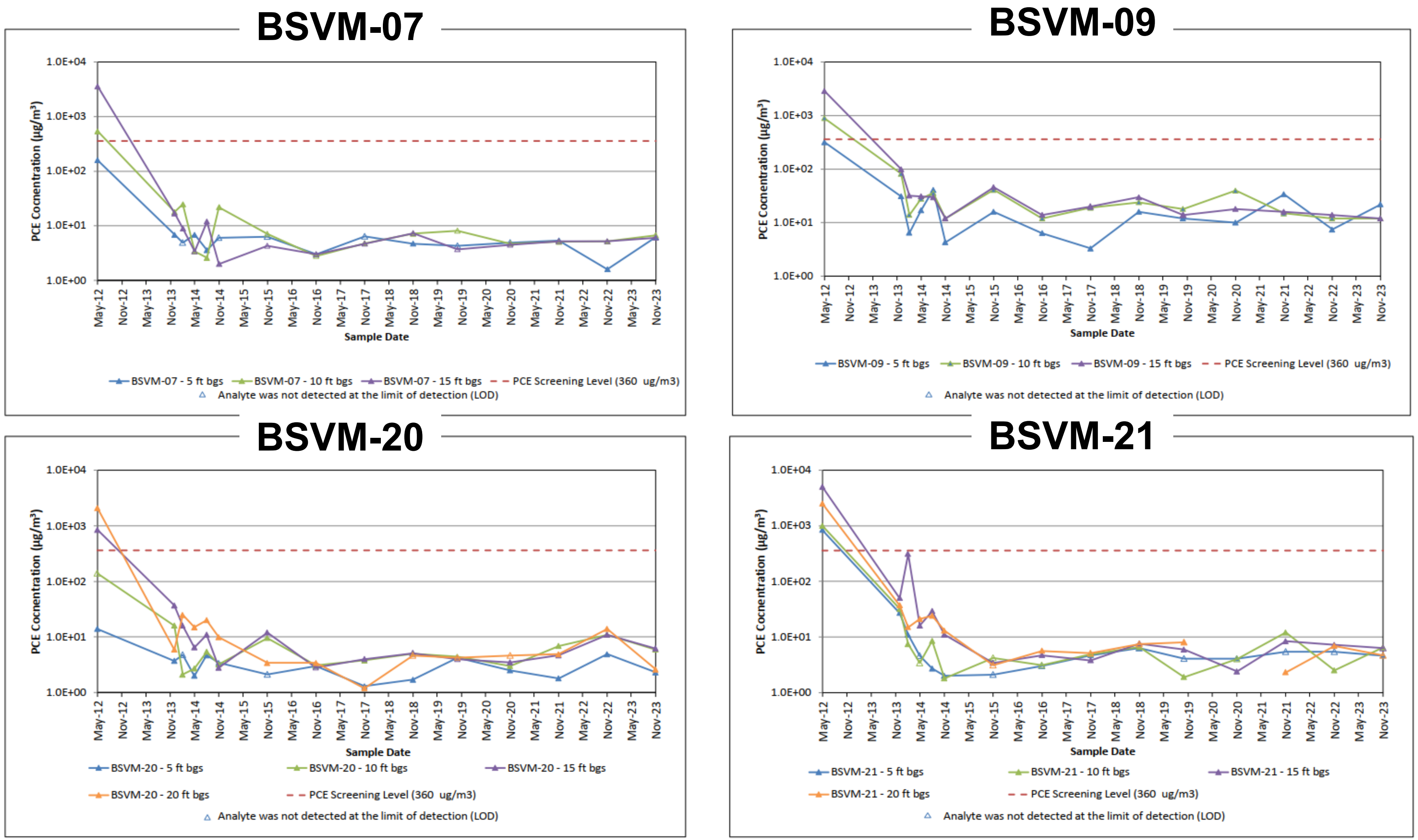
KEY POINTS

Second SVE/SVMC system effectively mitigated lateral migration from Backyard Area into Saint Elizabeth Church buildings

CVOC concentrations have reduced by 1 to 3 OOM since SVE/SVMC system startup in October 2013



(NAVFAC 2017)



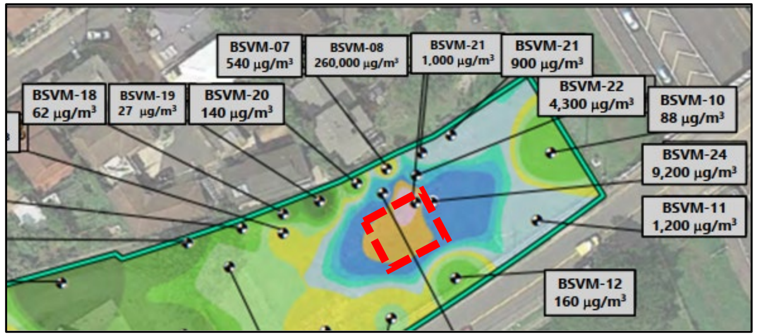
Backyard Area Fenceline Soil Vapor Results

Optimization Study: Data Summary

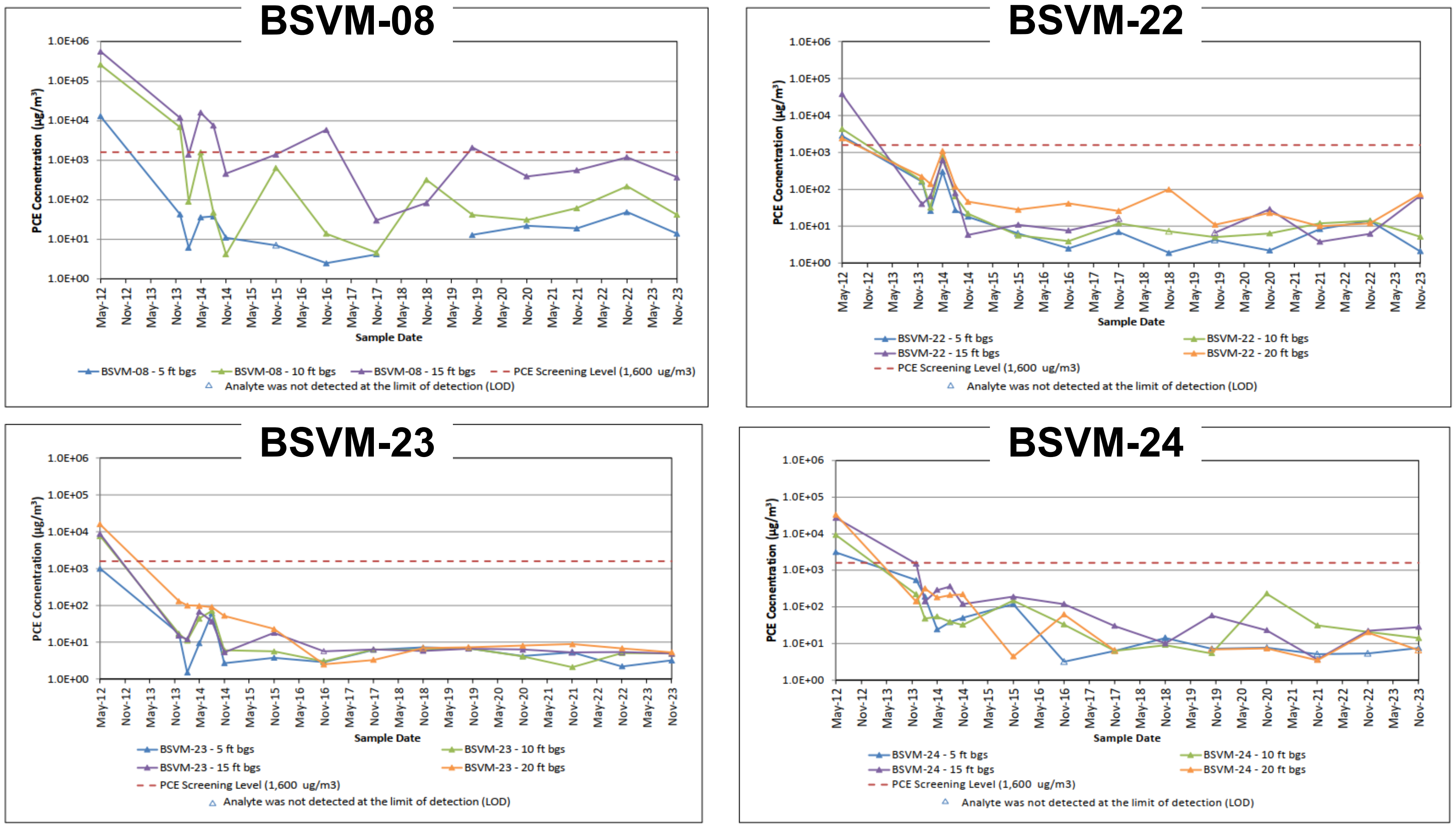
KEY POINTS

In the center of the Backyard Area, PCE concentrations decreased to less than the PSL following startup, except for BSMV-08

After 1 year, PCE concentrations were 1 to 2 OOM less than the PSL and 2 to 3 OOM less than baseline



(NAVFAC 2017)


BSVM-08

BSVM-22

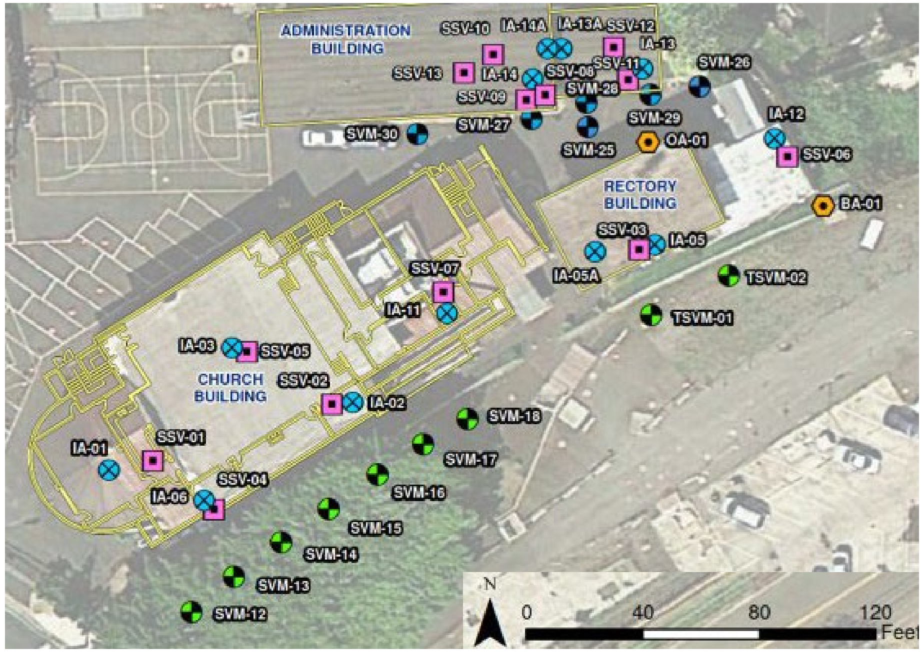
BSVM-23

BSVM-24

Center of Backyard Area Soil Vapor Results

Optimization Study: Data Summary

- Sub-slab soil vapor data indicate detected PCE concentrations decreased 2 to 3 OOM once second SVE/SVMC system began operations
- Indoor air concentrations have been less than project screening levels except when background sources are present
- Overall, second SVE/SVMC system effectively mitigated lateral migration of contamination from Laundry Area into buildings



(AECOM 2023a)

Legend

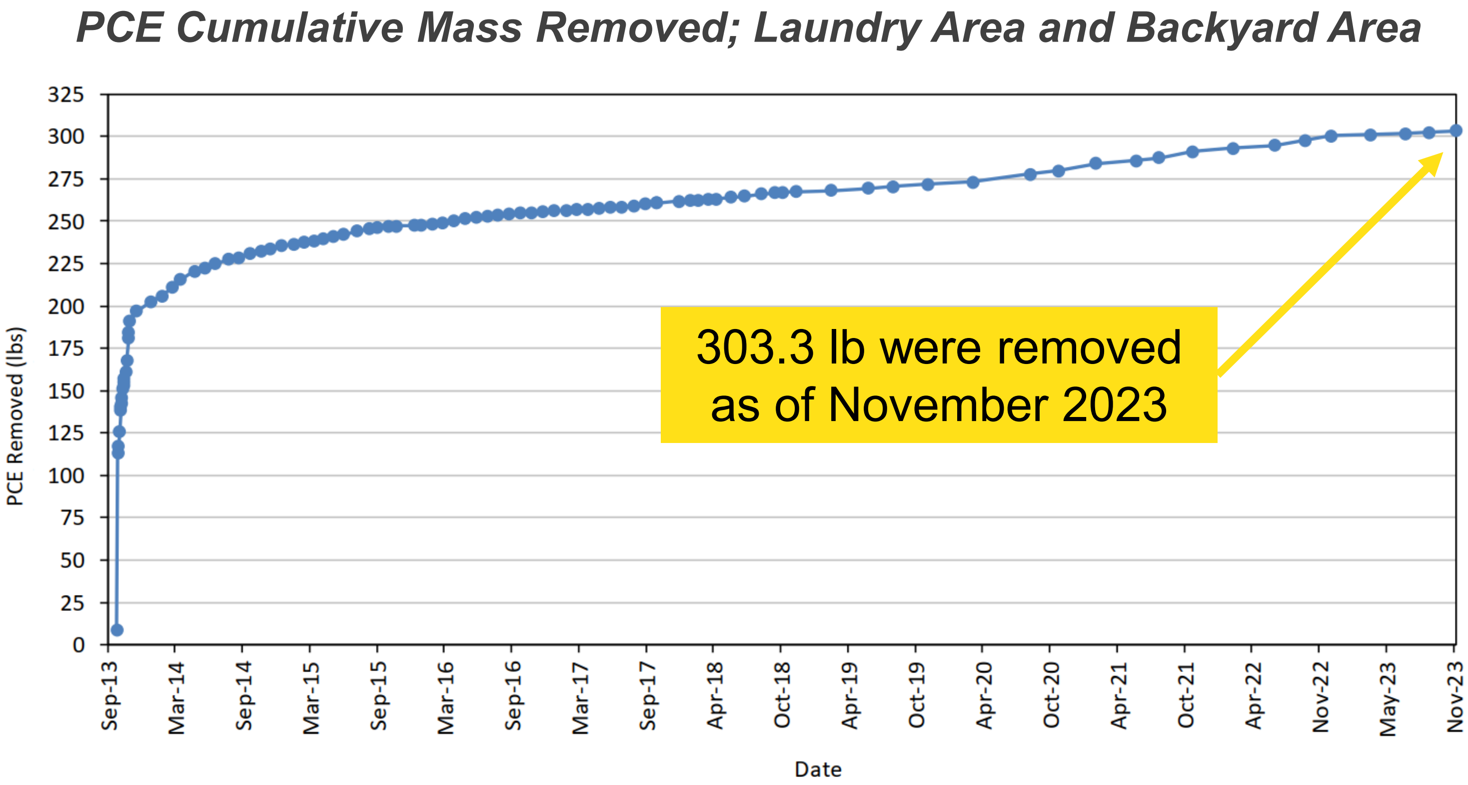
⊗	Indoor Ambient Air Sampling Location
▣	Subslab Soil Vapor Sampling Location
⬡	Outdoor Ambient Air Sampling Location
—	Church and Administration Building Floor Plan
◕	Soil Vapor Monitoring Well
◕	Soil Vapor Fenceline Wells

KEY POINT

Potential for VI concerns in church and rectory buildings is low.

Optimization Study: Data Summary

- Second SVE/SVMC system reduced PCE mass in source areas
- PCE removal rate has been asymptotic since 2022
    - About 0.01 lb per day

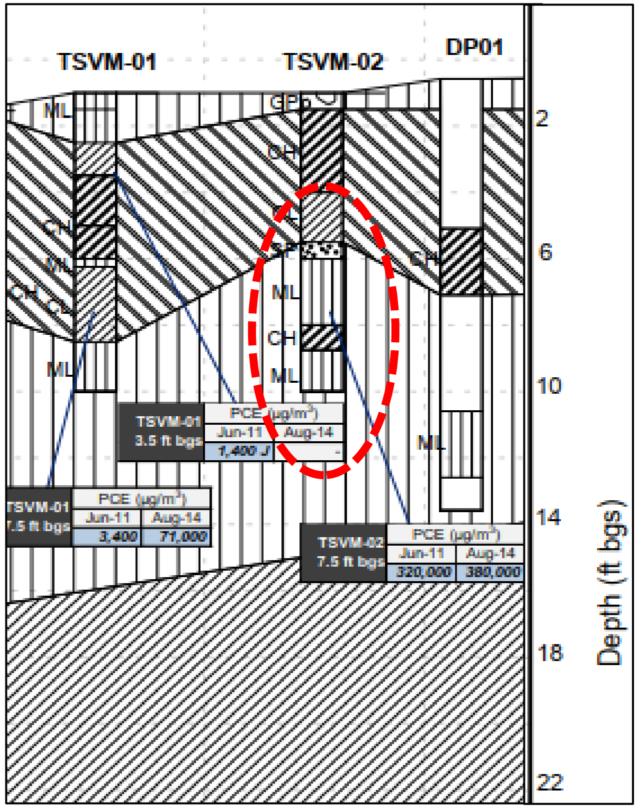


(AECOM 2023b)

lb: pound(s)

Optimization Study: Recommendations

Observation	Recommendation
PCE concentrations along western portion of fenceline decreased after second SVE/SVMC system startup in October 2013 and have been less than PSLs since 2014	• Shut down second SVE/SVMC wells • Perform a rebound study (with quarterly monitoring) to evaluate whether further operation of second SVE/SVMC along fenceline is necessary
PCE concentrations have fluctuated at TSVM-02 and SVM-24; subsurface lithology in these areas includes fat and high-plasticity clays that appear to be limiting mass removal	• Intermittently operate (e.g., 2 weeks on, 2 weeks off) second SVE/SVMC wells near TSVM-02 and SVM-24 to reduce energy cost and equipment wear • Reduce second SVE system inspections to semiannual • Perform HRSC in these areas and conduct an evaluation of additional remediation technologies (including soil removal options)



(Resolution Consultants 2017a)

Optimization Study: Recommendations

Observation	Recommendation
PCE concentrations decreased to less than PSL in center of Backyard Area	• Shut down second SVE/SVMC wells in Backyard Area • Conduct rebound study (with quarterly monitoring) to evaluate whether further operation is necessary
Nearly 10 years of data indicate second SVE/SVMC system has reduced source mass and prevented soil vapor migration onto Saint Elizabeth Church property, and there is a low potential for VI because subslab soil gas concentrations have remained below PSLs since 2014	• Continue second SVE/SVMC operation around TSVM-02 (per previous recommendation) • Discontinue quarterly monitoring activities in buildings on church property • Monitor potential soil vapor migration at multiple soil vapor probes along property border as part of rebound study

KEY POINT

Pending rebound monitoring results, the optimized monitoring program will reduce annual costs by $100,000 to $200,000.

Knowledge Check

- **Question:** What path forward or next steps would most likely allow for accelerated site closure?
- **Answers:**
  a. Shutdown of second SVE/SVMC system
  b. Targeted removal of source material bound in subsurface clay
  c. Reduced monitoring frequency of second SVE/SVMC system
  d. Rebound testing of second SVE/SVMC system

Knowledge Check

- **Question:** What path forward or next steps would most likely allow for accelerated site closure?
- **Answers:**
  - a. Shutdown of second SVE/SVMC system
  - b. **Targeted removal of source material bound in subsurface clay**
  - c. Reduced monitoring frequency of second SVE/SVMC system
  - d. Rebound testing of second SVE/SVMC system

Why Answer b?

Concentration trends showing asymptotic removal indicate system is likely nearing maximum mass removal that can be achieved.

Summary

NORM Phase(s)	2 (but with elements of 6)
Optimization trigger(s)	Sampling data are consistent and predictable, and contaminant mass recovery has become asymptotic
Key tools or concepts	• Vapor concentration trend analysis • Monitoring program optimization
Key constraint(s)	Sensitive receptors adjacent to site
Outcome	• Reduced second SVE/SVMC operation • Optimized vapor monitoring program
Path forward	• Consider HRSC to identify residual source mass • Operate second SVE/SVMC as needed and implement optimized vapor monitoring program
Potential financial impact	Annual cost reduction of $100,000 to $200,000

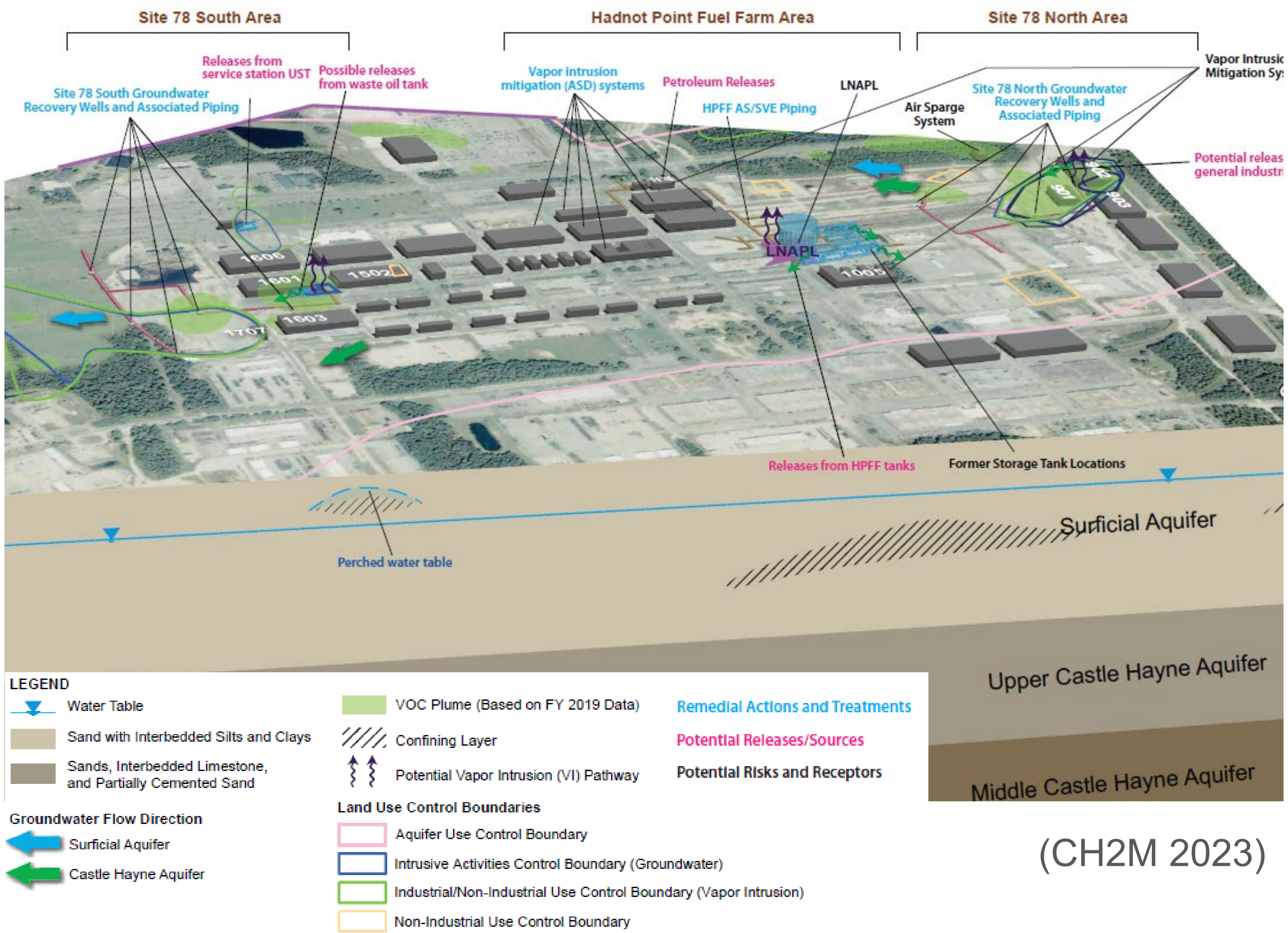
Presentation Overview

- Introduction
- Optimization Basics
- Case Study #1: JBPHH Former Aiea Laundry Facility
- Case Study #2: Camp Lejeune Site 78
- Case Study #3: NAPR SWMUs 7 and 8
- Case Study #4: ABL Site 10
- Key Takeaways

NORM Phase(s)	6 and then 2 (3 and 4 pending)
Optimization trigger(s)	Remedy not projected to meet RAOs
Key tools or concepts	• Bench and pilot studies • REMChlor modeling and development of active remediation goals • Partnering process
Key constraint(s)	• No defined exit strategy in decision document • Different state and federal cleanup levels

Site Background

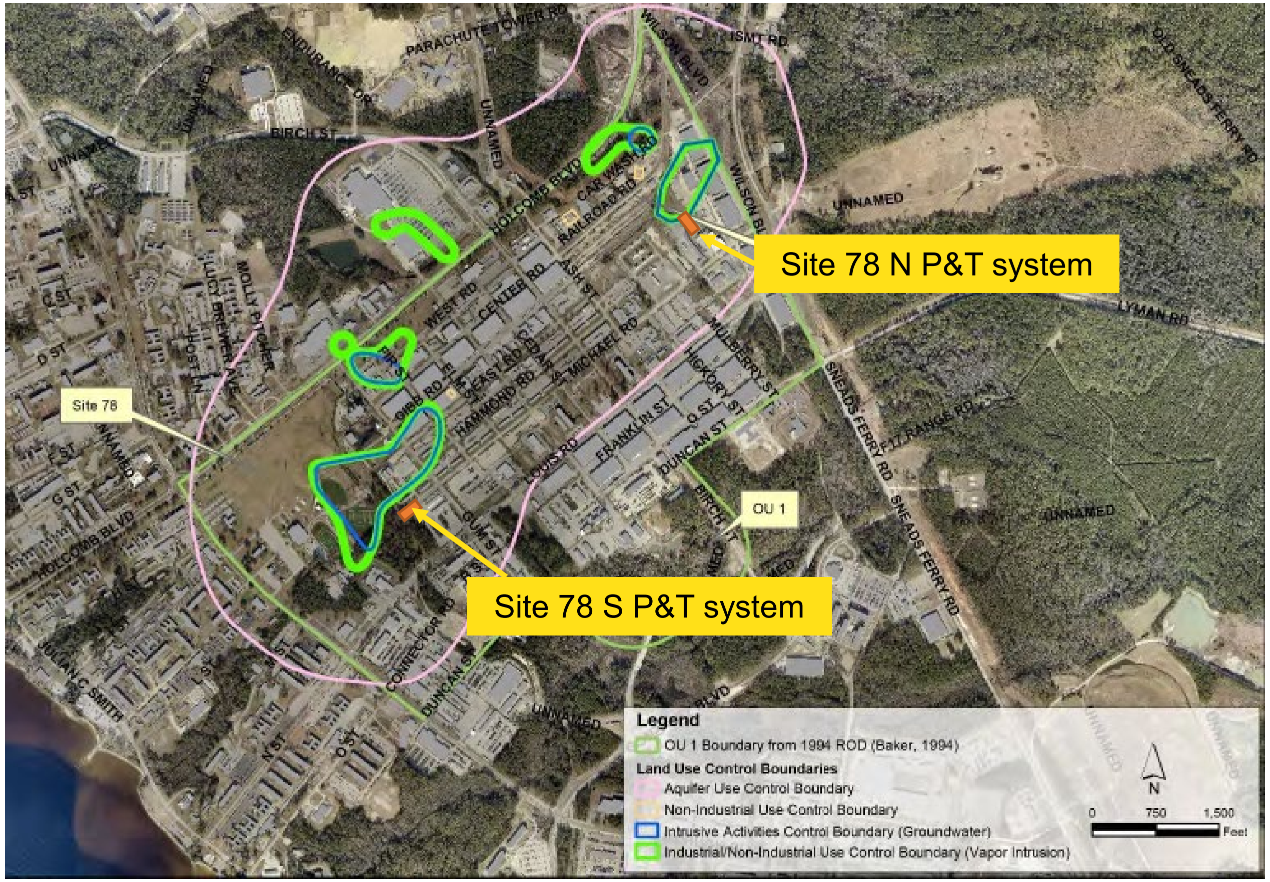
- Site background
  - 590 acres of industrial land developed in late 1930s
  - Maintenance shops, warehouses, painting shops, printing shops, auto body shops
  - Numerous spills and leaks of petroleum-related products and chlorinated solvents
- Potential risks
  - Human health risks from VOCs in groundwater
    - Potable water source for future residents
    - Construction



(CH2M 2023)

Long-term Remedy

- Two P&T systems (Sites 78 North and Site 78 South) began operation in 1994, along with LTM and LUCs
  - Originally, 15 recovery wells screened from 25 to 35 feet bgs
  - Currently, 9 recovery wells operational
  - Treatment via air strippers and carbon
  - Discharged to sanitary sewer
- No exit strategy defined in ROD
  - Operation to continue until NCGWQS achieved (more stringent than MCLs)



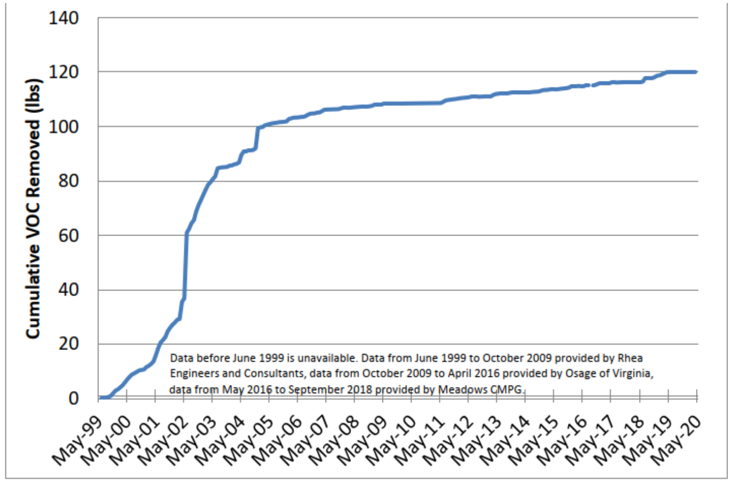
(CH2M 2023)

bgs: below ground surface
LTM: long-term monitoring
LUC: land use control
MCL: maximum contaminant level
NCGWQS: North Carolina Groundwater Quality Standards
P&T: (groundwater) pump and treat

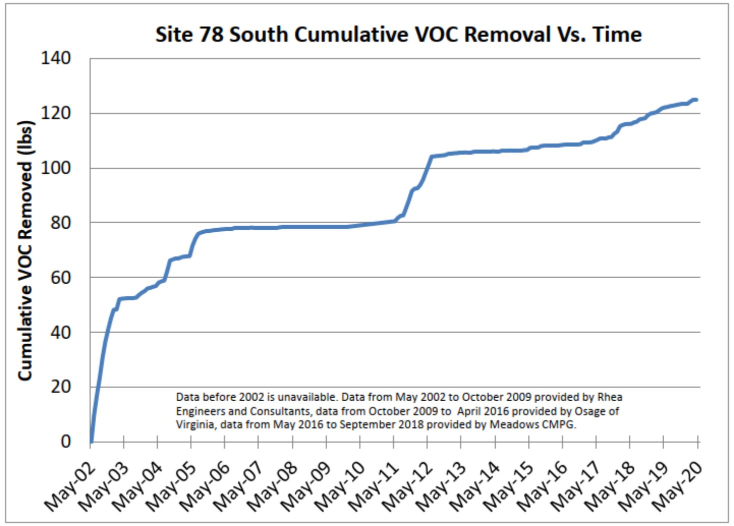
Optimization Rationale

- Remedy is **not functioning** as designed and RAOs will not be met
    - Contaminant mass removal is asymptotic
        - Approximately 0.32 lb of VOCs removed per month
        - >400 years of pumping required to achieve NCGWQS
    - Impacted groundwater **extends beyond influence** of extraction well network
        - Plume identified to northwest of site
        - Impacts observed up to 125 feet bgs; recovery wells screened to 35 feet bgs

Total of approximately 245 lb of VOCs removed



Data before June 1999 is unavailable. Data from June 1999 to October 2009 provided by Rhea Engineers and Consultants, data from October 2009 to April 2016 provided by Osage of Virginia, data from May 2016 to September 2018 provided by Meadows CMPG.



Site 78 South Cumulative VOC Removal Vs. Time

Data before 2002 is unavailable. Data from May 2002 to October 2009 provided by Rhea Engineers and Consultants, data from October 2009 to April 2016 provided by Osage of Virginia, data from May 2016 to September 2018 provided by Meadows CMPG.

(CH2M 2022)

Technology Evaluation (2003 to 2017): Site 78 North

Technologies Piloted	General Approach	Outcome
Aerobic bioremediation *(2003–2005)*	Focused Oxygen Release Compound injections to address elevated VC concentrations	Little change to dissolved oxygen concentrations and oxidation reduction potential, and no apparent contaminant concentration reductions
ISCO *(2012)*	Persulfate bench-scale study using site soil and groundwater	Not effective in lab; not recommended for field implementation
ISCR + ERD *(2012–2013)*	Bench-scale study testing using a buffered, micro-emulsion of slow-release, EHC® Liquid and bioaugmentation to target lower VOC concentrations	Not effective in lab; not recommended for field implementation
AS *(2017-2018)*	Air injection via stacked injection wells in Northwest Woods to target elevated VOC concentrations down to 125 feet bgs	Highly effective at mass reduction, influence observed 40 feet from injection wells, VOC accumulation not observed in shallower zones
Enhanced P&T *(2018–2019)*	Pumping test to evaluate groundwater extraction in deeper intervals	Determined extraction well radius of influence

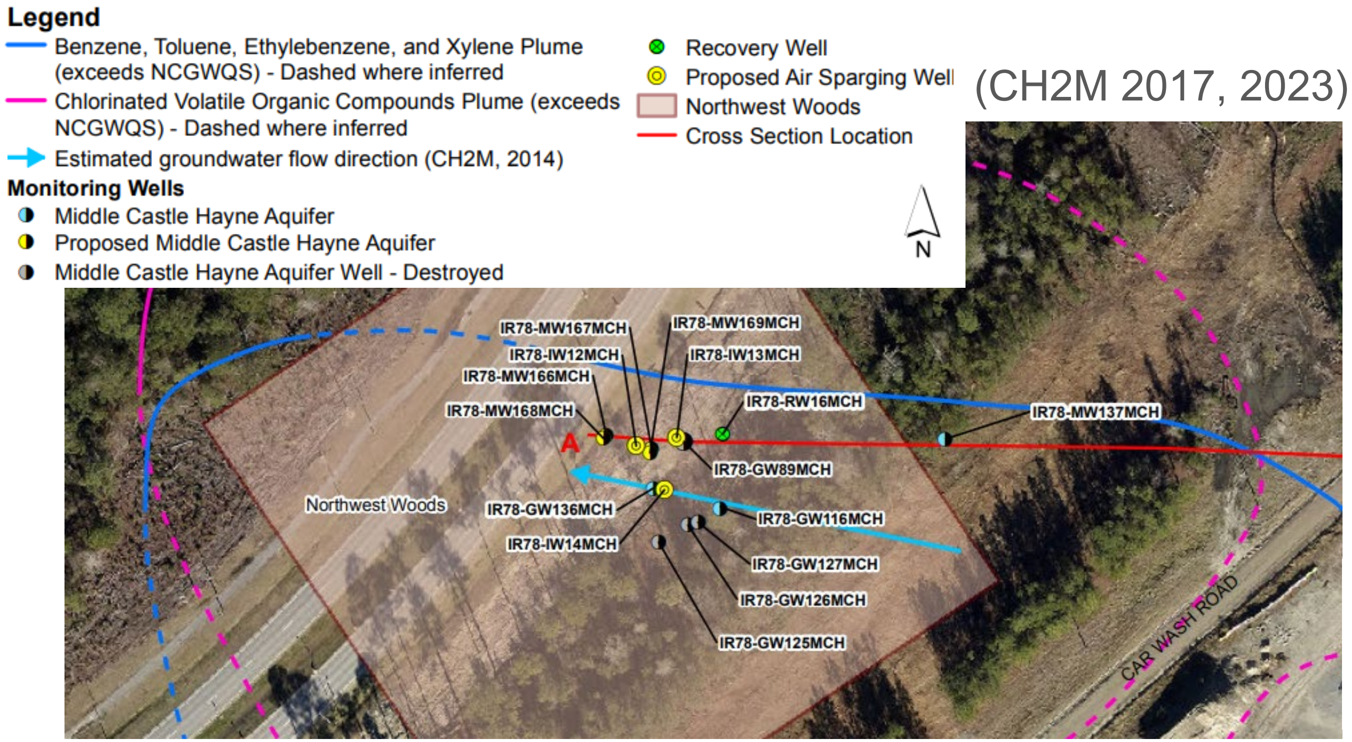
AS: air sparging

ERD: enhanced reductive dechlorination

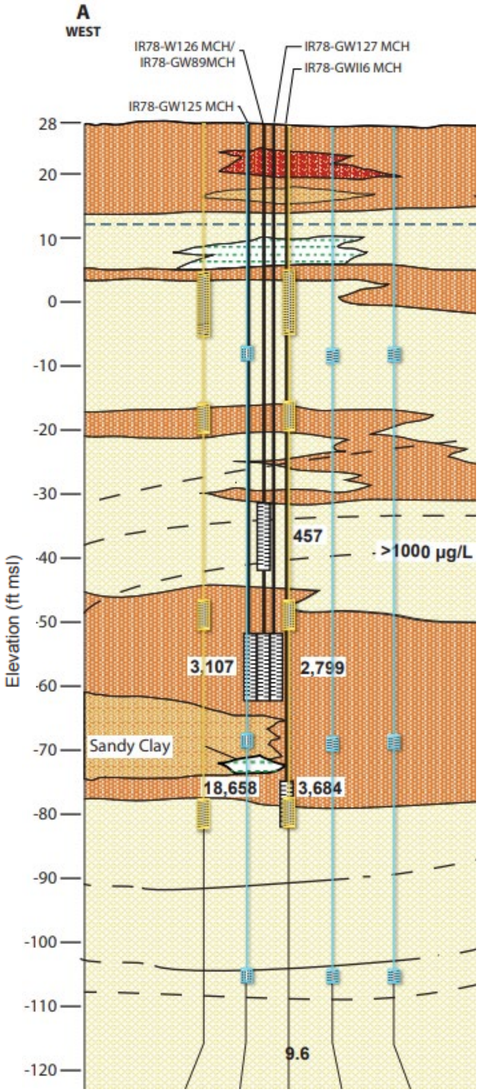
ISCO: in situ chemical oxidation

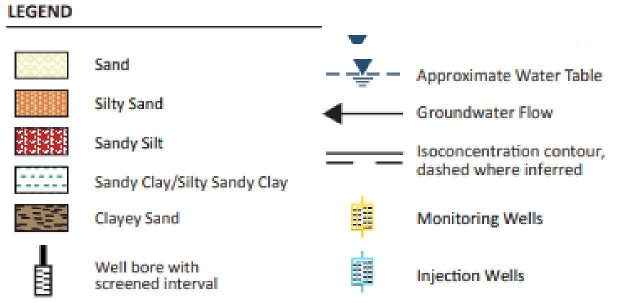
ISCR: in situ chemical reduction

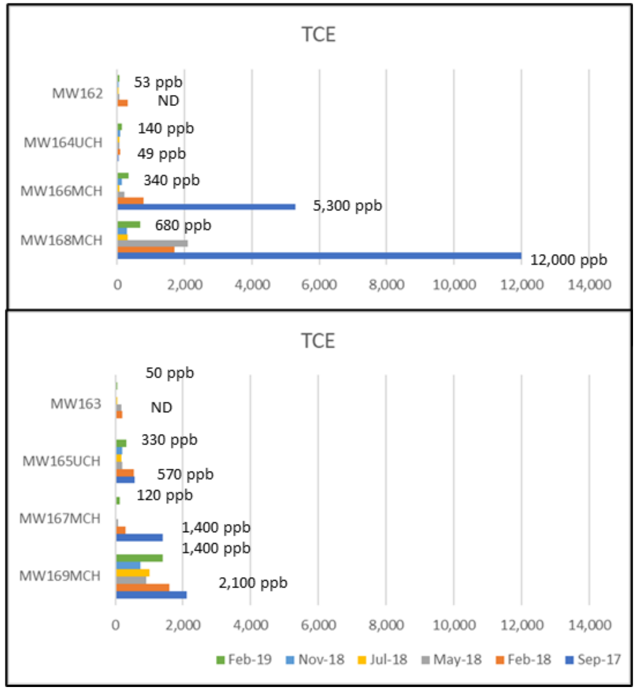
Technology Evaluation (2003 to 2017): Site 78 North



(CH2M 2017, 2023)







KEY POINT

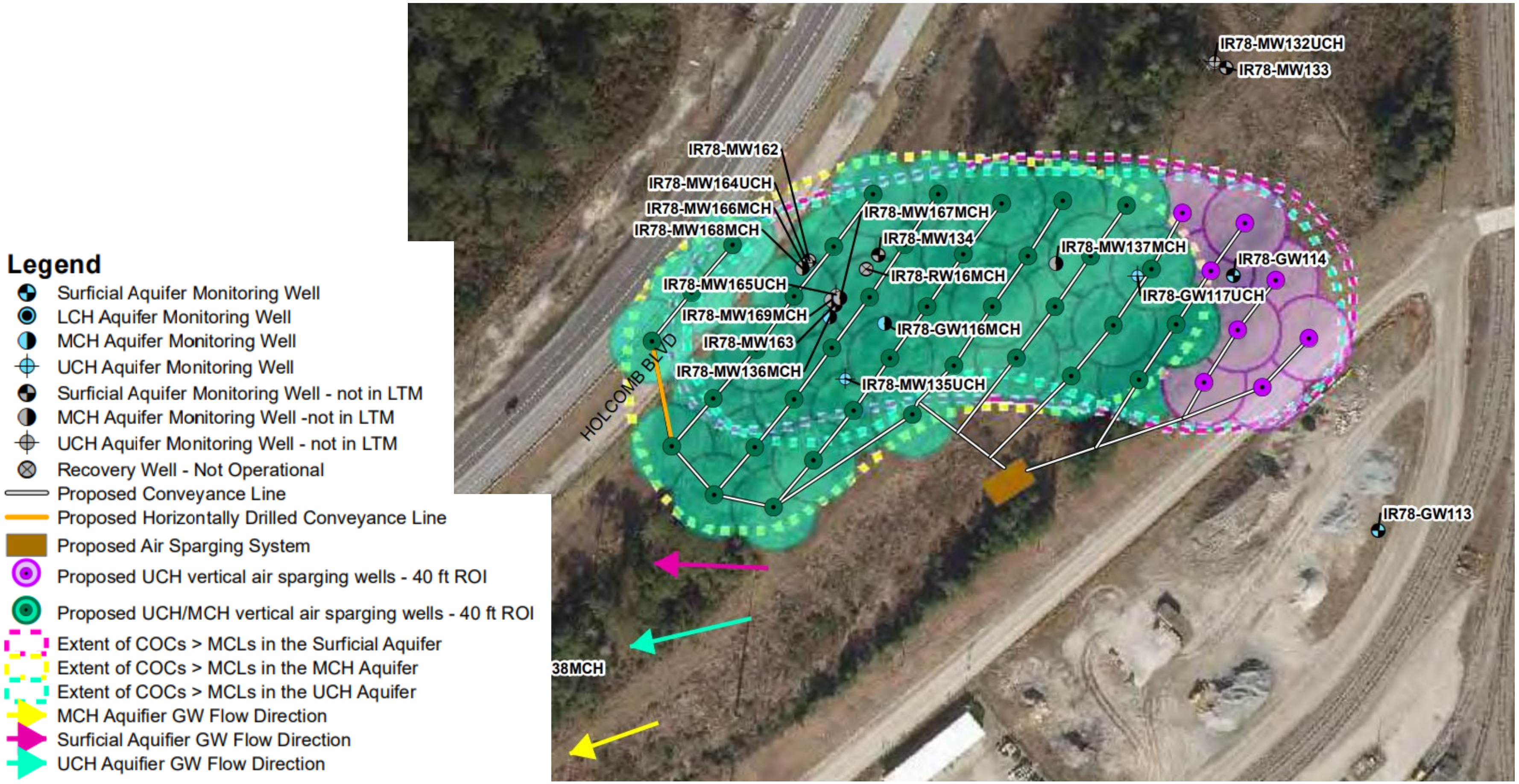
AS pilot study confirmed the effectiveness of a stacked wells system to overcome challenges of removing VOC mass from a stratified lithology.

Technology Evaluation (2003 to 2017): Site 78 South

Technologies Piloted	General Approach	Outcome
Enhanced bioremediation *(2003–2005)*	Focused Hydrogen Release Compound injections	Reductive dechlorination increased significantly following study, but was not complete and appeared to stall at cis-1,2-DCE
ISCO *(2012)*	Persulfate bench-scale study using site soil and groundwater	Not effective in lab; not recommended for field implementation
Enhanced bioremediation *(2012–2013)*	Sulfate bench-scale study using site soil and groundwater	No reduction in benzene, toluene, ethylbenzene, and xylene or CVOC concentrations; not recommended for field implementation
ISCR + ERD *(2015)*	Focused injections of EHC-L and bioaugmentation	TCE concentrations decreased by 94% and total CVOC concentrations decreased by 75%; treatment observed up to 18 feet from injections wells

Technology Evaluation (2003 to 2017): Outcome

- Technologies retained for FS Amendment
  - Enhanced P&T
  - ERD
  - AS
  - MNA



AS Alternative Layout for Site 78 North
(CH2M 2023)

Remediation Timeframe Quandary

- For this site, EPA determined reasonable timeframe is 100 years
- Focused treatment will reduce remediation timeframe by achieving MCLs (EPA's priority) within 100 years
- However, **REMChlor modeling** suggests timeframe to reduce COCs from MCLs to NCGWQS (applicable or relevant and appropriate requirement in ROD) via MNA >400 years
- Extensive active treatment would be required to achieve NCGWQS within 100 years, with no change to risk profile

COC	MCL (µg/L)	NCGWQS (µg/L)
PCE	5	0.7
TCE	5	3
Cis-1,2-DCE	70	70
VC	2	0.03

µg/L: microgram(s) per liter

Remediation Timeframe Quandary

- Selection of preferred alternative stagnated for several years
  - Conflicting stakeholder opinions on remediation timeframe
  - Concern about projected cost of active treatment to achieve NCGWQS
    - $28 million to $50 million sitewide
- EPA and NCDEQ managers and attorneys met to discuss conflict between cleanup levels and remediation timeframe, and reached agreement
  - Based on site-specific conditions, EPA and NCDEQ concurred that remedy will be optimized to meet MCLs within 100 years
  - Once active groundwater treatment is no longer necessary, LUCs will remain, and long-term monitoring will be conducted until NCGWQS achieved
- NAVFAC agreed to focused treatment and defined short-term operation period to optimize mass removal

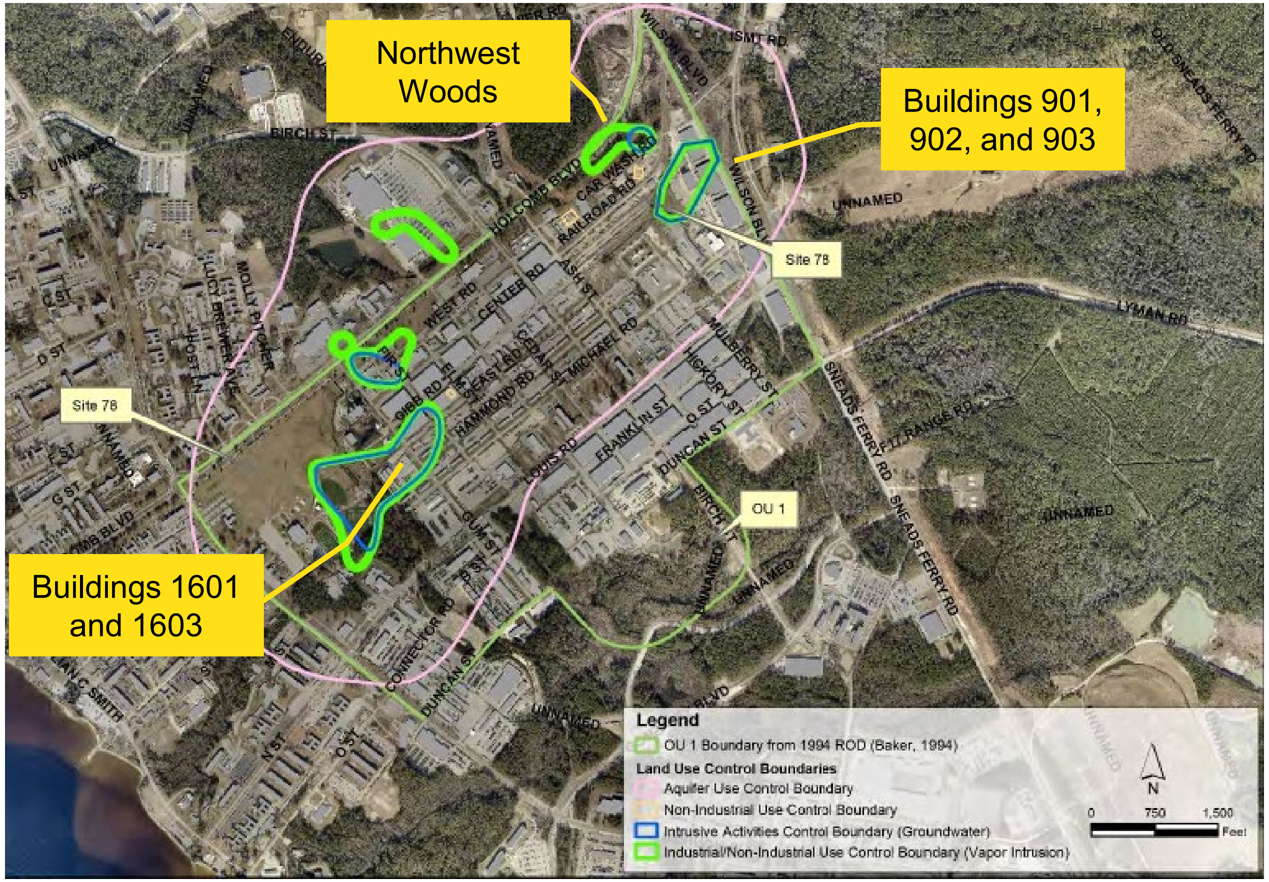
KEY POINT

Regulatory stakeholder collaboration facilitated an alternate interpretation of reasonable timeframe and active remediation goals.

NCDEQ: North Carolina Department of Environmental Quality

Revised Optimization Approach

- Three target treatment areas
  - Buildings 901, 902, and 903
  - Northwest Woods
  - Buildings 1601 and 1603
- Model ARGs within each area
  - COC concentrations that will attenuate to MCLs within 100 years
  - Determined by
    - Using REMChlor to back into ARG
    - Reviewing trend analysis using empirical data
- Develop alternatives in FS Amendment



(CH2M 2023)

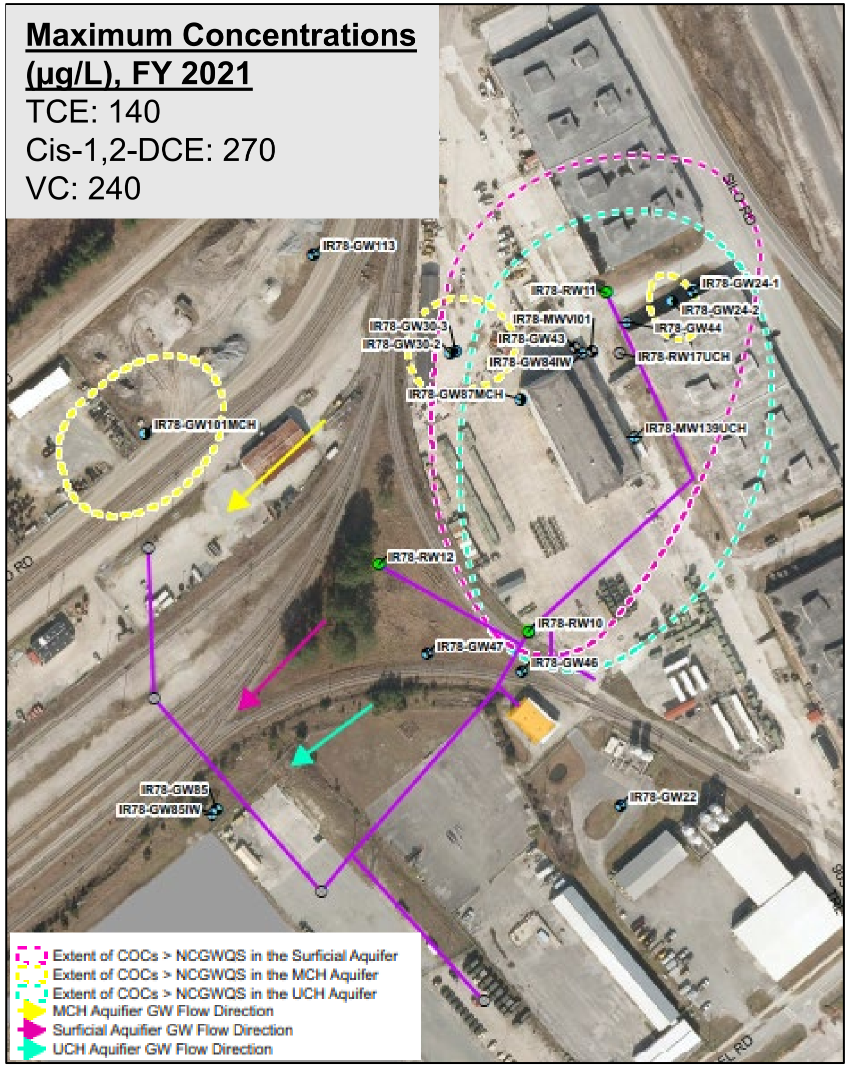
ARG: active remediation goal

Optimized Remedies

- Buildings 901, 902, and 903: MNA
  - REMChlor modeling and empirical data trend analysis indicates COC concentrations will be less than MCLs within 100 years via MNA
  - Additional active treatment not required

Key Element	Current Remedy (P&T)	Optimized Remedy (MNA)
Description	Continued operation of pump and treat system, LTM, and LUCs	MNA using existing well network, LTM, and LUCs
Remediation timeframe	>400 years (to NCGWQS)	Approximately 60 years (to MCL) >400 years (to NCGWQS)
Sampling program	Annual monitoring	Monitoring every 5 years
Capital costs	$0	$0
Annual costs	$100,000	$50,000
Total costs	$6,500,000	$600,000

FY: fiscal year



Maximum Concentrations (µg/L), FY 2021
TCE: 140
Cis-1,2-DCE: 270
VC: 240

(CH2M 2023)

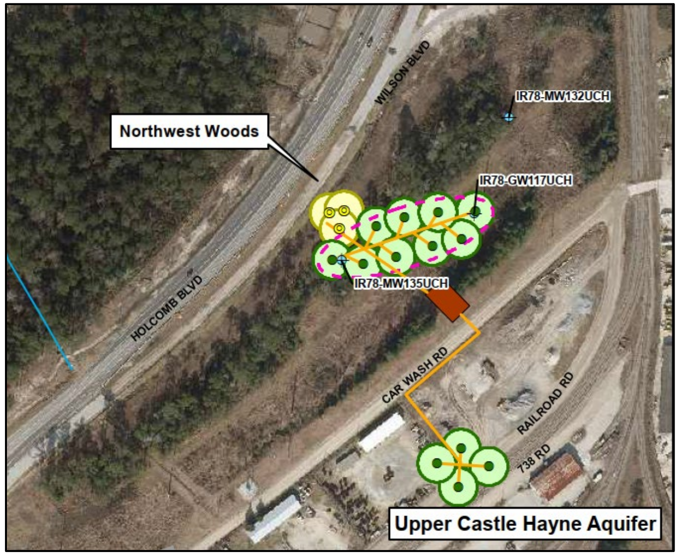
Optimized Remedies

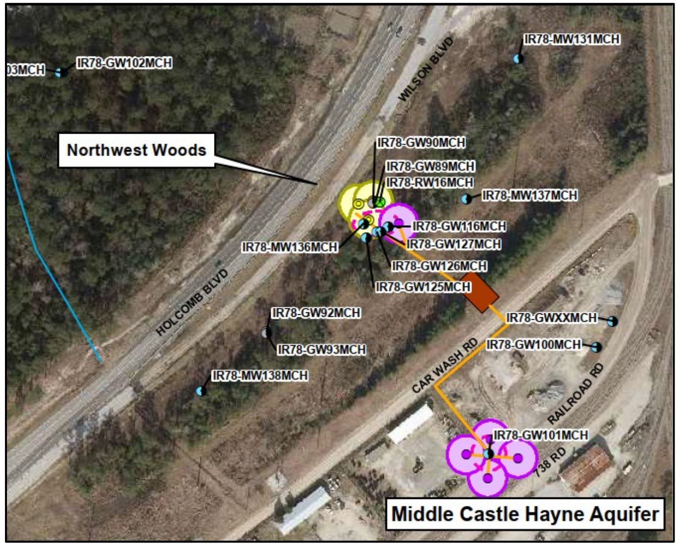
- Northwest Woods: AS
    - ARG
        - TCE = 15 µg/L

Legend

- ● Surficial Aquifer Monitoring Well
- ◐ Middle Castle Hayne Aquifer Monitoring Well
- ⊕ Upper Castle Hayne Aquifer Monitoring Well
- ⊗ Recovery Well
- 🟥 Proposed Air Sparging System
- — Proposed Conveyance Line
- ◎ Existing air sparging well - 40 foot radius of influence (ft ROI)
- ◎ Proposed MCH air sparging well - 40 foot radius of influence (ft ROI)
- ◎ Proposed UCH air sparging well - 40 foot radius of influence (ft ROI)
- ⁞ Active Remediation Goals (ARGs) Exceedance

Key Element	Current Remedy (MNA)	Optimized Remedy (AS)
Description	LTM and LUCs	AS via 24 wells, followed by MNA, LTM, and LUCs
Remediation timeframe	>400 years	Active operation: 2 years (to ARGs)
Sampling program	Annual monitoring	Annual performance monitoring, followed by MNA monitoring every 5 years
Capital costs	$0	$1,770,000
Total annual costs	$30,000	$200,00 AS | $40,000 MNA
Total costs	$2,000,000	$2,230,000



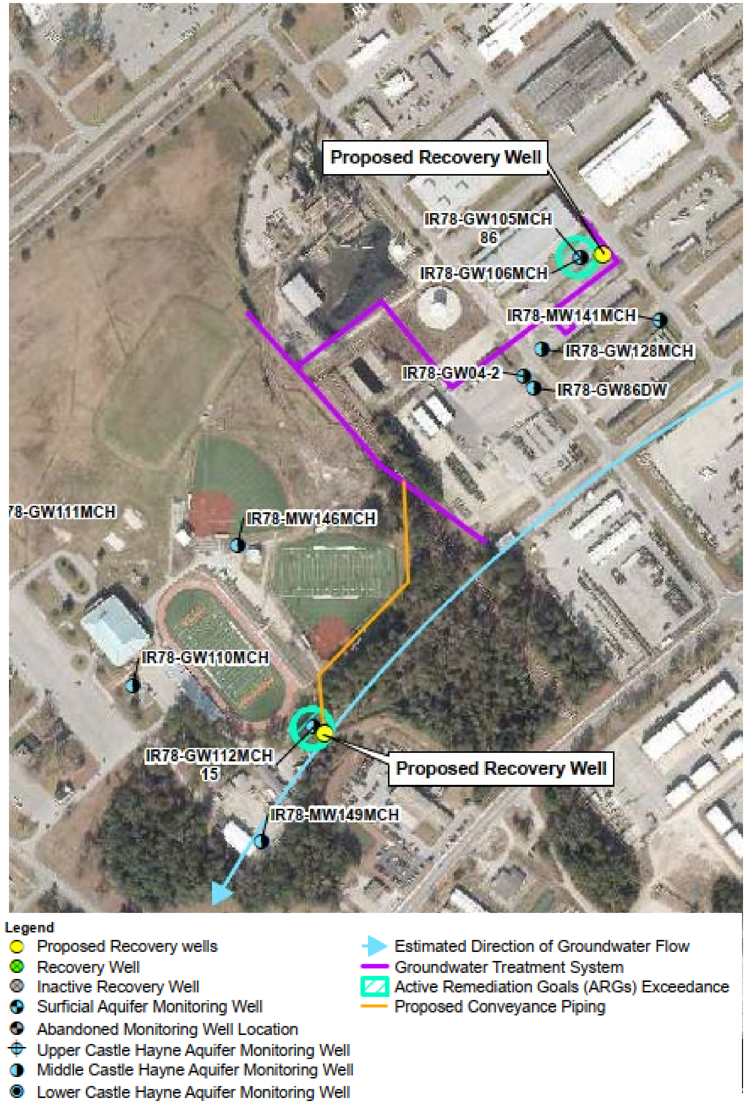


(CH2M 2024)

Optimized Remedies

- Buildings 1601 and 1603: Enhanced P&T
  - ARGs
    - TCE = 13 µg/L
    - VC = 23 µg/L

Key Element	Current Remedy (P&T)	Optimized Remedy (Enhanced P&T)
Description	Continued operation of pump and treat system, LTM, and LUCs	Operate three existing recovery wells and two new recovery wells
Remediation timeframe	>400 years	Active operation to achieve ARGs or maximum of 5 years
Sampling program	Annual monitoring	Annual performance monitoring, followed by MNA monitoring every 5 years
Capital costs	$0	$184,000
Total annual costs	$108,000	$104,000 | $55,000 MNA
Total costs	$7,200,000	$683,000



(CH2M 2024)

Next Steps

- Proposed Plan and ROD Amendment: 2025
  - Will memorialize the following key attributes of the new remedy
    - ARGs (to facilitate transition to MNA)
    - Limit of 5 years of additional operation of the expanded P&T system
- Pre-design investigation: 2026
  - To finalize the layout of the new remedies
- Remedial design: 2027
- Remedial action: 2028

KEY POINT

Optimized remedies will save $12.4M (LCC) and define active remediation exit strategy.

Knowledge Check

- **Question:** Which of the following was **not** a critical component of the optimization effort?
- **Answers:**
  a. Use of REMChlor modeling to determine active remediation goals for focused remediation
  b. Collaboration among stakeholders
  c. Continued active treatment until goals in ROD are achieved
  d. Clearly defined exit strategy

Knowledge Check

- **Question:** Which of the following was **not** a critical component of the optimization effort?
- **Answers:**
  a. Use of REMChlor modeling to determine active remediation goals for focused remediation
  b. Collaboration among stakeholders
  c. **Continued active treatment until goals in ROD are achieved**
  d. Clearly defined exit strategy

Why Answer c?

The optimized remedy prioritized stakeholder positions and focused on clearly defined treatment end points based on modeling to save LCCs.

Summary

NORM Phase(s)	6 and then 2 (3 and 4 pending)
Optimization trigger(s)	Remedy not projected to meet RAOs
Key tools or concepts	• Bench and pilot studies • REMChlor modeling and development of active remediation goals • Partnering process
Key constraint(s)	• No defined exit strategy in decision document • Different state and federal cleanup levels
Outcome	• Stakeholder agreement on updated remediation alternative that includes multiple technologies, and a defined active remediation exit strategy
Path forward	• Prepare Proposed Plan and ROD Amendment • Conduct predesign investigation to refine remaining treatment areas • Design and implement updated remedy • Transition to MNA within 5 years of active remedy implementation
Potential financial impact	$12.4 million reduction in LCC

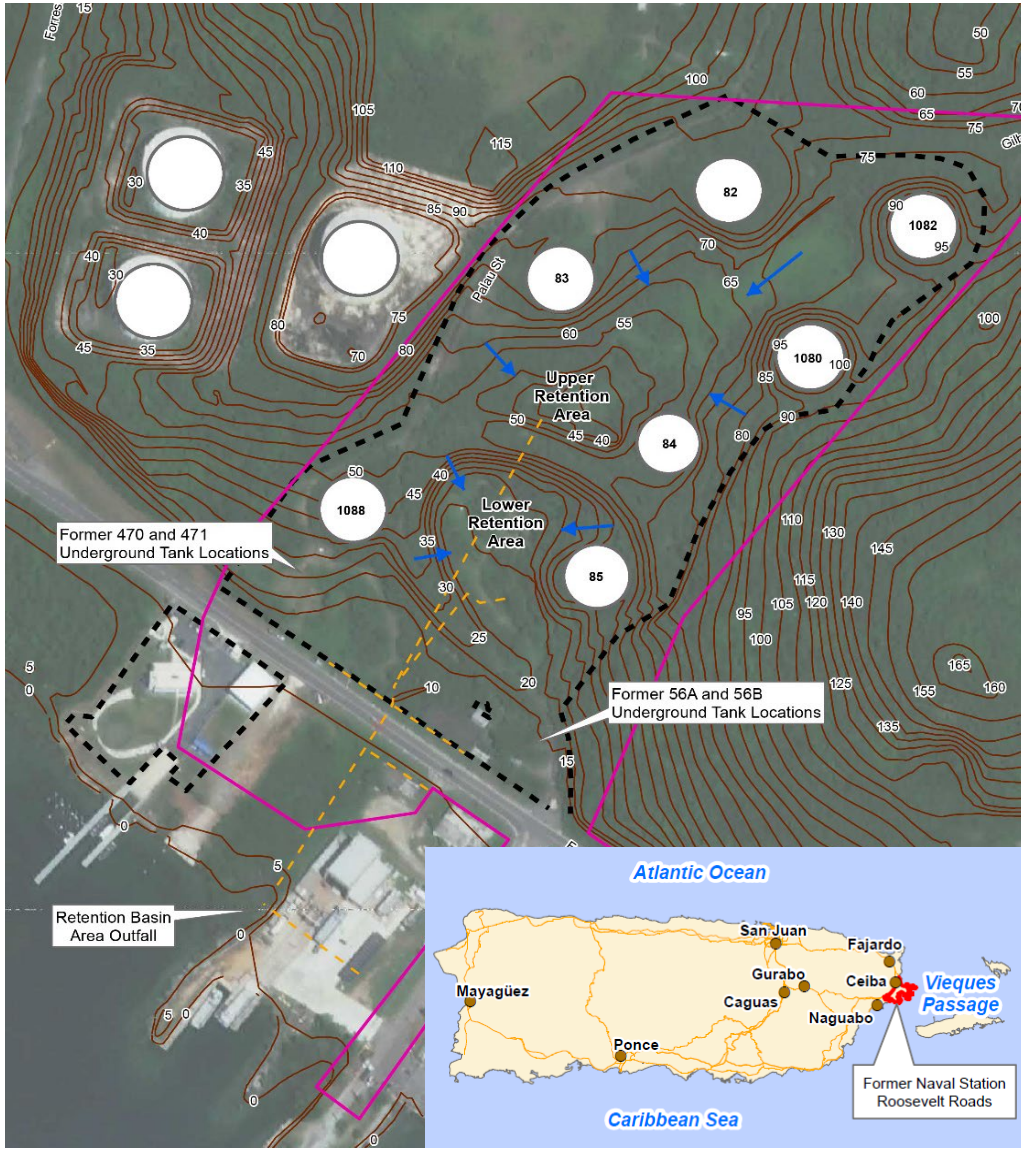
Presentation Overview

- Introduction
- Optimization Basics
- Case Study #1: JBPHH Former Aiea Laundry Facility
- Case Study #2: Camp Lejeune Site 78
- Case Study #3: NAPR SWMUs 7 and 8
- Case Study #4: ABL Site 10
- Key Takeaways

NORM Phase(s)	6 and 7
Optimization trigger(s)	Contaminant mass recovery has become asymptotic
Key tools or concepts	• Lines of evidence approach outlined in *Case Study Review of Optimization Practices and Navy Petroleum Sites* (NAVFAC EXWC 2021) • NSZD • Pilot study
Key constraint(s)	Insufficient data to transition to NSZD and MNA

Site History

- Former TWFF constructed in 1957 on a hillside along Forrestal Drive north of Ensenada Honda
- Nine bombproof and two additional USTs
  - Marine diesel fuel, JP-5, Bunker C fuel, and leaded and high-octane aviation gasoline
- Two 10,000-gallon bombproof USTs and associated soil, and the two additional USTs were removed in 1996
- Fueling operations ceased in 2004



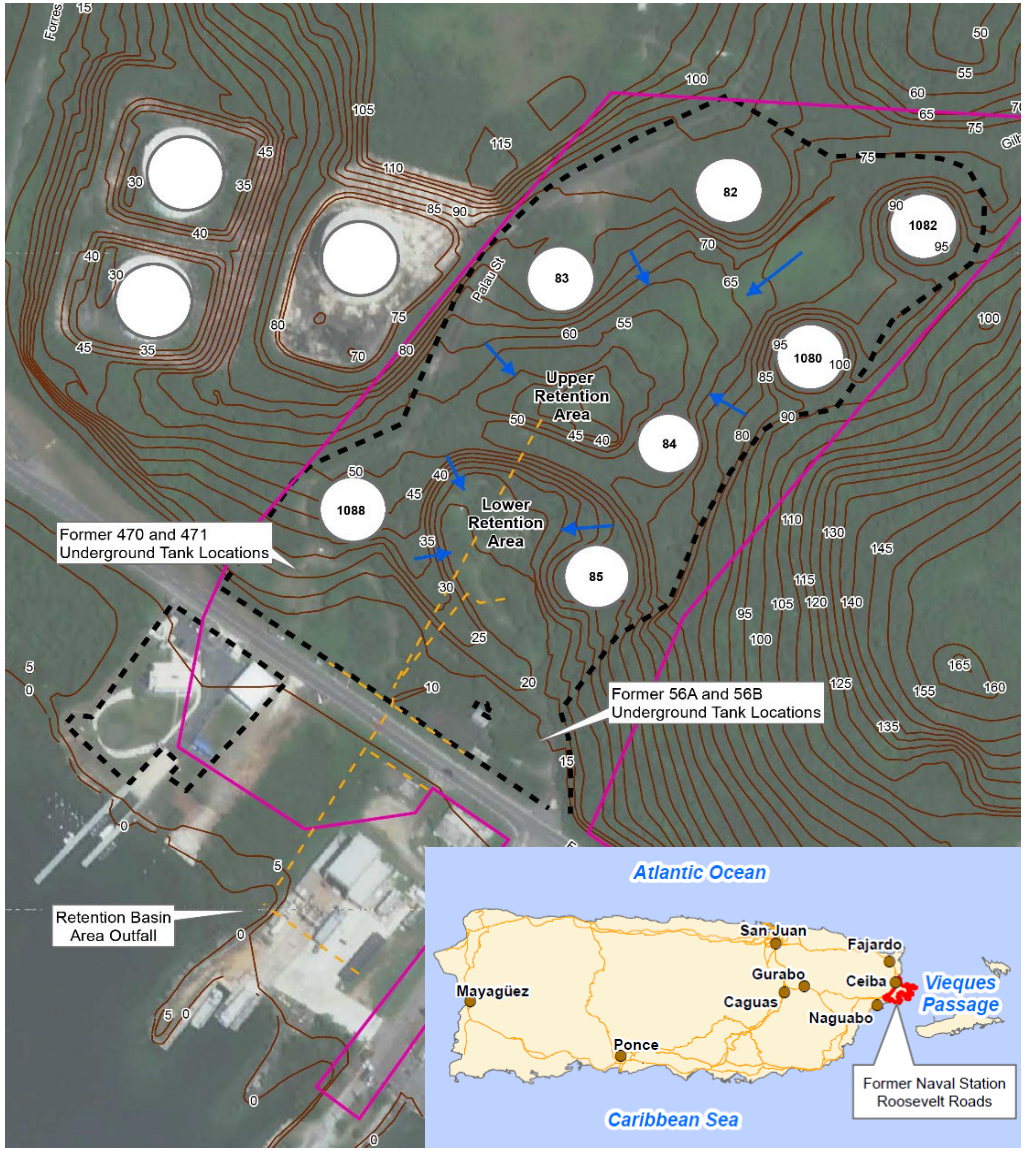
JP-5: jet fuel
TWFF: Tow Way Field Farm

(CH2M 2025)

Site History

- Remaining USTs were drained and cleaned, and conveyance piping was purged and grouted in place in 2012 and 2013
- SWMU 7 is result of environmental impacts from the USTs
- SWMU 8 is TWFF sludge disposal
- CAOs
  - LNAPL goal is 0.01 foot or less
  - Benzene goal is 160 µg/L
    - Based industrial worker inhalation of benzene from groundwater vapors in an industrial building

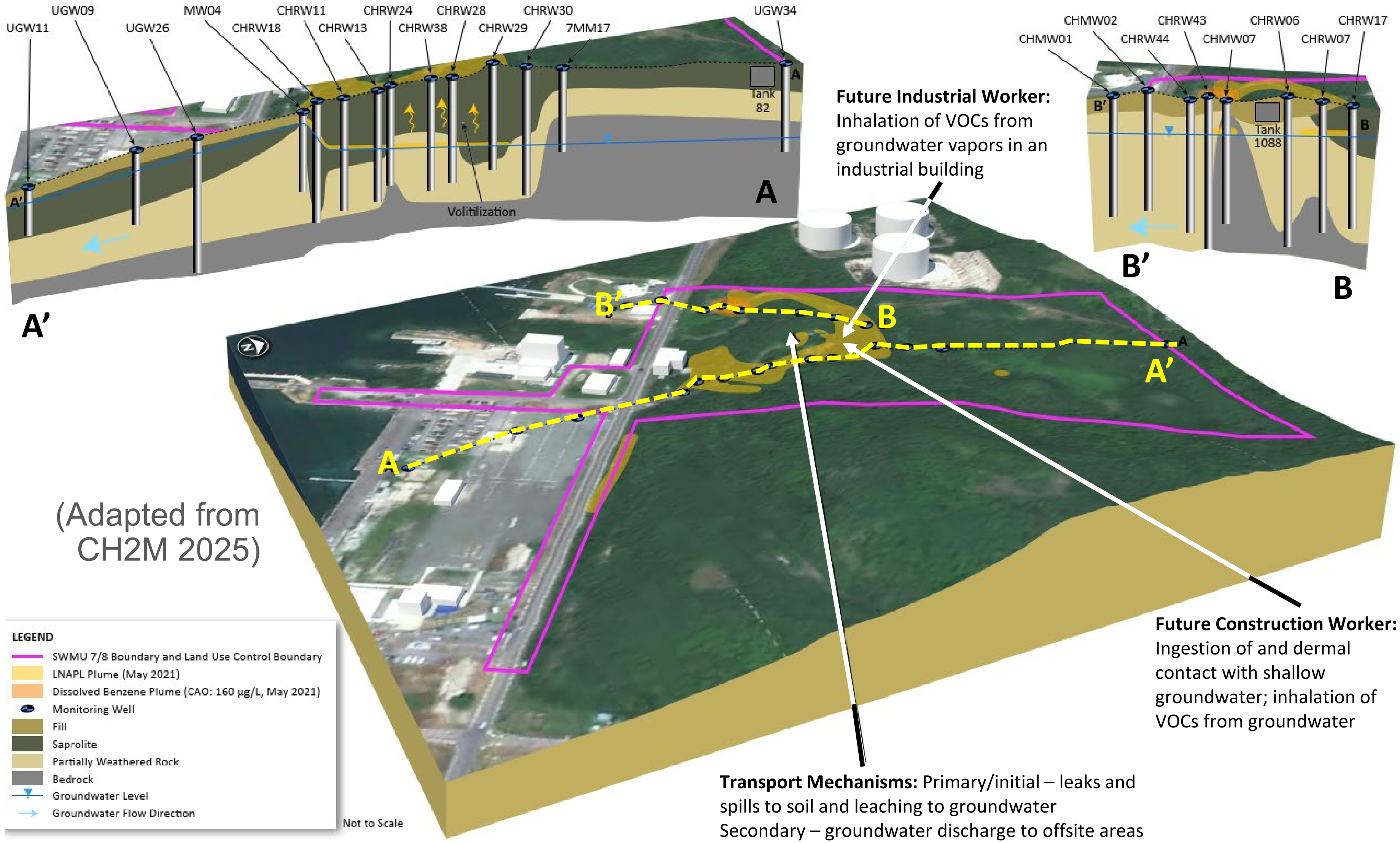
CAO: Corrective Action Objective



(CH2M 2025)

Site Characteristics

- Lithology consists of fill material and weathered rock overlying bedrock
- Groundwater depths can range between 10 and 57 feet bgs
- Groundwater flow is controlled by topography and presence and competency of the bedrock



(Adapted from CH2M 2025)

Future Industrial Worker: Inhalation of VOCs from groundwater vapors in an industrial building

Future Construction Worker: Ingestion of and dermal contact with shallow groundwater; inhalation of VOCs from groundwater

Transport Mechanisms: Primary/initial – leaks and spills to soil and leaching to groundwater
Secondary – groundwater discharge to offsite areas

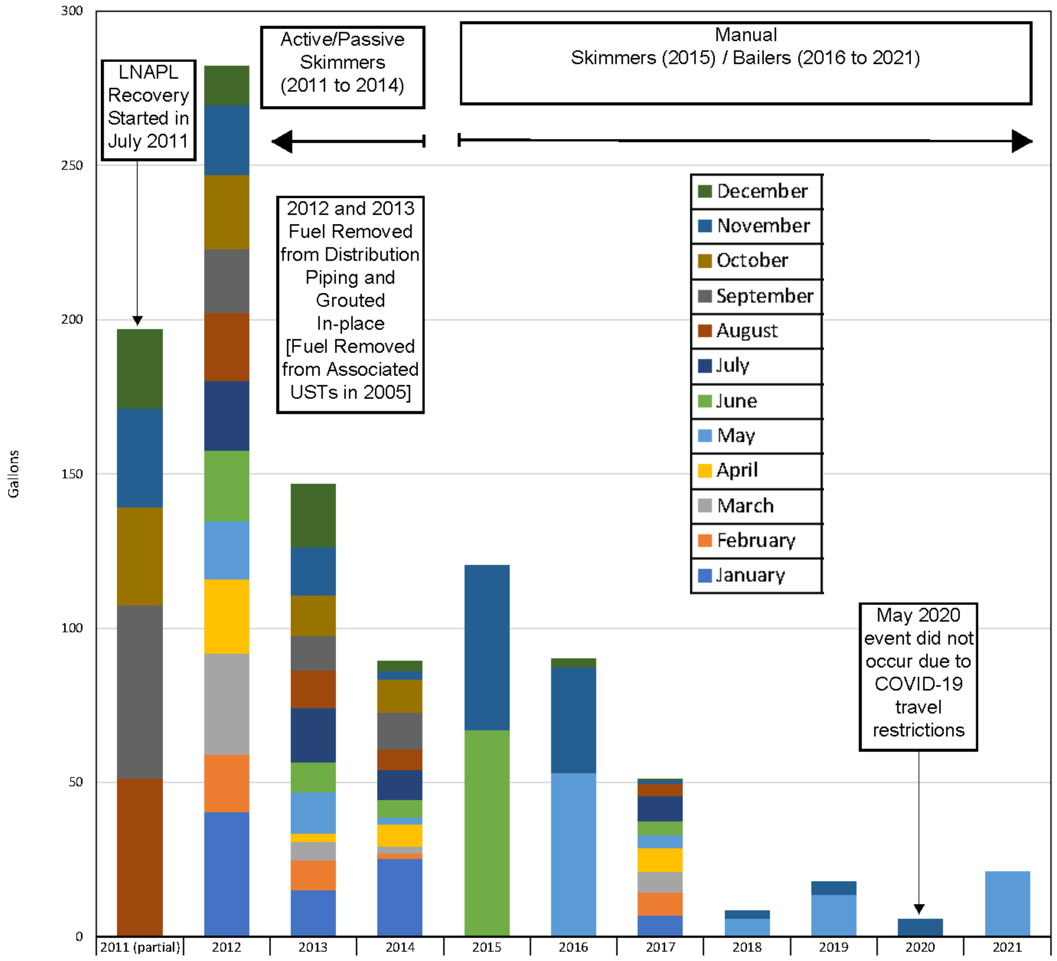
How Has LNAPL Been Removed?

- **Since 1994:** Biodegradation
  - Estimated 23,000 to 30,000 gallons removed based on sulfate utilization and CO_2 production
- **1994 to 1996:** Multi-stage product recovery
  - 13,700 gallons recovered; asymptotic recovery reached in 2 years
- **1996 to 2010:** Clean Ox injections, pneumatic fracturing, aggressive fluids vacuum recovery, SVE, and total fluids recovery
  - Estimated 3,900 gallons were removed using all five technologies
  - 2012 Corrective Measures Implementation Plan included LNAPL-only recovery skimmer pumps, MNA, and LUCs (AGVIQ-CH2M 2012)
    - All other implemented technologies were rejected due to limited radius of influence, rapidly declining rates of LNAPL recovery, or production of contaminated water containing emulsified oil

CO_2: carbon dioxide
TFR: total fluids recovery

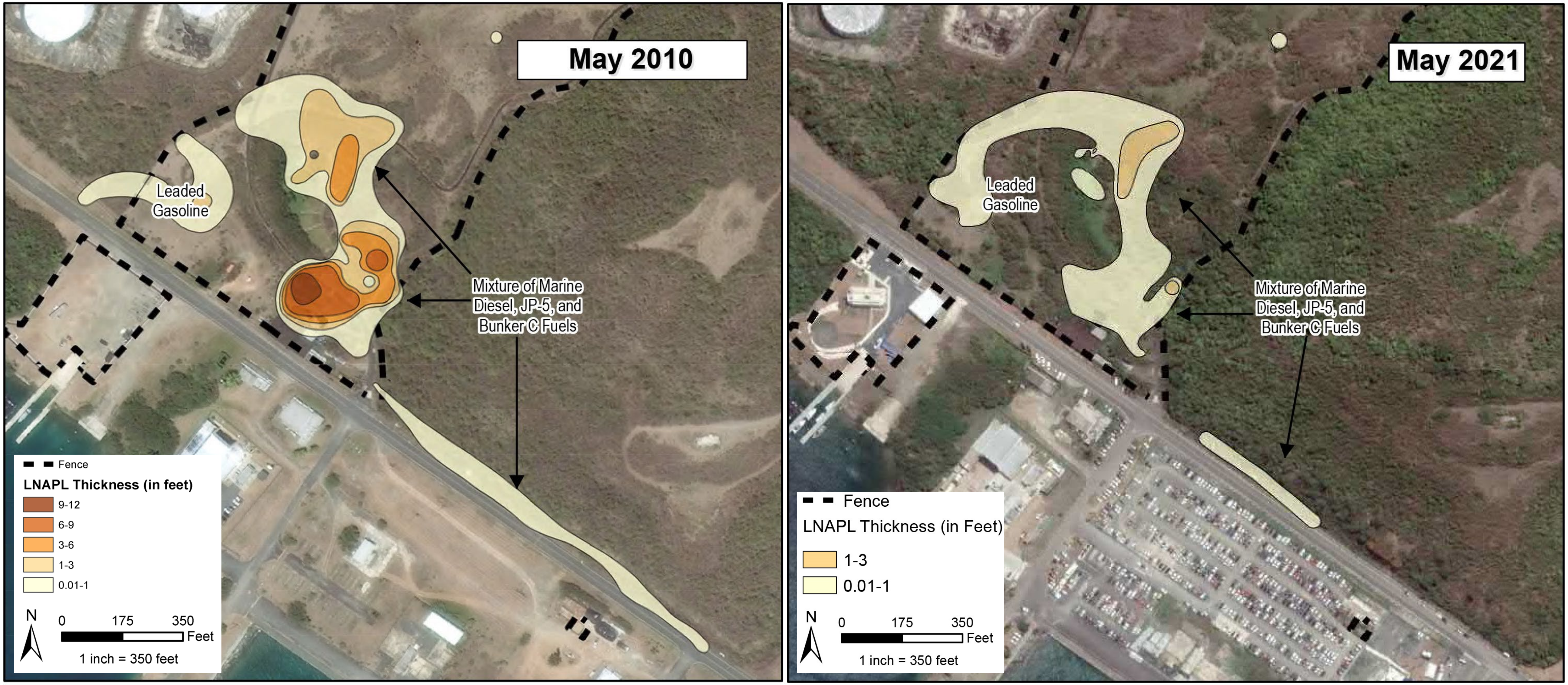
How Has LNAPL Been Removed?

- **2011 to 2014:** Full-time active and passive and skimming
  - 715 gallons recovered, but decreased each year
- **Since 2015:** Manual product recovery
  - 315 gallons recovered
  - Last 4 years averaged 13 gallons per year compared to at least 900 gallons a year via biodegradation
- Demonstrations from 11 years of LNAPL monitoring at up to 60 wells
  - Average LNAPL thickness in site wells decreased by more than 75%
  - Remaining LNAPL is not moving downgradient
  - Thicknesses of remaining LNAPL are being reduced by natural attenuation processes



(CH2M 2023)

Significant LNAPL Thickness Reductions Observed



(AGVIQ-CH2M 2015)

(CH2M 2023)

Optimization Approach

- Follows **lines of evidence approach** outlined in *Case Study Review of Optimization Practices and Navy Petroleum Sites* (NAVFAC EXWC 2021)
  1. No lateral LNAPL migration: *Is LNAPL at risk of migrating?*
  2. Restricted LNAPL exposure: *Are there any potential risk exposure scenarios if LNAPL remains?*
  3. Limited LNAPL recoverability: *How much LNAPL is recoverable?*
  4. Effective natural attenuation: *Will naturally occurring processes serve to attenuate remaining LNAPL and dissolved contaminants in a reasonable timeframe?*

LNAPL Migration?

- LNAPL mobility was evaluated using intact soil coring from the smear zone within LNAPL plume and laboratory analysis
  - Collected two intact soil cores
  - Core photography under natural and ultraviolet light
  - Pore fluids saturation via Dean Stark method
  - Gravity drain and water drive testing of samples with peak LNAPL saturation based on other observations


Boring locations

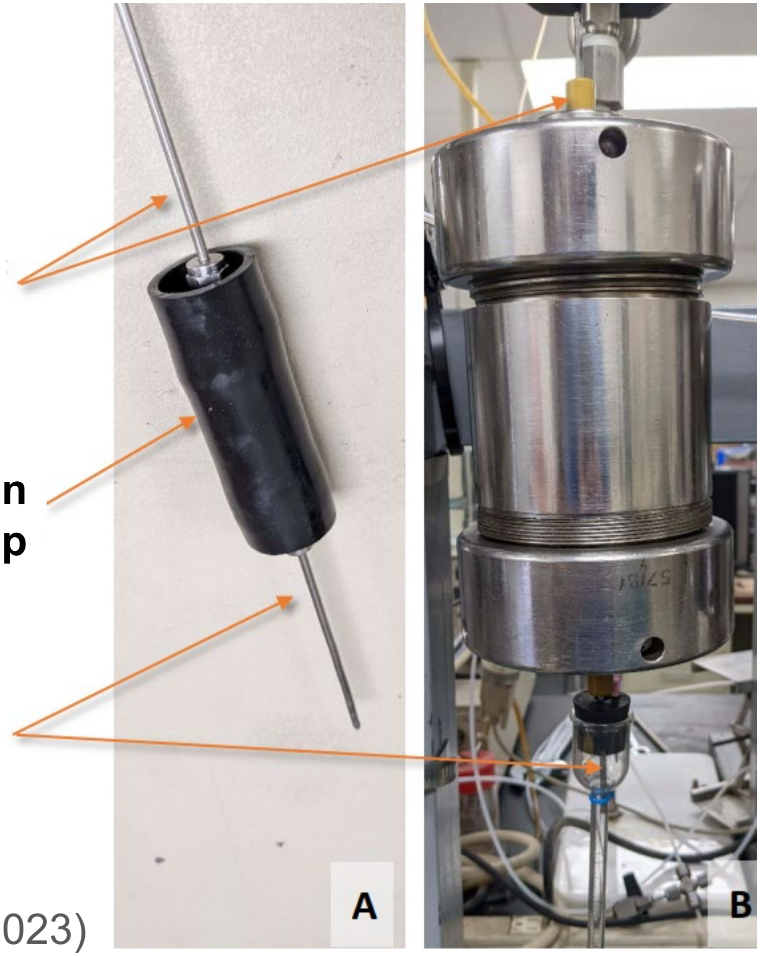
(CH2M 2023)

LNAPL Migration?

- Findings
  - LNAPL detections and thickness monitoring over past 11 years demonstrate plume stability
  - LNAPL saturations were less than 5% of total pore volume in soil, indicative of residual levels
  - LNAPL at sample depths with highest recorded LNAPL pore fluid saturation was not mobilized during gravity and water drive test

KEY POINT

No lateral LNAPL migration is occurring.



Influent Port

Soil plug in shrink wrap

Effluent Port

(CH2M 2023)

Photograph of soil plug in shrink wrap and fitted with influent and effluent ports (A) before loading into cell for gravity drain and water drive testing (B); note graduated effluent catchment below test device

Risk Exposure?

- Findings
  - LUCs prevent unintended receptor exposure to groundwater and prevent unrestricted use of property and groundwater
  - No Further Action was approved for SWMUs 7 and 8 soil under an industrial land use scenario
  - Remaining LNAPL plume is located at depths greater than 10 feet bgs, with LNAPL core deeper than 20 feet bgs

KEY POINT

Potential for human exposure is very low.

LNAPL Recoverability?

- Baildown tests were performed at seven locations to determine hydrocarbon transmissivity associated with in-well LNAPL
  - Using a pump or bailer, LNAPL is removed from test well and surrounding borehole sand and then recovery rate is measured
  - 11-day recovery period
- Transmissivity is calculated using in-well LNAPL thickness, recharge data, and Bouwer and Rice (1976) method for variable discharge, variable drawdown conditions

Baildown test locations

(CH2M 2023)

LNAPL Recoverability?

- Findings
  - Results of baildown tests were primarily below Interstate Technology and Regulatory Council transmissivity threshold metric of 0.1 to 0.8 square foot per day (ITRC 2018)
    - Metric established as benchmark for remedial decision making or technology transitions

KEY POINT

Negligible amount of LNAPL remains for recovery.

(CH2M 2023)

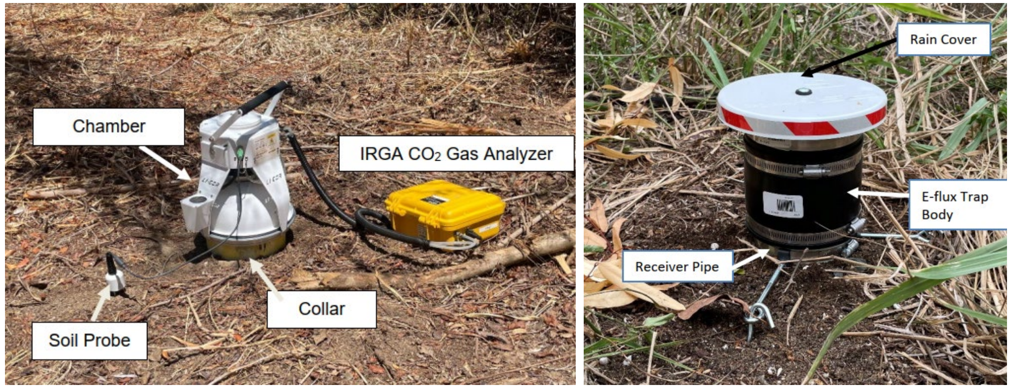
Baildown test locations

Product thicknesses and contours depict LNAPL accumulation in wells between LNAPL recovery events.
LNAPL = Light Non-Aqueous Phase Liquids
LNAPL measurements are from May 2021.
NA - Not Applicable
< - less than
Imagery: Esri October 12, 2019

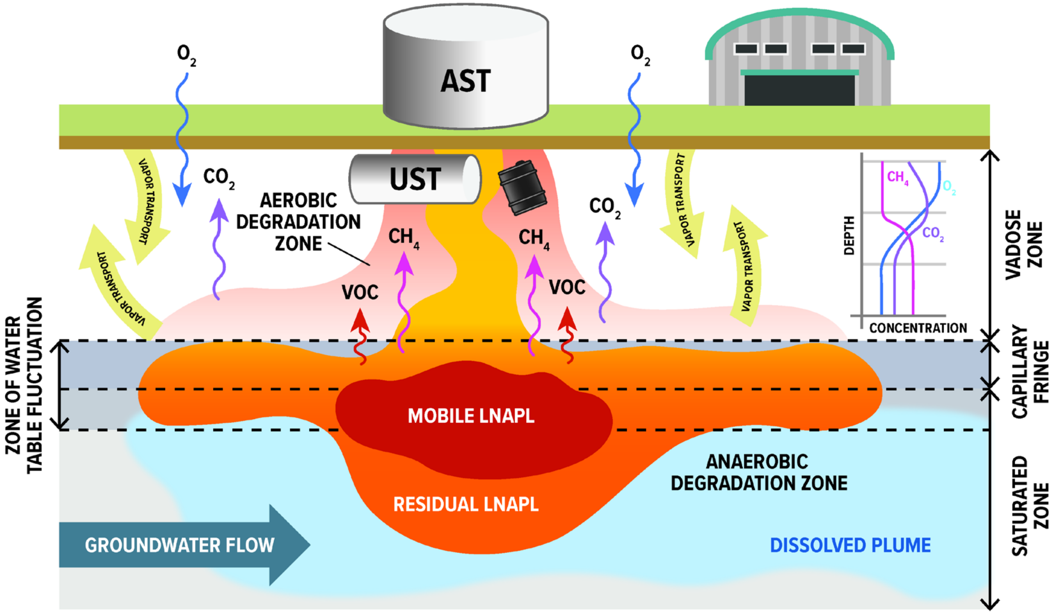
FIGURE 1
LNAPL Thickness and Average Transmissivity
SWMUs 7/8, Naval Activity Puerto Rico

Natural Attenuation via NSZD?

- CO_2 generated from NSZD processes can be measured at ground surface and stoichiometrically converted to LNAPL degradation and loss rates
- Two methods used to measure CO_2 efflux at ground surface
  - LI-COR dynamic closed chamber and infrared gas analyzer
    - 27 locations, including 6 background
    - Two 1-day sampling events
  - CO_2 passive flux trap (E-flux trap)
    - 11 locations, including 1 background
    - One 10-day sampling event



(CH2M 2023)



(Jacobs 2025)

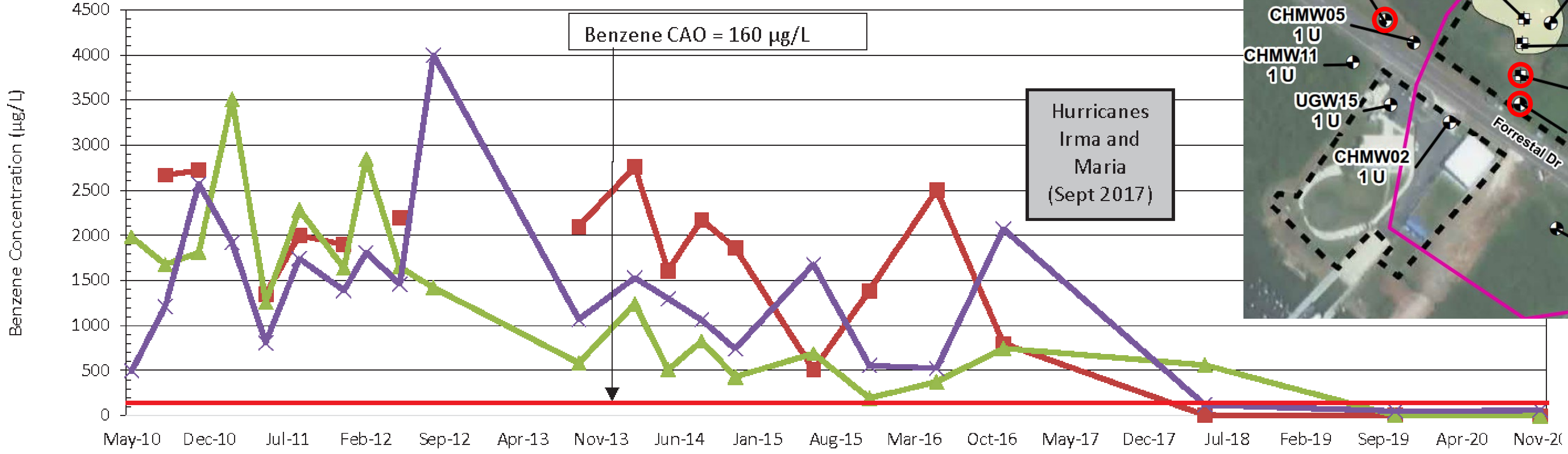
Natural Attenuation?

- Findings
  - LI-COR results were used to estimate sitewide annual NSZD rate because its survey network had a more complete coverage than E-Flux traps
  - Sitewide NSZD rates ranged from 300 to 800 gallons per acre per year, consistent with literature values
  - LNAPL mass removal rates by NSZD far surpass removals using mechanical and manual removal methods over past 11 years

KEY POINT

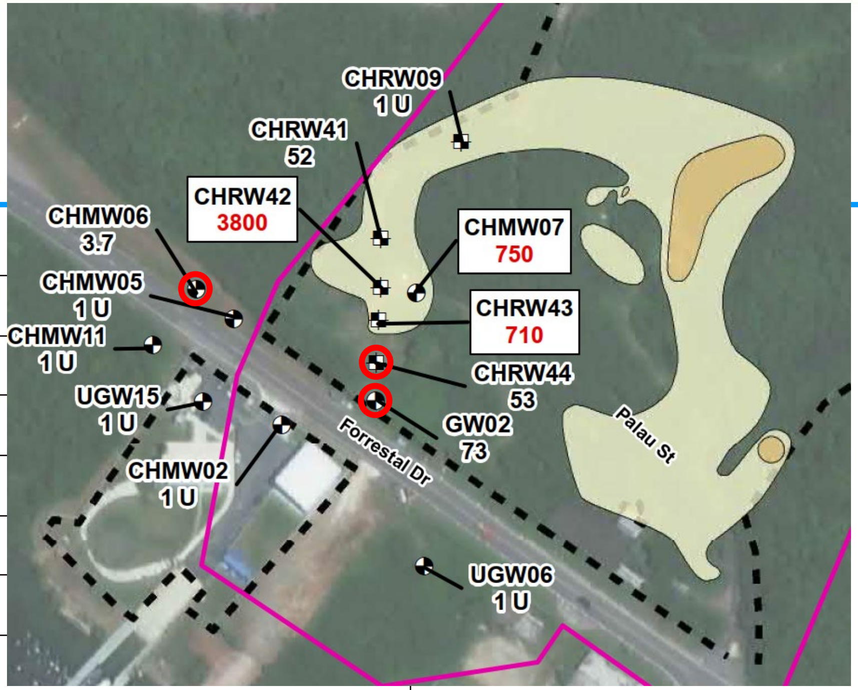
NSZD is estimated at 900 to 3,600 gallons removed per year, while manual recovery from all wells has yielded only 13 gallons per year from 2018 to 2021.

Natural Attenuation?



	May-10	Aug-10	Nov-10	Feb-11	May-11	Aug-11	Dec-11	Feb-12	May-12	Aug-12	Sep-13	Feb-14	May-14	Aug-14	Nov-14	Jun-15	Nov-15	May-16	Nov-16	May-18	Oct-19	Nov-20
CHMW06	LNAPL	2670	2720	LNAPL	1350	2000	1900	LNAPL	2200	LNAPL	2100	2760	1610	2170	1860	508	1390	2500	802	7.76	5.5	0
CHRW44	1980	1680	1810	3510	1260	2280	1640	2850	1650	1420	584	1240	512	828	433	692	196	378	749	563	4.4	0
GW02	498	1210	2570	1920	810	1740	1390	1810	1460	4000	1070	1530	1300	1060	743	1680	558	528	2070	123	53	59

(CH2M 2024)



May 2021 Benzene Concentrations and LNAPL Extent
(CH2M 2022)

- In addition to LNAPL, natural attenuation reduced benzene concentrations downgradient of LNAPL by more than 96% from 2010 to 2021
- Recent analytical data indicate benzene concentrations were not detected above laboratory detection limit of 1 µg/L in downgradient sentry well samples

Natural Attenuation?

- Conclusions
  - Naturally occurring processes will attenuate remaining LNAPL and dissolved contaminants in reasonable timeframe
  - Dissolved benzene plume continues to be stable and does not extend south of Forrestal Drive
  - LNAPL recovery at site has been completed to maximum extent practical

KEY POINT

Continued product recovery is not needed to maintain LNAPL and dissolved-phase plume stability.*

*Consistent with UST Technical Compendium: Release Investigation, Confirmation, and Corrective Action (EPA), which indicates that EPA's intention is to *mitigate the risk of free product spreading to uncontaminated areas of a site*, and not necessarily to achieve a specific LNAPL thickness as only end goal.

Proposed Revised CAOs

- Reduce groundwater concentrations to approved risk-based CAOs for dissolved petroleum-related constituents in groundwater (for example, benzene to below 160 µg/L)
- Provide groundwater monitoring to demonstrate continued benzene and LNAPL plume stability by monitoring 10 downgradient wells*
- Enforce existing industrial LUCs restricting contact with subsurface LNAPL, groundwater use, and excavations deeper than 10 feet

**No more LNAPL recovery*

Additional Optimization

- Benzene is being biodegraded anaerobically through sulfate reduction
  - Average upgradient sulfate concentration is 394 mg/L
  - Average plume sulfate concentration is 3.9 mg/L
- Addition of sulfate solution was selected as a **pilot study** to enhance benzene natural attenuation
- In August 2023, three injection wells received
  - 81,397 gallons of injectant
  - 1,450 lb of Nutrisulfate-LT Granular Sulfate Salts (magnesium sulfate heptahydrate)
  - 150 lb of TersOx Nutrients QR blend (nitrogen, phosphorus, and microbial growth enhancers)

Note: *Hydraulic tests were conducted at three recovery wells to see if they could supply water for injection. Because of low recovery rates, hydrant water was used for injection.*

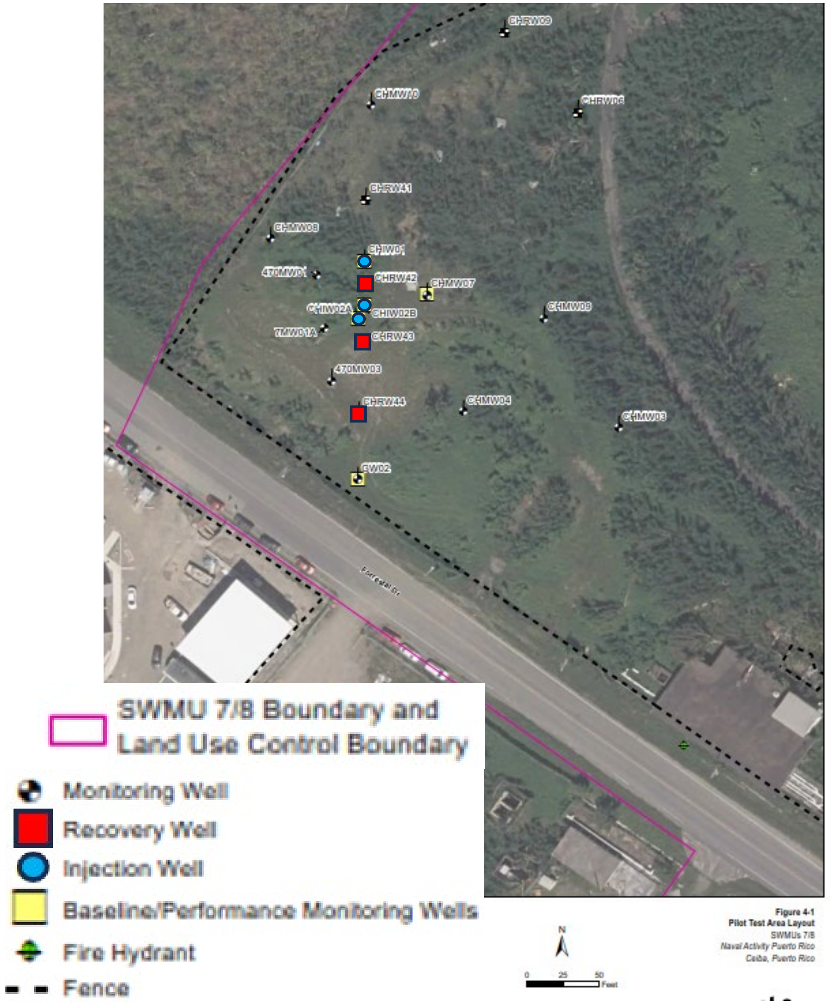


Figure 4-1
Pilot Test Area Layout
SWMUs 7/8
Naval Activity Puerto Rico
Ceiba, Puerto Rico

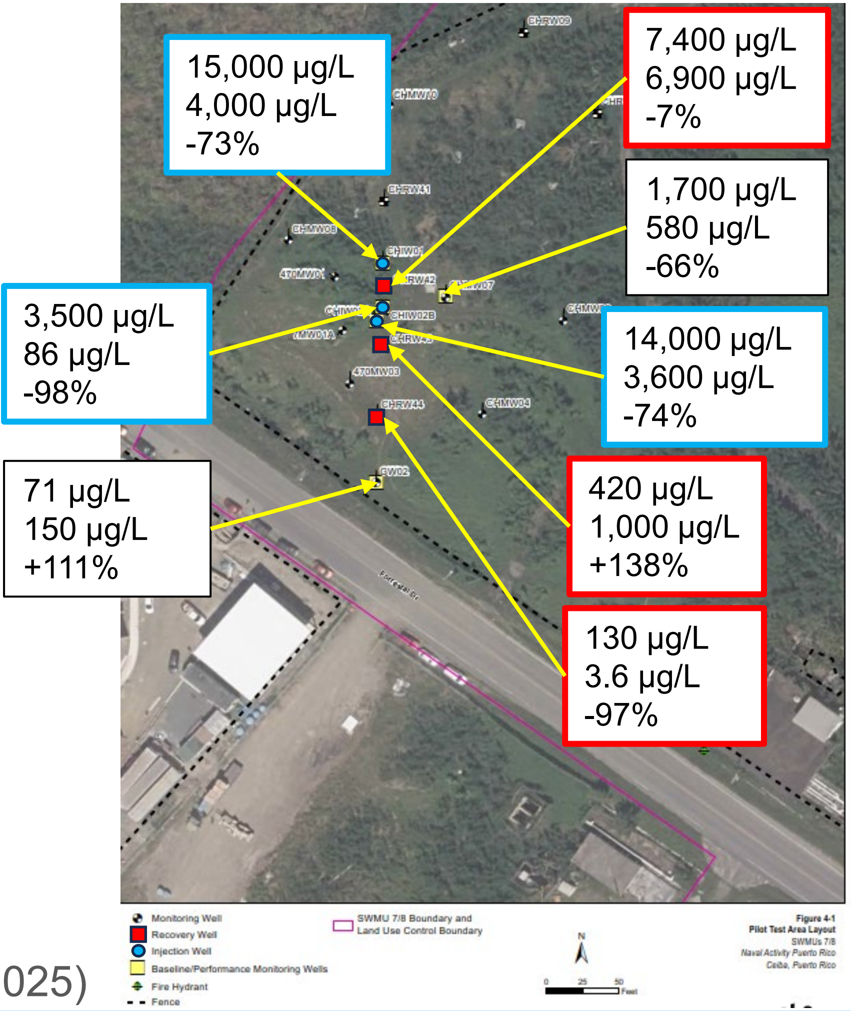
mg/L: milligram(s) per liter

(CH2M 2025)

Additional Optimization

- Findings after 14 months
  - Benzene concentrations decreased at injection wells by 73% to 98%
  - Benzene concentration changes at recovery and monitoring wells ranged from a 66% decrease to a 138% increase
  - Sulfate distribution and persistence was inconsistent
- Conclusions
  - Additional monitoring required to assess feasibility for full-scale implementation
  - Consider other technologies for benzene remediation (e.g., AS)
  - Consider revising risk assessment to increase benzene concentration goal from 160 µg/L

Note: *Hydraulic tests were conducted at three recovery wells to see if they could supply water for injection. Because of low recovery rates, hydrant water was used for injection.*



15,000 µg/L
4,000 µg/L
-73%

7,400 µg/L
6,900 µg/L
-7%

1,700 µg/L
580 µg/L
-66%

3,500 µg/L
86 µg/L
-98%

14,000 µg/L
3,600 µg/L
-74%

71 µg/L
150 µg/L
+111%

420 µg/L
1,000 µg/L
+138%

130 µg/L
3.6 µg/L
-97%

(CH2M 2025)

Knowledge Check

- **Question:** What was most robust indicator that LNAPL attenuation was occurring?
- **Answers:**
  a. LNAPL thickness measurements over time

  b. Dissolved phase benzene concentration trends

  c. Elevated carbon dioxide flux rates at ground surface

  d. Diminishing LNAPL recovery rates

Knowledge Check

- **Question:** What was most robust indicator that LNAPL attenuation was occurring?
- **Answers:**
  a. LNAPL thickness measurements over time
  b. Dissolved phase benzene concentration trends
  c. **Elevated carbon dioxide flux rates at ground surface**
  d. Diminishing LNAPL recovery rates

Why Answer c?

CO_2 generated from NSZD processes can be measured at ground surface and stoichiometrically converted to LNAPL degradation/loss rates.

Summary

NORM Phase(s)	6 and 7
Optimization trigger(s)	Contaminant mass recovery has become asymptotic
Key tools or concepts	• Lines of evidence approach outlined in *Case Study Review of Optimization Practices and Navy Petroleum Sites* (NAVFAC 2021) • NSZD • Pilot study
Key constraint(s)	Insufficient data to transition to NSZD and MNA
Outcome	• Active LNAPL recovery no longer required • Sulfate injection shown to enhance benzene MNA
Path forward	• Shift to LTM for LNAPL • Consider additional remediation for benzene to reduce time to achieve response complete or negotiate new clean-up standard
Potential financial impact	Not estimated

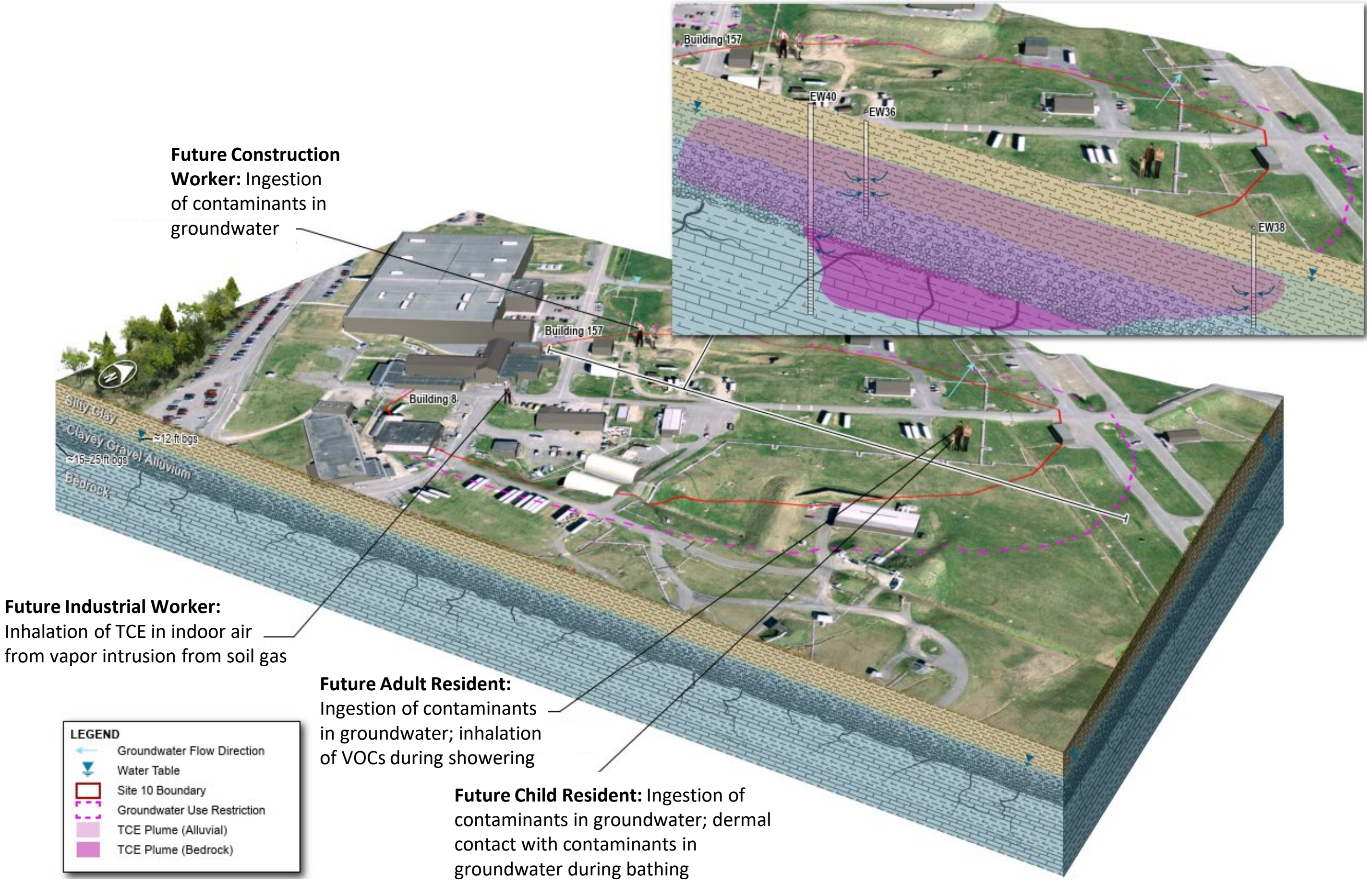
Presentation Overview

- Introduction
- Optimization Basics
- Case Study #1: JBPHH Former Aiea Laundry Facility
- Case Study #2: Camp Lejeune Site 78
- Case Study #3: NAPR SWMUs 7 and 8
- Case Study #4: ABL Site 10
- Key Takeaways

NORM Phase(s)	6 and 7
Optimization trigger(s)	Contaminant mass recovery has become asymptotic
Key tools or concepts	• Pilot study rebound monitoring with Mann-Kendall trend analysis • SERDP TA^2 tool
Key constraint(s)	Potential discharge to surface water without active remedy and insufficient data to transition to MNA

Site Background

- Former TCE still
  - Operated in early 1960s
  - TCE recovered by distilling, then used and stored onsite
- VOC plumes (<100 µg/L)
  - PCE, TCE, and VC
  - Alluvial and bedrock aquifers affected
  - Human health risks from VOCs in groundwater
    - Potable water source for future residents
    - Construction



Future Construction Worker: Ingestion of contaminants in groundwater

Future Industrial Worker: Inhalation of TCE in indoor air from vapor intrusion from soil gas

Future Adult Resident: Ingestion of contaminants in groundwater; inhalation of VOCs during showering

Future Child Resident: Ingestion of contaminants in groundwater; dermal contact with contaminants in groundwater during bathing

(Adapted from CH2M 2014)

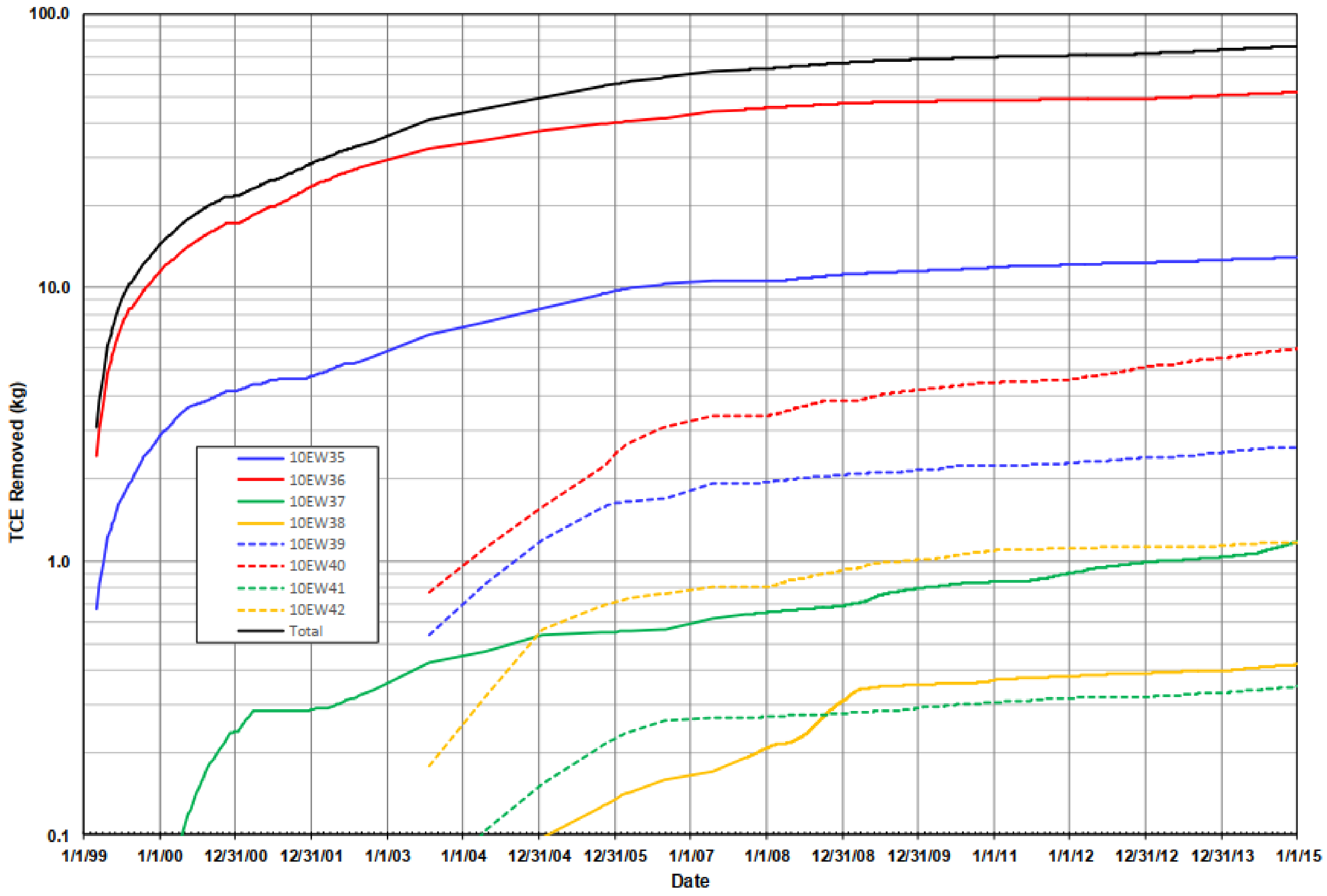
Long-Term Remedy

- Selected remedy in ROD is P&T to meet the following RAOs
  - Prevent or minimize exposure of potential future onsite residents and construction workers to contaminated groundwater
  - Achieve chemical-specific MCLs, where practical
- P&T began operation in 1999
  - Four alluvial and four bedrock extraction wells
  - Treatment via air stripping
  - Discharge to North Branch Potomac River
- LUCs in place
- Groundwater LTM every 5 years

(NAVFAC 2024)

Optimization Rationale

- Mass removal with P&T is asymptotic
- 2018 Five-Year Review indicated uncertainty associated with timeframe to achieve MCL-based RAO
- Optimization of existing groundwater remediation system recommended in an Optimization Technical Memorandum

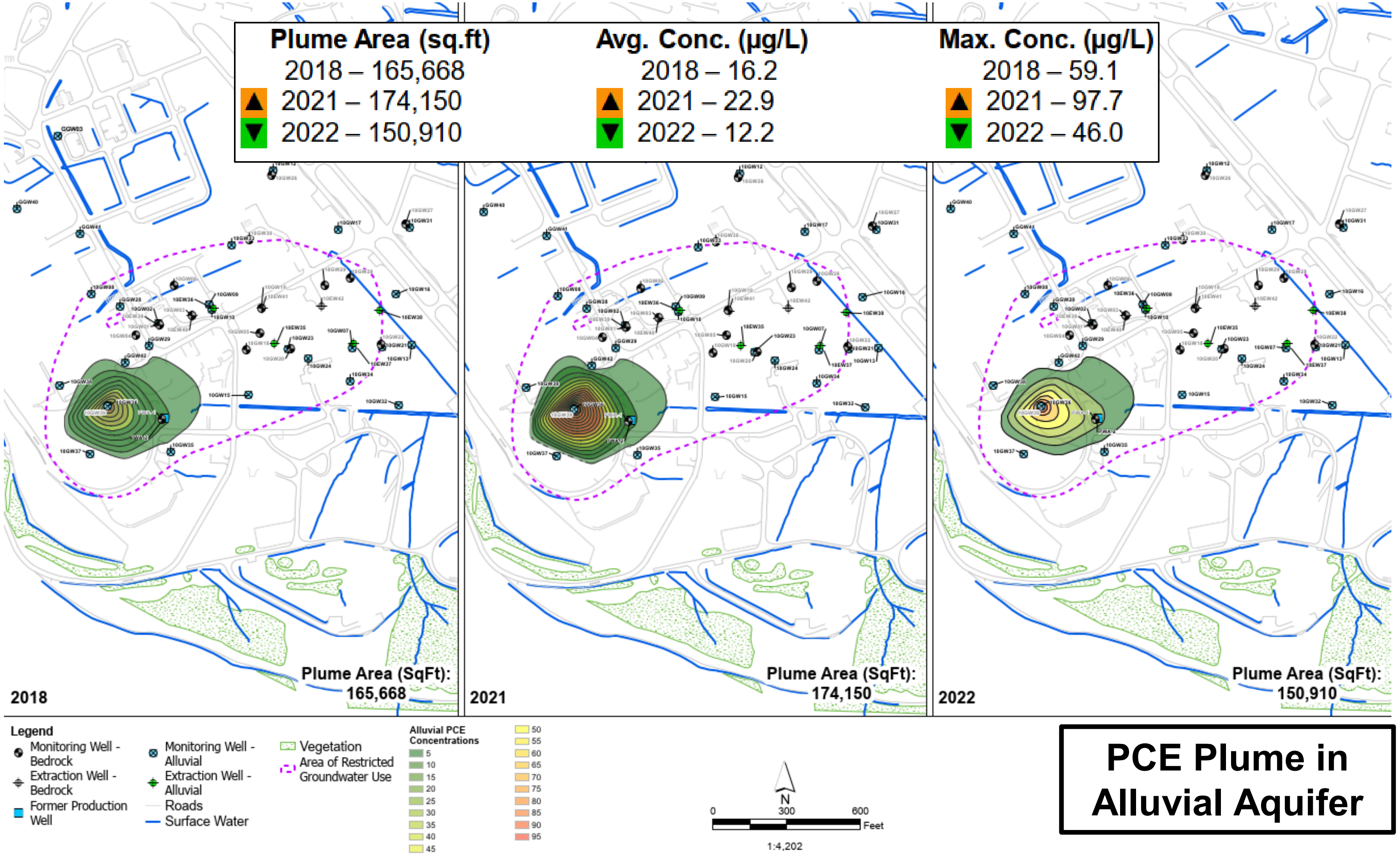


(CH2M 2023)

Shutdown Pilot Study: Approach

- 2-year **shutdown (rebound) pilot study** began Summer 2020
  - Baseline sampling June/July 2020
  - Site 10 pumping ceased July 2, 2020
  - Semi-annual post-shutdown sampling from January 2021 through July 2022
    - Four total sampling events including baseline

Shutdown Pilot Study: Monitoring Results

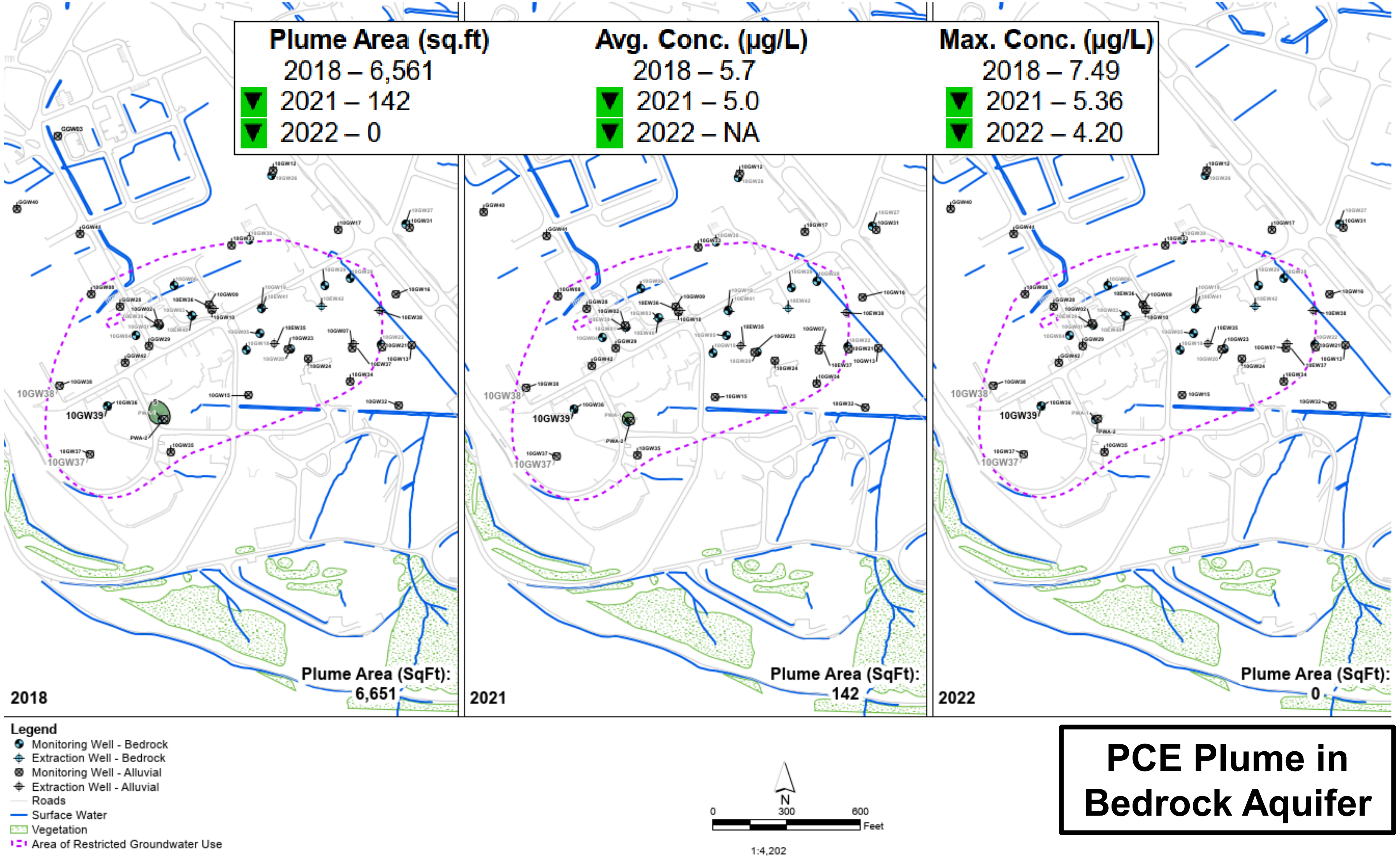


Plume Area (sq.ft)	Avg. Conc. (µg/L)	Max. Conc. (µg/L)
2018 – 165,668	2018 – 16.2	2018 – 59.1
▲ 2021 – 174,150	▲ 2021 – 22.9	▲ 2021 – 97.7
▼ 2022 – 150,910	▼ 2022 – 12.2	▼ 2022 – 46.0

PCE Plume in Alluvial Aquifer

(CH2M 2023)

Shutdown Pilot Study: Monitoring Results

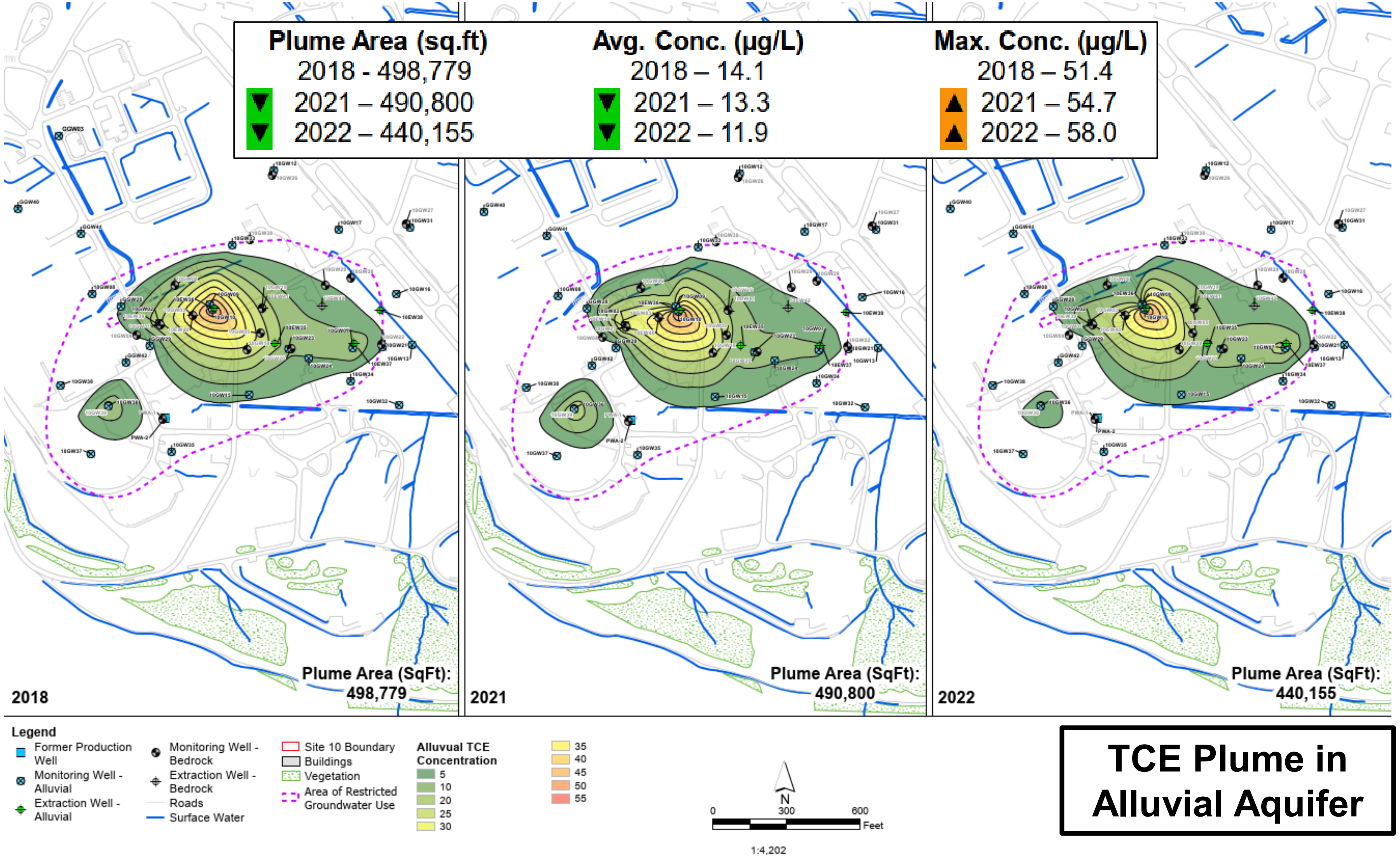


Plume Area (sq.ft)	Avg. Conc. (µg/L)	Max. Conc. (µg/L)
2018 – 6,561	2018 – 5.7	2018 – 7.49
▼ 2021 – 142	▼ 2021 – 5.0	▼ 2021 – 5.36
▼ 2022 – 0	▼ 2022 – NA	▼ 2022 – 4.20

PCE Plume in Bedrock Aquifer

(CH2M 2023)

Shutdown Pilot Study: Monitoring Results

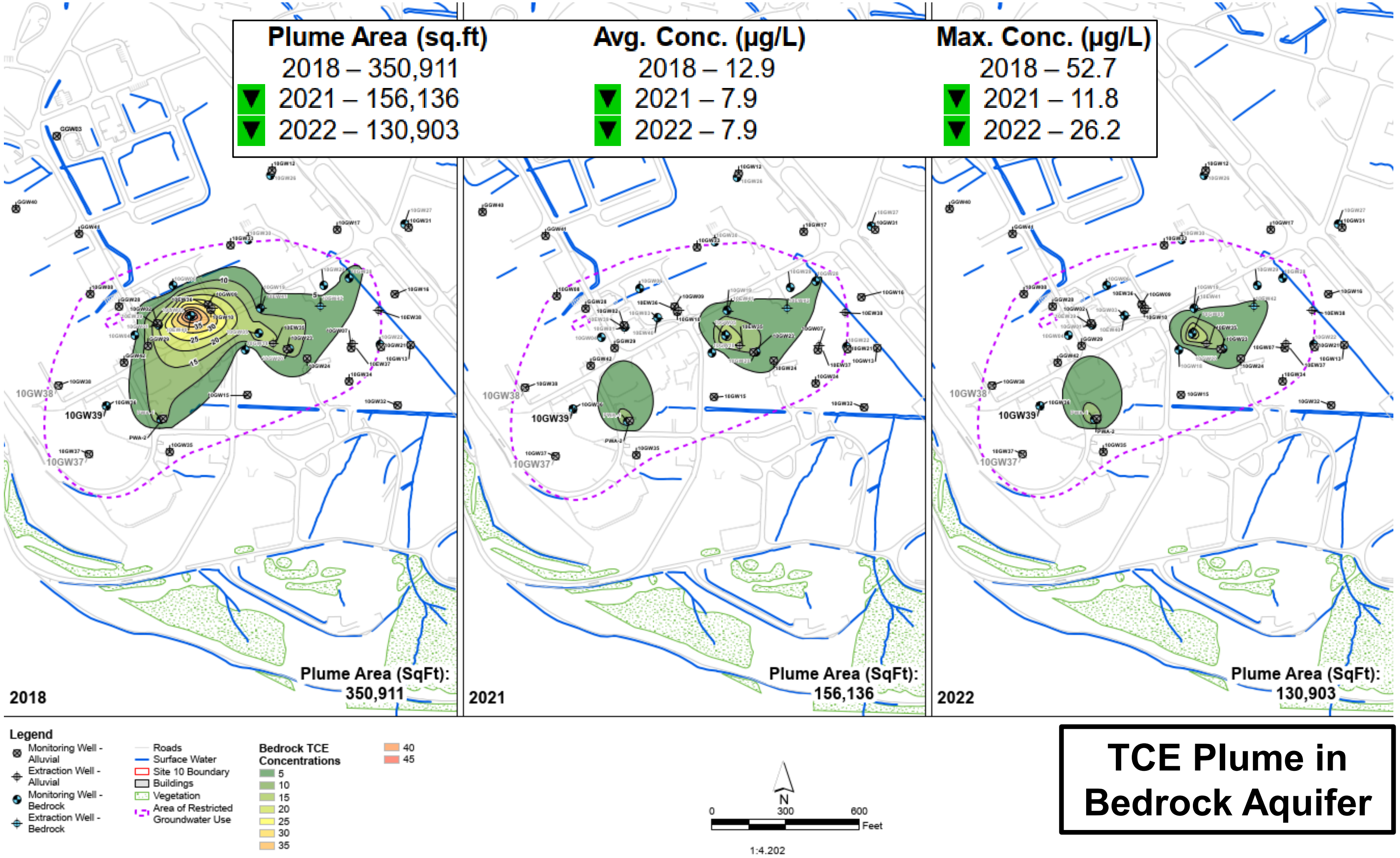


Plume Area (sq.ft)	Avg. Conc. (µg/L)	Max. Conc. (µg/L)
2018 - 498,779	2018 – 14.1	2018 – 51.4
▼ 2021 – 490,800	▼ 2021 – 13.3	▲ 2021 – 54.7
▼ 2022 – 440,155	▼ 2022 – 11.9	▲ 2022 – 58.0

TCE Plume in Alluvial Aquifer

(CH2M 2023)

Shutdown Pilot Study: Monitoring Results



Plume Area (sq.ft)	Avg. Conc. (µg/L)	Max. Conc. (µg/L)
2018 – 350,911	2018 – 12.9	2018 – 52.7
▼ 2021 – 156,136	▼ 2021 – 7.9	▼ 2021 – 11.8
▼ 2022 – 130,903	▼ 2022 – 7.9	▼ 2022 – 26.2

TCE Plume in Bedrock Aquifer

(CH2M 2023)

Shutdown Pilot Study: Findings

- COCs
  - Generally decreasing PCE and TCE concentrations
  - Plumes stable or decreasing via Mann-Kendall analysis
  - No sentinel well concentrations exceeded remedial goals
  - Remediation timeframe estimates remain uncertain because of small post-shutdown sample size and effects of matrix back diffusion
    - Evaluation method: well-by-well evaluation of concentration trends
    - Non-pumping scenario anticipated to slightly lengthen remediation timeframe
- Lines of evidence for MNA
  - Presence of PCE/TCE daughter products
  - Favorable microbial populations
  - Reducing geochemical conditions
  - Evidence of abiotic dechlorination

Shutdown Pilot Study: Recommendations

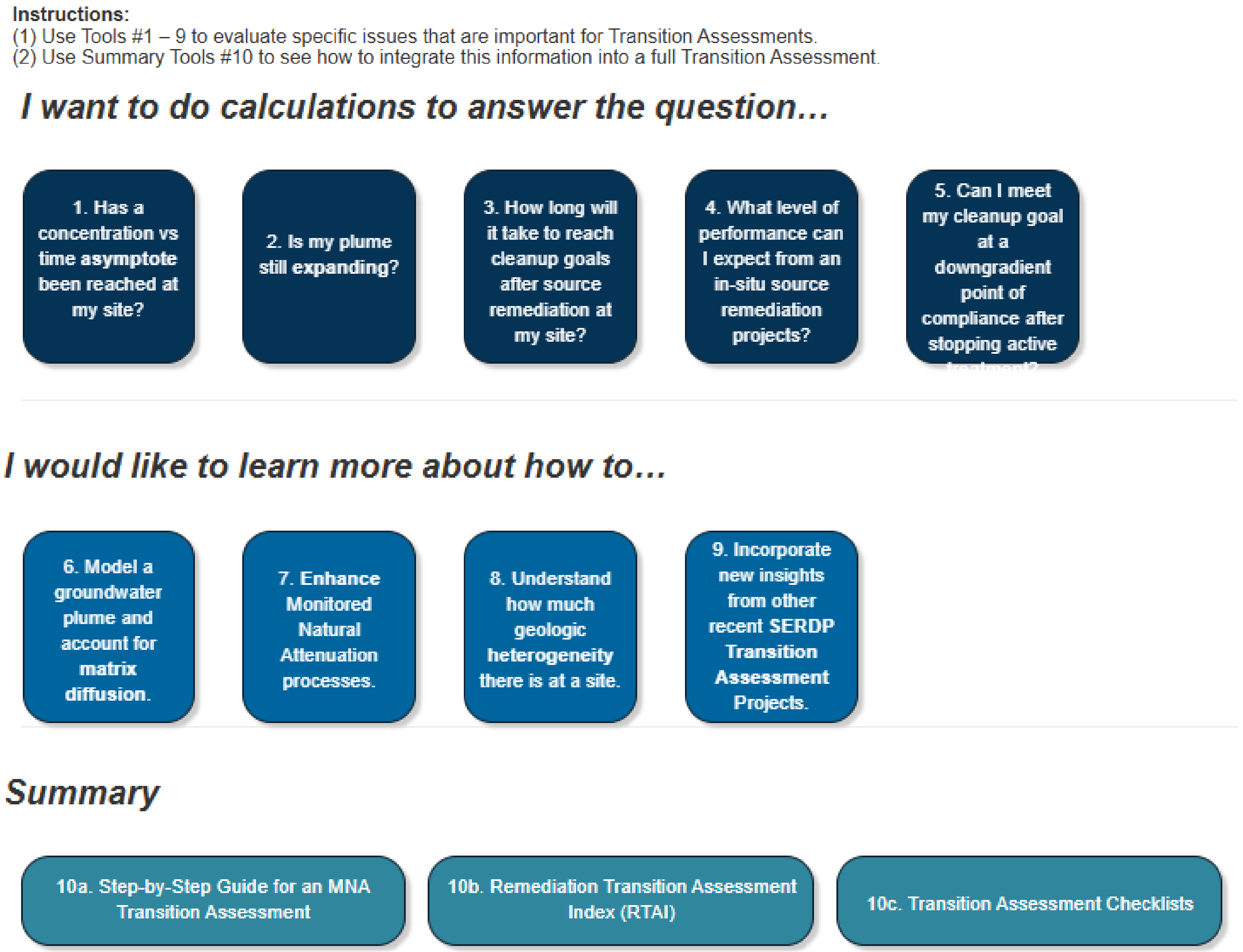
KEY POINT

The rebound data indicated a transition to MNA was feasible but additional monitoring was required to finalize the optimization.

- Recommendations
  - P&T system should remain off while additional data are gathered to support MNA
  - Continue semi-annual monitoring
- Benefits of remaining shut down
  - Energy and resource savings
  - Reduced operation and maintenance cost (estimated at $50K per year), despite similar remediation timeframe
- Challenges of remaining shut down
  - ROD does not specify MNA after P&T; ROD Amendment or Explanation of Significant Differences may be required
  - Additional data needed to support potential remedy transition to MNA with LUCs
    - Evaluate the prevalence of biotic and abiotic natural attenuation processes
    - Analyze statistical trends

Path Forward

- Use SERDP TA^2 tool to support transition to MNA
  - Step-by-step guide
  - Remediation transition assessment index (lines of evidence)
  - Checklists



Instructions:
(1) Use Tools #1 – 9 to evaluate specific issues that are important for Transition Assessments.
(2) Use Summary Tools #10 to see how to integrate this information into a full Transition Assessment.

I want to do calculations to answer the question…

1. Has a concentration vs time asymptote been reached at my site?

2. Is my plume still expanding?

3. How long will it take to reach cleanup goals after source remediation at my site?

4. What level of performance can I expect from an in-situ source remediation projects?

5. Can I meet my cleanup goal at a downgradient point of compliance after stopping active

I would like to learn more about how to…

6. Model a groundwater plume and account for matrix diffusion.

7. Enhance Monitored Natural Attenuation processes.

8. Understand how much geologic heterogeneity there is at a site.

9. Incorporate new insights from other recent SERDP Transition Assessment Projects.

Summary

10a. Step-by-Step Guide for an MNA Transition Assessment

10b. Remediation Transition Assessment Index (RTAI)

10c. Transition Assessment Checklists

(Adapted from Adamson 2024)

Knowledge Check

- **Question:** What challenge resulted from the shutdown pilot study?
- **Answers:**
  a. Statistically significant concentration increases were observed following shutdown
  b. Limited number of post-shutdown samples
  c. SERDP TA^2 Tool indicated that transition to MNA is not recommended
  d. Increased operation and maintenance costs

Knowledge Check

- **Question:** What challenge resulted from the shutdown pilot study?
- **Answers:**
  a. Statistically significant concentration increases were observed following shutdown
  b. **Limited number of post-shutdown samples**
  c. SERDP TA^2 Tool indicated that transition to MNA is not recommended
  d. Increased operation and maintenance costs

Why Answer b?

Multiple lines of evidence are required to evaluate whether a transition to MNA is appropriate.

Summary

NORM Phase(s)	6 and 7
Optimization trigger(s)	Contaminant mass recovery has become asymptotic
Key tools or concepts	• Rebound monitoring with Mann-Kendall trend analysis • SERDP TA^2 tool
Key constraint(s)	Potential discharge to surface water without active remedy and lack of data to transition to MNA
Outcome	Shutdown of P&T with minimal impact to remediation timeframe is feasible
Path forward	Extend rebound monitoring another two years and use SERDP TA^2 tool to support decision to transition to MNA
Potential financial impact	$50K reduction in annual costs

Presentation Overview

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- Case Study #4: ABL Site 10
- Key Takeaways

Key Takeaways

- Optimization can occur throughout lifespan of a remediation project, not just to address diminishing performance
- Optimization may include reducing remediation timeframes and/or LCCs
- Asymptotic remedy performance can be addressed with a range of optimization tools including desktop, laboratory, and field methods
- Collaboration with partnering teams to revise objectives or updating risk assessment may be as effective of an optimization strategy as technical modifications
- Use technical resources within the Navy to support optimization

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Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Questions

Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Managing Lead-Impacted Sites under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Chris Saranko, PhD, DABT
Geosyntec Consultants

RITS 2025

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This presentation concerns the updated EPA Residential Soil Lead Guidance. Guidance does not set response actions or cleanup levels. Changes to Navy site management following the updated EPA Guidance must be approved by Navy leadership.

Information in this presentation is current as of May 22, 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Chris Saranko, PhD, DABT
Principal
Geosyntec Consultants

- PhD in Toxicology
  North Carolina State University
- Board-certified toxicologist with over 25 years of experience evaluating health effects associated with exposures to chemicals in the environment and the workplace
- Extensive experience with assessing and remediating sites with lead contamination, including blood-lead modeling and site-specific bioavailability testing
- Adjunct Professor
  College of Public Health, University of Georgia

PhD: Doctor of Philosophy
DABT: Diplomate, American Board of Toxicology

Speaker Introduction

- Worked on risk assessments for several launch complexes at Kennedy Space Center and got to see Space Shuttle Atlantis on the pad just before STS-106 mission in 2000

Presentation Overview

- Introduction
- Lead Risk Assessment Primer
- EPA 2024 Updated Residential Soil Lead Guidance
- Case Studies
- Summary/Key Takeaways

EPA: United States Environmental Protection Agency

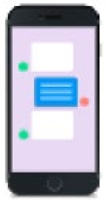
Interactive Polling

This presentation will feature several interactive poll questions

Join by Web

1) Go to **PollEv.com**
2) Enter **RITSn200**
3) Respond to activity

Join by Text



1) Text **RITSn200** to **22333**
2) Text in your response

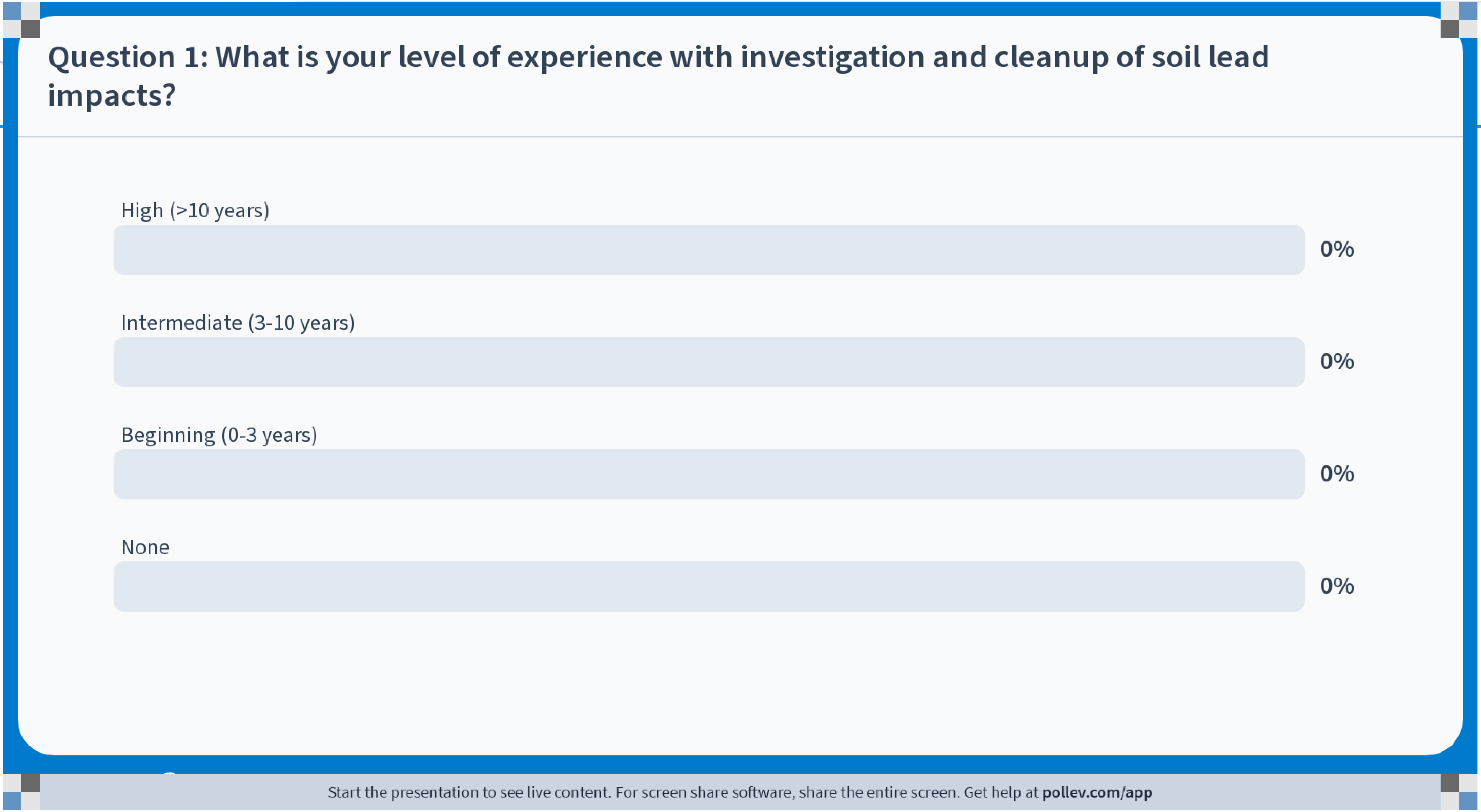
Poll Question 1

What is your level of experience with investigation and cleanup of soil lead impacts?

A. High (>10 years)
B. Intermediate (3–10 years)
C. Beginning (<3 years)
D. None

Options to respond

1. **Text RITSn200 to 22333** to join session then enter response
2. Enter **PollEv.com/ritsn200** in browser
3. **Scan the QR code** and open session in browser



Question 1: What is your level of experience with investigation and cleanup of soil lead impacts?

High (>10 years) 0%

Intermediate (3-10 years) 0%

Beginning (0-3 years) 0%

None 0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Lead Overview

- Lead is a soft metal that is easy to work with and abundant in the environment
- Lead has been used throughout recorded history for weapons, metalwork, coins, fuel additive, paint, medicines, flavorings, makeup, and other uses
- It is a common by-product of mining and smelting operations
- Lead poisoning causes learning disabilities and behavioral problems, and, at high enough levels, can cause seizure, coma, or death
- Young children are most sensitive population
    - Damage can occur before symptoms appear—early detection is key
    - Concentration of lead in blood is a reliable exposure/effect biomarker
    - A threshold level below which adverse effects do not occur is not available for CERCLA projects (NBUMD 2017)

82 207.2

Pb

Lead

(Virginia Department of Health, 2024; CDC n.d.)

Pb: lead

Navy/DoD Sources of Lead

- Munitions constituents
  - Small arms bullets/shot
  - Primary explosives (lead azide, lead styphnate)
  - Primer compositions (lead mononitroresorcinate)
  - Propellants (lead oxide)
- Lead-acid storage batteries, alloys such as brass in plumbing fixtures, nuclear and x-ray shielding, etc.
- Lead-based paint
  - 2014 NAVFAC LBP Guidance / Frequently Asked Questions
  - Check with leadership if there is uncertainty
- Naturally occurring lead compounds (ubiquitous)
- Anthropogenic background sources
  - Leaded compounds from vehicle exhaust (e.g., gasoline additives)
  - Stack emissions from industrial processes
  - Pesticide application

(MSE Group 2018)

DoD: Department of Defense LBP: lead-based paint

Presentation Overview

- Introduction
- Lead Risk Assessment Primer
- EPA 2024 Updated Residential Soil Lead Guidance
- Case Studies
- Summary/Key Takeaways

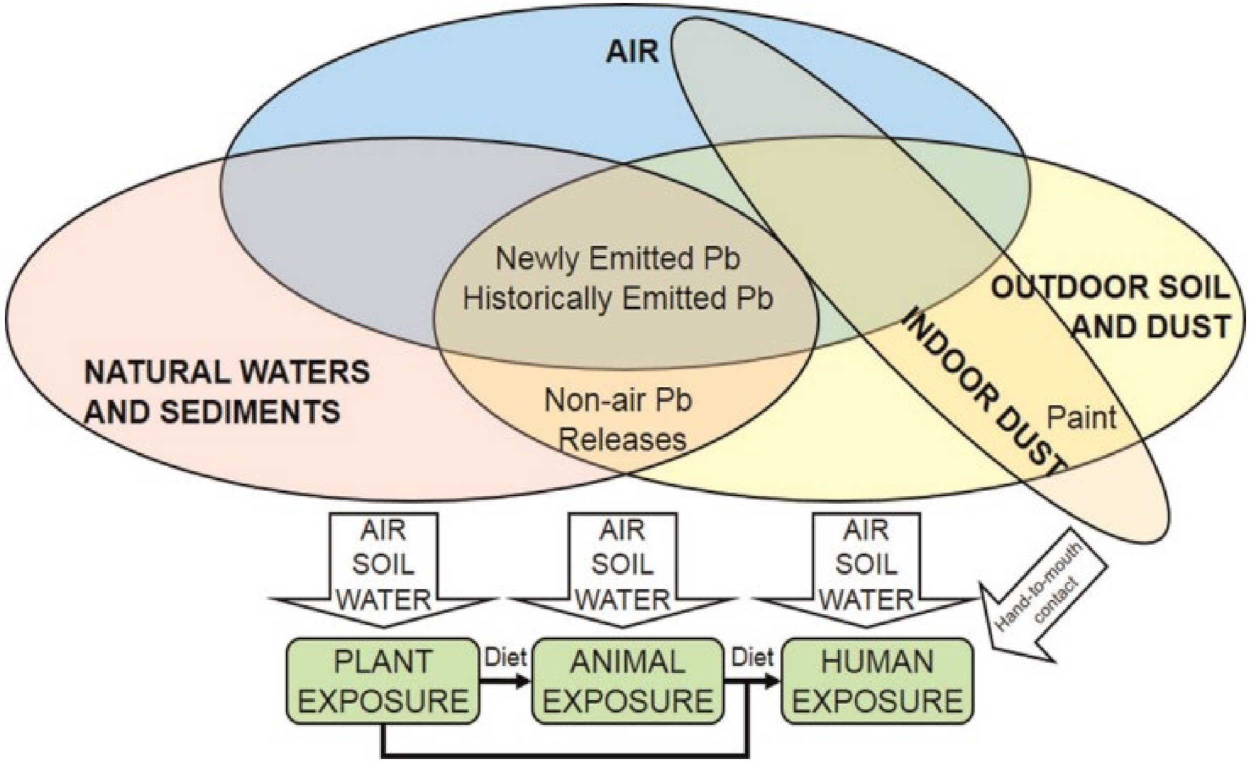
Section Overview

- Lead Risk Assessment Primer
  - Lead risk assessment is unique
  - EPA biokinetic models for lead
  - EPA screening/cleanup level guidance 1994–2023
  - Navy risk assessment process for lead
  - IEUBK Model overview
  - ALM overview
  - Scientific basis for EPA guidance updates

ALM: Adult Lead Methodology
IEUBK: Integrated Exposure Uptake Biokinetic Model for Lead in Children

Lead Risk Assessment is Unique

- Multimedia exposure
  - Lead HHRAs assess site contribution to total risk of adverse health effects from multiple sources and exposure pathways
  - Nonsite-related background sources contribute to the total lead body burden
- Lead does not have traditional toxicity values (e.g., RfD and/or CSF)
- Lead exposure evaluated using BLLs (also known as "PbB")
- Environmental exposures to lead are modeled to predict BLLs associated with those exposures

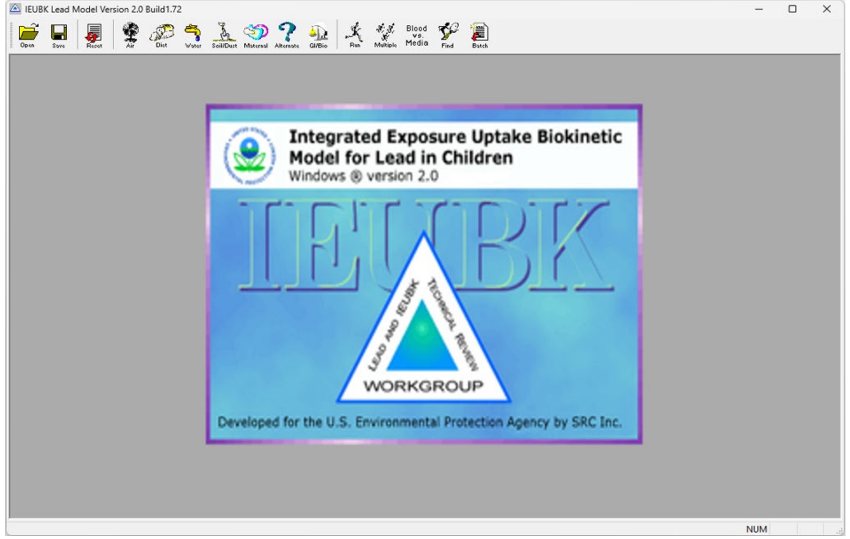


(EPA 2013)

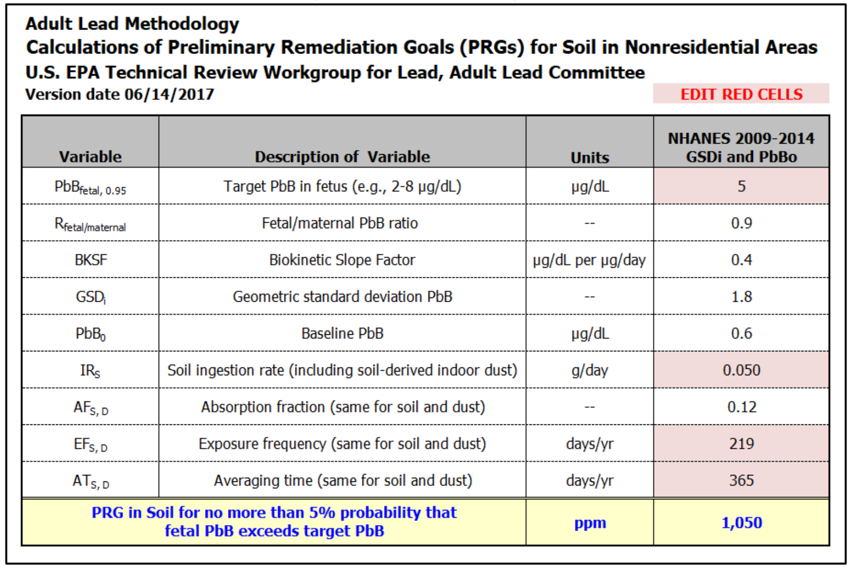
BLL or PbB: blood lead level
CSF: cancer slope factor
HHRA: human health risk assessment
RfD: reference dose

EPA Biokinetic Models for Lead

- Integrated Exposure Uptake Biokinetic Model (IEUBK)
    - Estimates BLLs in young children based on exposure to lead in different media (e.g., soil, water, air, food)
    - Estimates the probability of exceeding specified BLL targets
    - Calculates soil cleanup levels for residential land use
- Adult Lead Methodology (ALM)
    - Simple spreadsheet-based model
    - Estimates BLLs in women of childbearing age exposed to soil in nonresidential settings
    - Evaluates the transfer of lead from a mother to a fetus in utero
    - Calculates soil PRGs for nonresidential land use
- All-Ages Lead Model (AALM)
    - More sophisticated, but still under review and not yet approved by EPA for use



(EPA 2021)



Adult Lead Methodology
Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 06/14/2017

EDIT RED CELLS

Variable	Description of Variable	Units	NHANES 2009-2014 GSDi and PbBo
$PbB_{fetal, 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		ppm	1,050

KEY POINT

IEUBK = Residential

ALM = Non-Residential

PRG: preliminary remediation goal

Poll Question 2

What is your familiarity with any of EPA's lead models?

A. I have used them myself

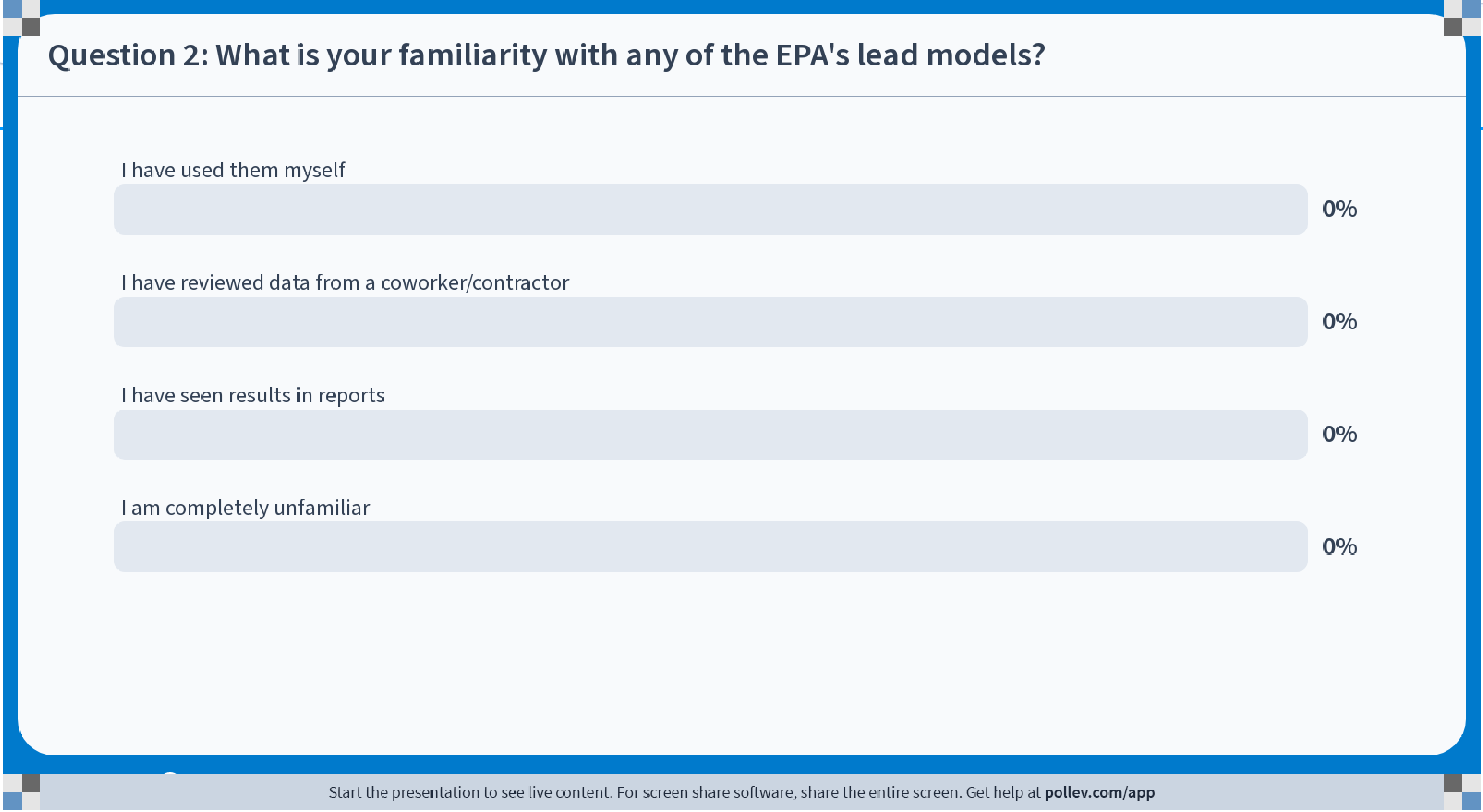
B. I have reviewed data from a coworker/contractor

C. I have seen results in reports

D. I am completely unfamiliar

Options to respond

1. **Text RITSn200 to 22333** to join session then enter response
2. Enter **PollEv.com/ritsn200** in browser
3. **Scan the QR code** and open session in browser



Question 2: What is your familiarity with any of the EPA's lead models?

I have used them myself 0%

I have reviewed data from a coworker/contractor 0%

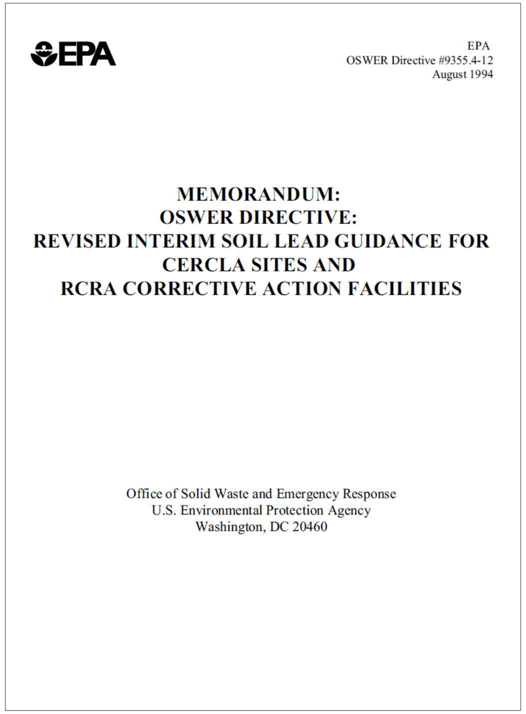
I have seen results in reports 0%

I am completely unfamiliar 0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Historical Perspective

- 1994 OSWER Directive
  - Established 400 ppm (mg/kg) soil screening level for residential land use
  - Screening level derived using the IEUBK Model for Lead in Children
  - Based on a modeled risk of ≤5% of exceeding a blood lead level of 10 µg/dL for a typical child or group of children
  - If site concentrations exceed 400 ppm, recommends using the IEUBK model with site-specific information to evaluate risk and calculate PRGs



EPA
EPA
OSWER Directive #9355.4-12
August 1994

MEMORANDUM:
OSWER DIRECTIVE:
REVISED INTERIM SOIL LEAD GUIDANCE FOR
CERCLA SITES AND
RCRA CORRECTIVE ACTION FACILITIES

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

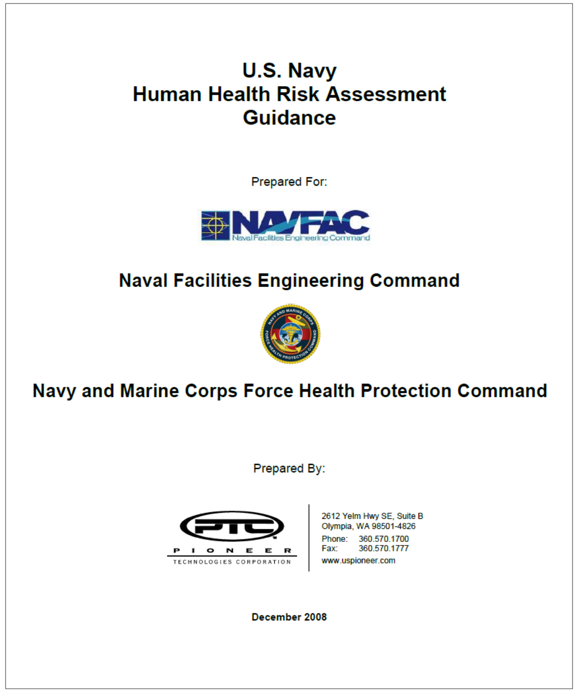
(EPA 1994)

KEY POINT

400 ppm remained the default screening level until 2024 (~30 years).

OSWER: Office of Solid Waste and Emergency Response
ppm: part(s) per million, equivalent to mg/kg
mg/kg: milligram(s) per kilogram
µg/dL: microgram(s) per deciliter

Navy Risk Assessment Process for Lead



U.S. Navy
Human Health Risk Assessment
Guidance

Prepared For:

NAVFAC
Naval Facilities Engineering Command

Naval Facilities Engineering Command

Navy and Marine Corps Force Health Protection Command

Prepared By:

PTC
PIONEER
TECHNOLOGIES CORPORATION

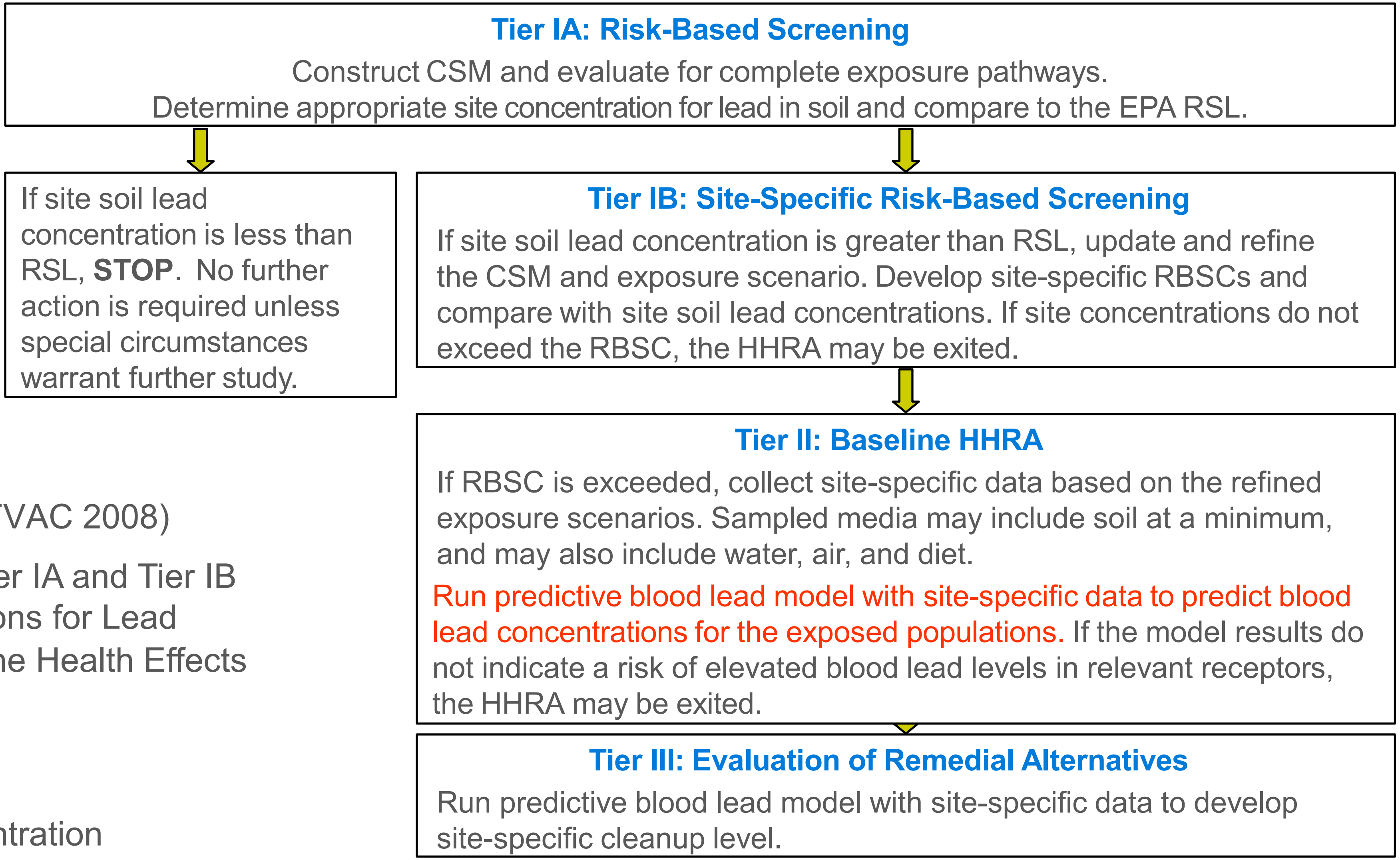
2612 Yelm Hwy SE, Suite B
Olympia, WA 98501-4826
Phone: 360.570.1700
Fax: 360.570.1777
www.uspioneer.com

December 2008

(NAFVAC 2008)

Tier I—Section 7.3.4: Identifying Tier IA and Tier IB Risk-Based Screening Concentrations for Lead

Tier II—Section 8.7.2: Evaluating the Health Effects Associated with Lead



Tier IA: Risk-Based Screening

Construct CSM and evaluate for complete exposure pathways.
Determine appropriate site concentration for lead in soil and compare to the EPA RSL.

If site soil lead concentration is less than RSL, **STOP**. No further action is required unless special circumstances warrant further study.

Tier IB: Site-Specific Risk-Based Screening

If site soil lead concentration is greater than RSL, update and refine the CSM and exposure scenario. Develop site-specific RBSCs and compare with site soil lead concentrations. If site concentrations do not exceed the RBSC, the HHRA may be exited.

Tier II: Baseline HHRA

If RBSC is exceeded, collect site-specific data based on the refined exposure scenarios. Sampled media may include soil at a minimum, and may also include water, air, and diet.

Run predictive blood lead model with site-specific data to predict blood lead concentrations for the exposed populations. If the model results do not indicate a risk of elevated blood lead levels in relevant receptors, the HHRA may be exited.

Tier III: Evaluation of Remedial Alternatives

Run predictive blood lead model with site-specific data to develop site-specific cleanup level.

CSM: conceptual site model
RBSC: risk-based screening concentration
RSL: regional screening level

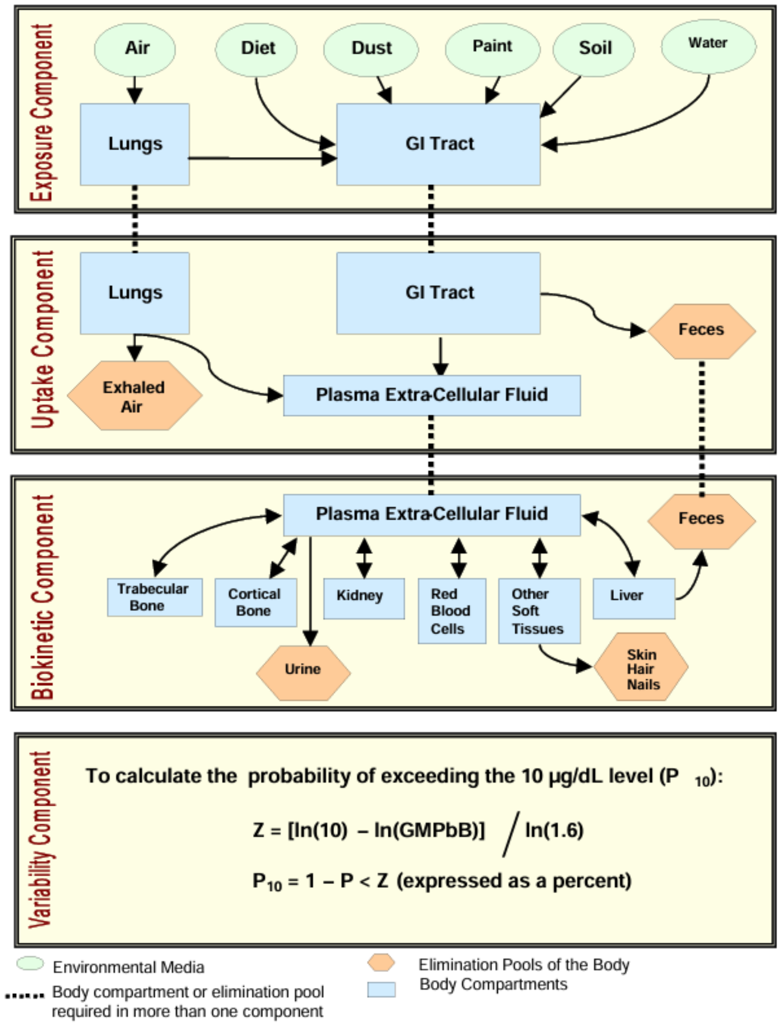
IEUBK Model Overview

- Developed by EPA in the early 90s
- Evaluates exposure of young children to lead in soil/dust and other media (i.e., water, air, diet, other)
- Basis for former 400 ppm residential soil lead screening level (with 10 µg/dL BLL target)
- Some Superfund sites have adopted cleanup levels higher than 400 ppm based on site-specific inputs
- EPA released new version of model with updates to several default parameters in 2021, including the following
  - Default target BLL of 5 µg/dL
  - Soil and dust ingestion rates
  - Inhalation rates
  - Dietary lead exposures
  - Maternal blood lead concentration

KEY POINT

The IEUBK Model only evaluates lead exposures during childhood.

IEUBK Model Structure



Exposure Component

Air, Diet, Dust, Paint, Soil, Water

Lungs, GI Tract

Uptake Component

Lungs, GI Tract, Feces, Exhaled Air, Plasma Extra-Cellular Fluid

Biokinetic Component

Plasma Extra-Cellular Fluid, Feces, Trabecular Bone, Cortical Bone, Kidney, Red Blood Cells, Other Soft Tissues, Liver, Urine, Skin Hair Nails

Variability Component

To calculate the probability of exceeding the 10 µg/dL level (P_{10}):

$$Z = [\ln(10) - \ln(GMPbB)] / \ln(1.6)$$

$$P_{10} = 1 - P < Z \text{ (expressed as a percent)}$$

Environmental Media

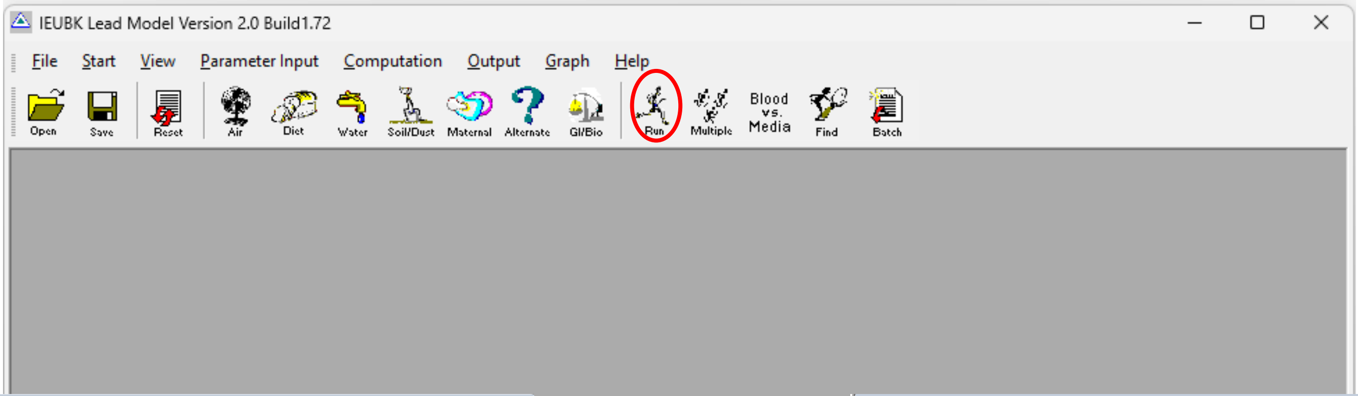
Body compartment or elimination pool required in more than one component

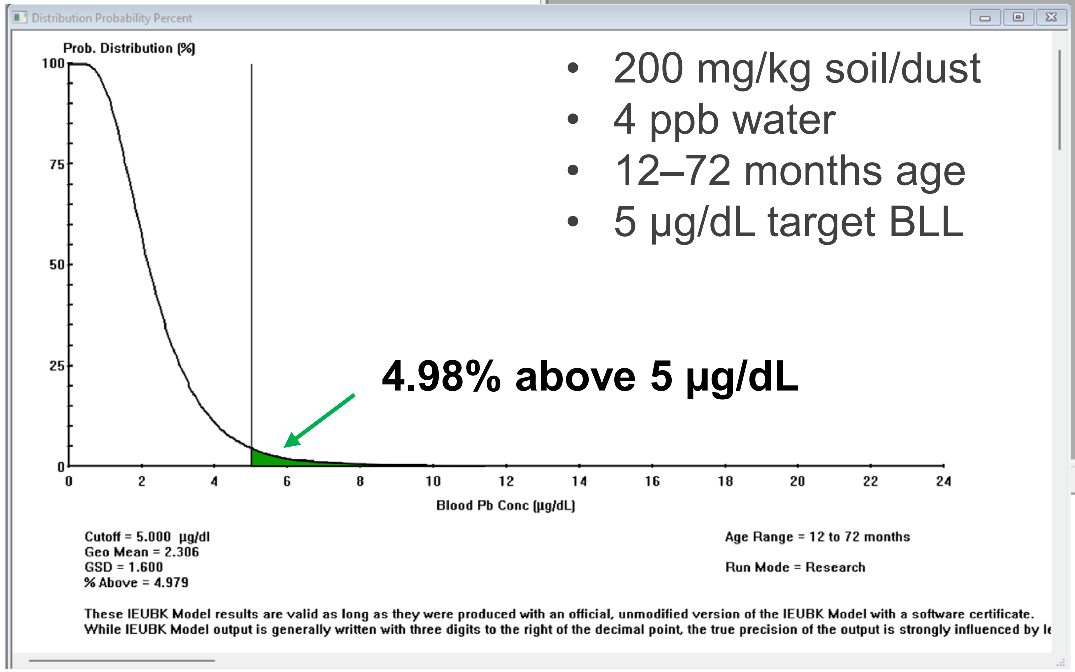
Elimination Pools of the Body

Body Compartments

(EPA n.d.)

IEUBK Overview: Run Model Function





Cutoff = 5.000 µg/dl
Geo Mean = 2.306
GSD = 1.600
% Above = 4.979

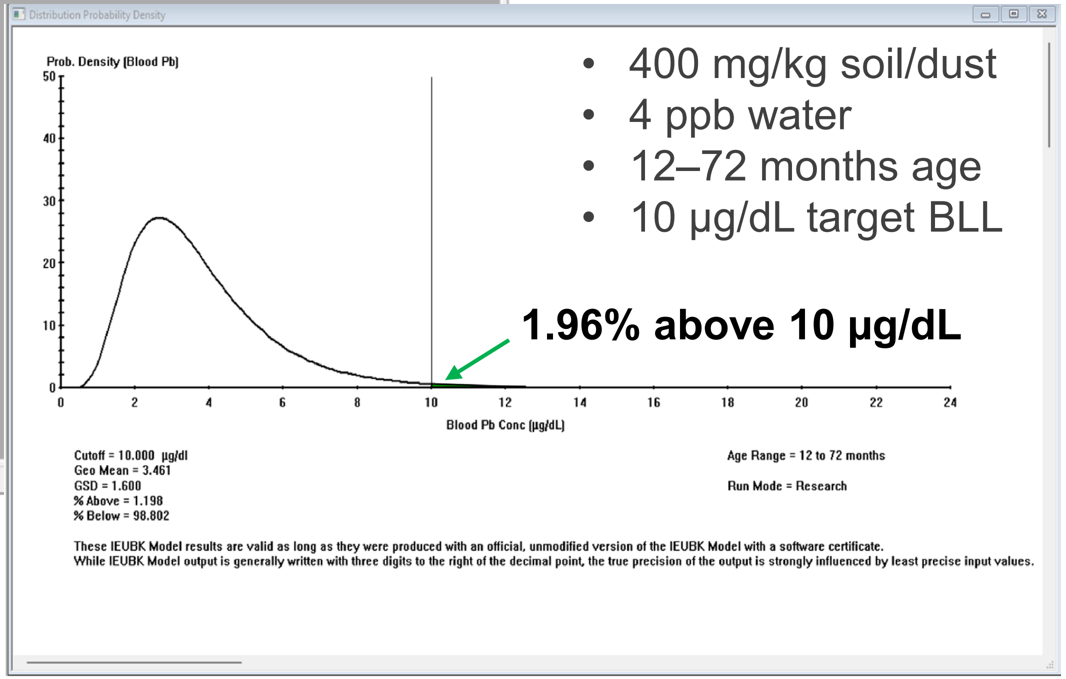
Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by le

- 200 mg/kg soil/dust
- 4 ppb water
- 12–72 months age
- 5 µg/dL target BLL

4.98% above 5 µg/dL



Cutoff = 10.000 µg/dl
Geo Mean = 3.461
GSD = 1.600
% Above = 1.198
% Below = 98.802

Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

- 400 mg/kg soil/dust
- 4 ppb water
- 12–72 months age
- 10 µg/dL target BLL

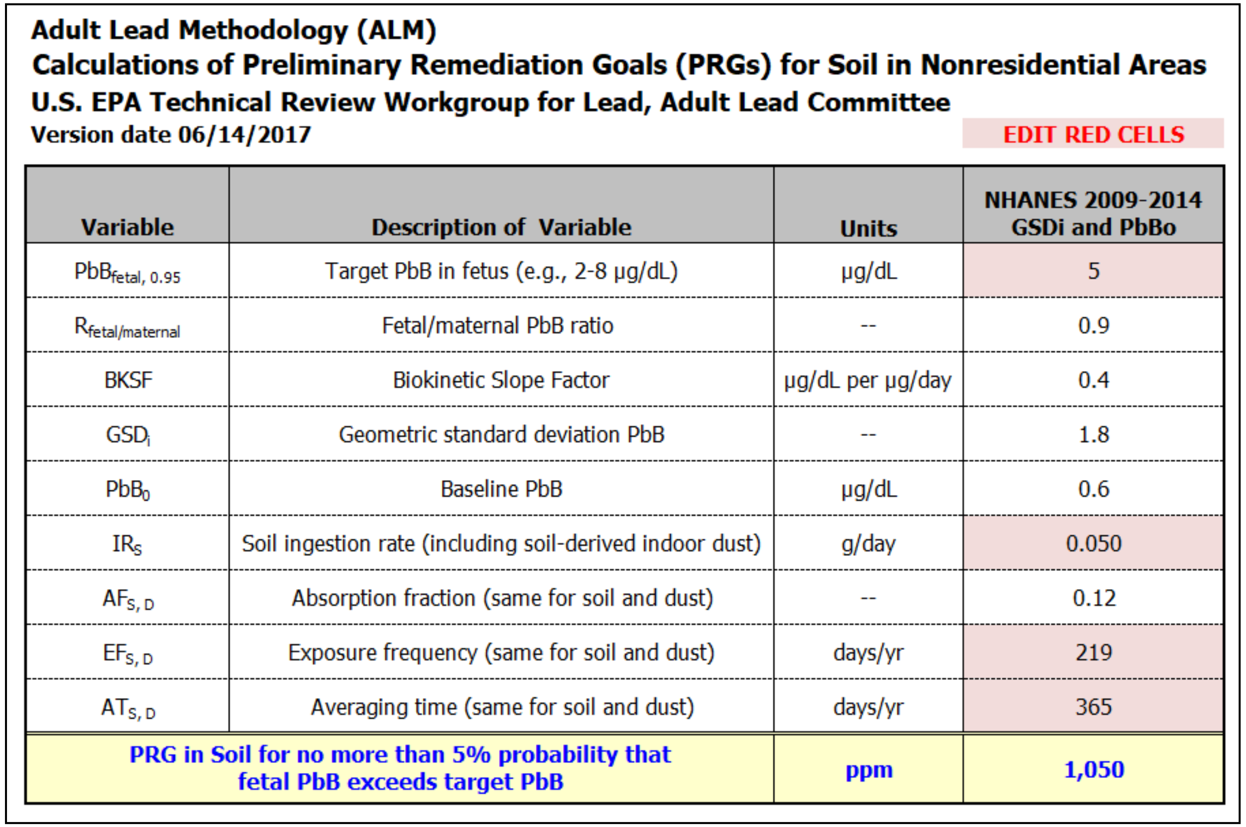
1.96% above 10 µg/dL

ppb: parts per billion

(EPA 2021)

Adult Lead Model Overview: PRG Calculation

- Microsoft Excel spreadsheet-based model
- Uses a simplified “slope factor” approach
- Slope factor relates change in BLL (µg/dL) per µg/day of lead absorbed
- The ALM can also be used to calculate soil PRGs for nonresidential land use
- Using model default parameters (including 5 µg/dL BLL target)
  - PRG = 1,050 ppm



Adult Lead Methodology (ALM)
Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 06/14/2017

EDIT RED CELLS

Variable	Description of Variable	Units	NHANES 2009-2014 GSDi and PbBo
$PbB_{fetal, 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**1,050**

(EPA 2003)

KEY POINT

Default nonresidential PRG is more than 5-fold higher than default residential screening level of 200 ppm.

Public Health Research Drives Changes to EPA Guidance

- Public health studies published in 1990s and early 2000s provided evidence of adverse health effects of lead in children at BLLs <10 μg/dL
- In-depth compilations/reviews of primary literature on lead health effects were prepared by United States government in 2012–2013
  - 2012 NTP monograph: *Health Effects of Low-level Lead*
  - 2012 CDC-ACCLPP report: *Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention*
  - 2013 EPA report: *Integrated Science Assessment for Lead*

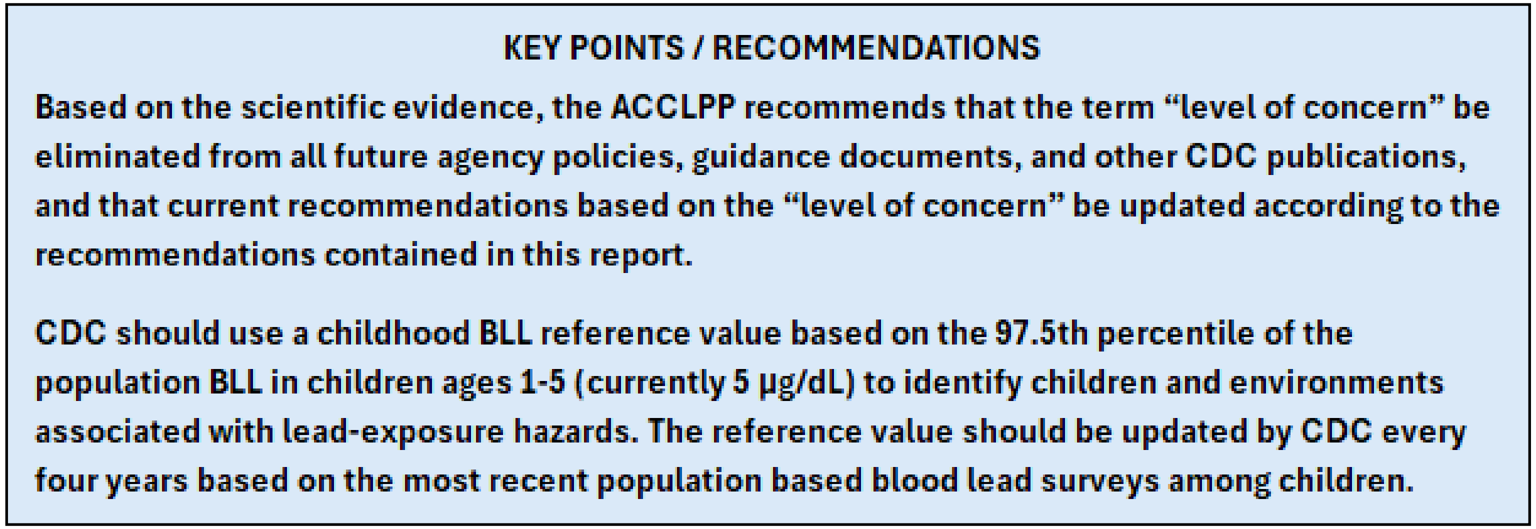
ACCLPP: Advisory Committee on Childhood Lead Poisoning and Prevention

CDC: Centers for Disease Control and Prevention
NTP: National Toxicology Program

2012 CDC Report

Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention

- Presents scientific rationale for eliminating CDC’s 10 µg/dL blood lead “level of concern”

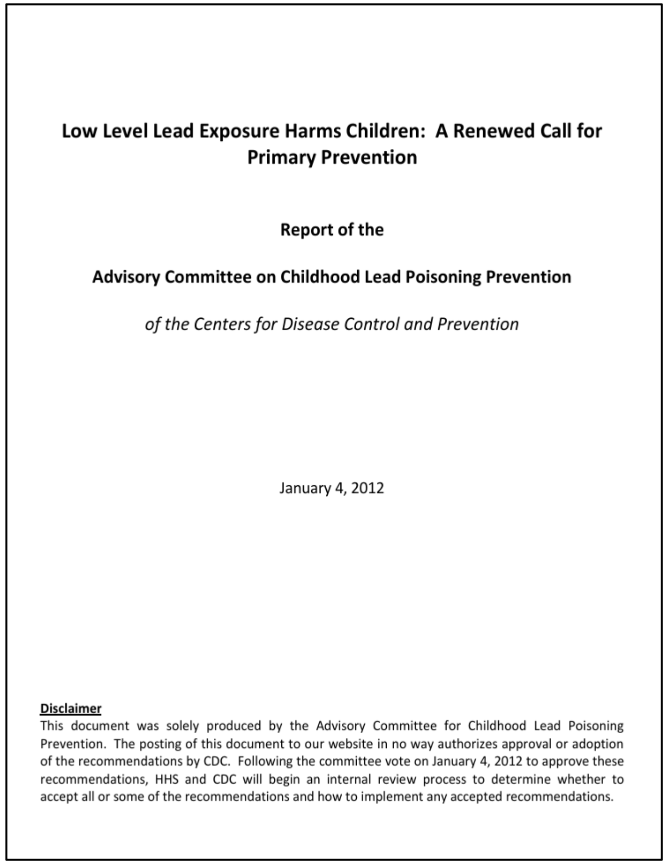


KEY POINTS / RECOMMENDATIONS

Based on the scientific evidence, the ACCLPP recommends that the term “level of concern” be eliminated from all future agency policies, guidance documents, and other CDC publications, and that current recommendations based on the “level of concern” be updated according to the recommendations contained in this report.

CDC should use a childhood BLL reference value based on the 97.5th percentile of the population BLL in children ages 1-5 (currently 5 µg/dL) to identify children and environments associated with lead-exposure hazards. The reference value should be updated by CDC every four years based on the most recent population based blood lead surveys among children.

- Established blood lead “reference value” concept
  - Moving target, theoretically updated on a 4-year cycle
  - Based on 97.5th percentile BLL in US children ages 1–5
  - BLLs above reference value defined as “elevated”



Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention

Report of the

Advisory Committee on Childhood Lead Poisoning Prevention

of the Centers for Disease Control and Prevention

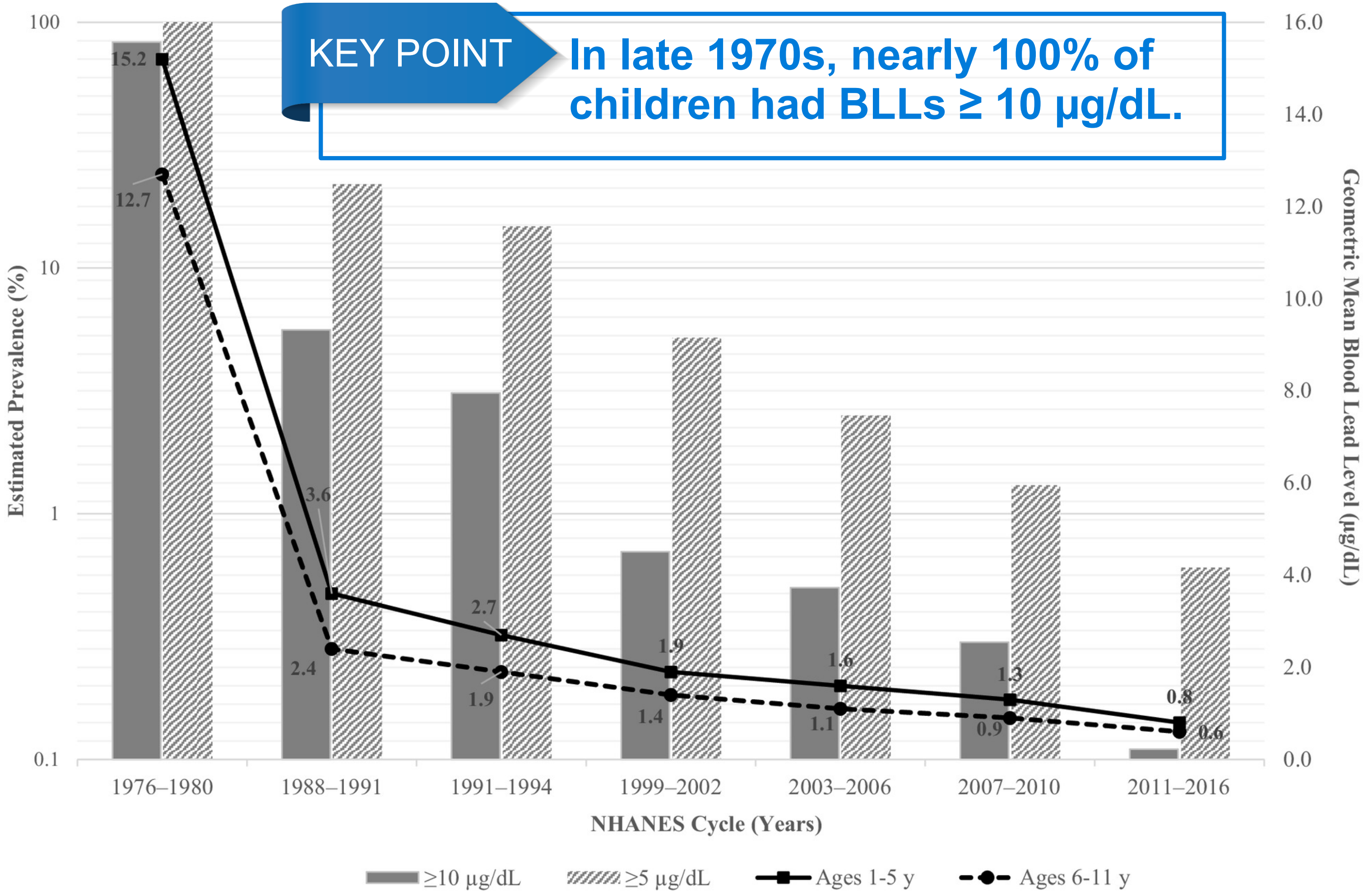
January 4, 2012

Disclaimer
This document was solely produced by the Advisory Committee for Childhood Lead Poisoning Prevention. The posting of this document to our website in no way authorizes approval or adoption of the recommendations by CDC. Following the committee vote on January 4, 2012 to approve these recommendations, HHS and CDC will begin an internal review process to determine whether to accept all or some of the recommendations and how to implement any accepted recommendations.

(CDC 2012)

BLLs in United States Children 1976–2016

- Lead Regulation Milestones
  - 1971 Lead-Based Paint Poisoning Prevention Act
  - 1978 CPSC ban of residential paint with >600 ppm lead
  - 1986 Ban of lead in pipe, solder, and flux
  - 1992 Lead-Based Paint Hazard Reduction Act
  - 1995 FDA ban of lead solder in food packaging
- Blood Lead Reference Values
  - 2012: 5 µg/dL
  - **2021: ? µg/dL**



KEY POINT **In late 1970s, nearly 100% of children had BLLs ≥ 10 µg/dL.**

(Egan et al. 2021)

CPSC: Consumer Product Safety Commission
FDA: Food and Drug Administration

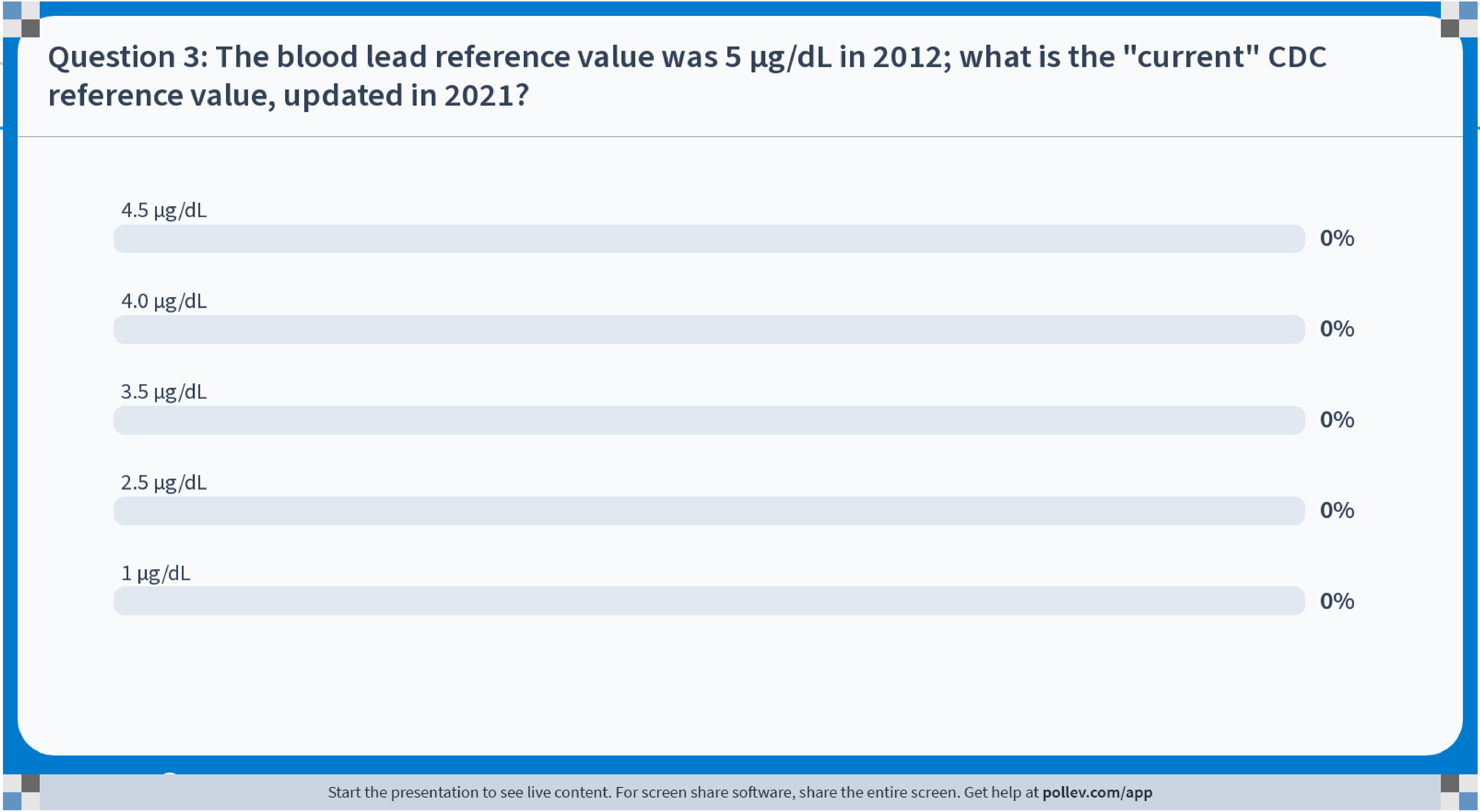
Poll Question 3

The blood lead reference value was 5 µg/dL in 2012; what is the “current” CDC reference value, updated in 2021?

A. 4.5 µg/dL
B. 4.0 µg/dL
C. 3.5 µg/dL
D. 2.5 µg/dL
E. 1 µg/dL

Options to respond

1. **Text RITSn200 to 22333** to join session then enter response
2. Enter **PollEv.com/ritsn200** in browser
3. **Scan the QR code** and open session in browser



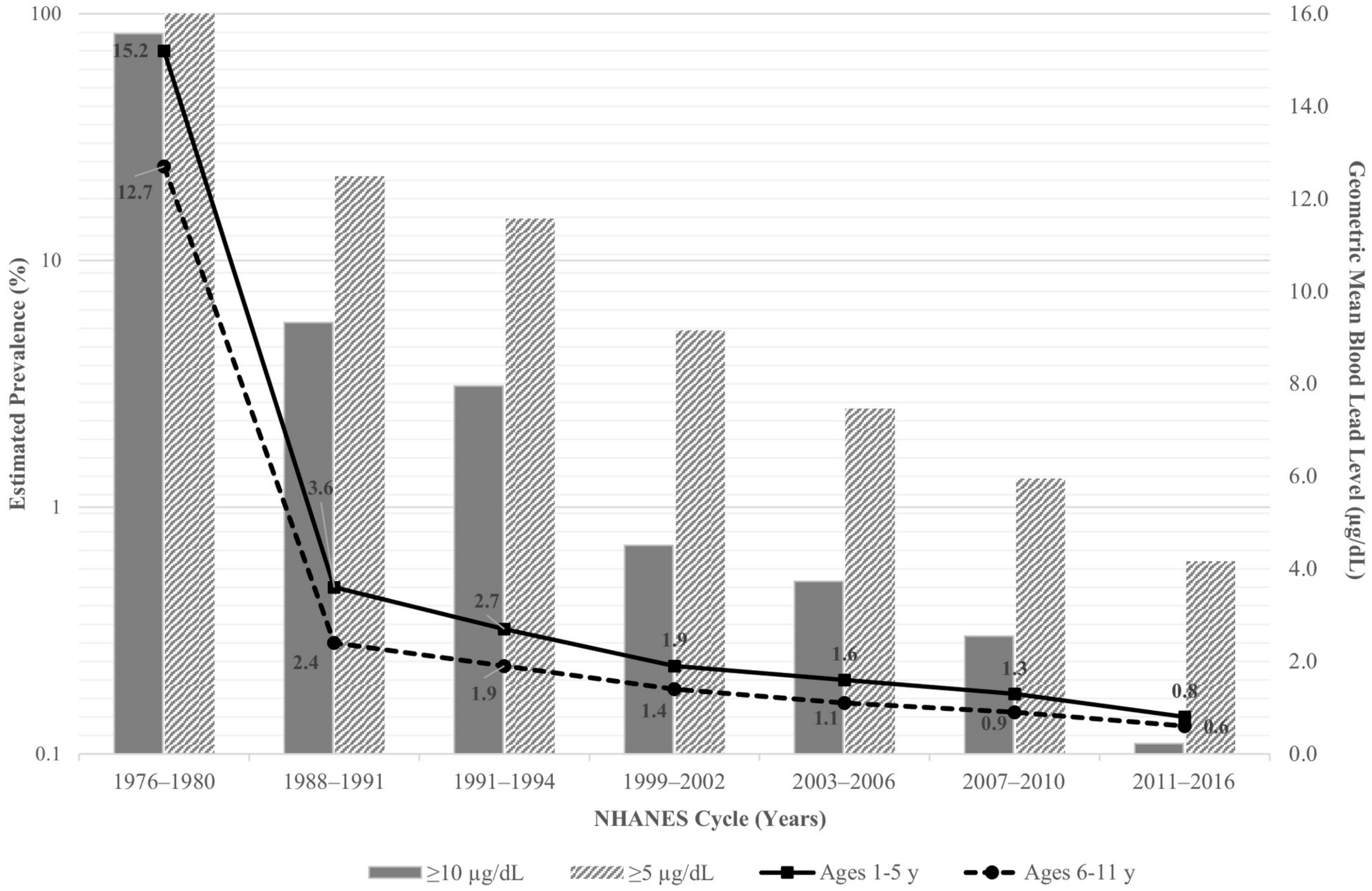
Question 3: The blood lead reference value was 5 µg/dL in 2012; what is the "current" CDC reference value, updated in 2021?

4.5 µg/dL	0%
4.0 µg/dL	0%
3.5 µg/dL	0%
2.5 µg/dL	0%
1 µg/dL	0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

BLLs in US Children 1976–2016

- Lead Regulation Milestones
  - 1971 Lead-Based Paint Poisoning Prevention Act
  - 1978 CPSC ban of residential paint with >600 ppm lead
  - 1986 Ban of lead in pipe, solder, and flux
  - 1992 Lead-Based Paint Hazard Reduction Act
  - 1995 FDA ban of lead solder in food packaging
- Blood Lead Reference Values
  - 2012: 5 µg/dL
  - **2021:** **3.5** µg/dL



(Egan et al. 2021)

Presentation Overview

- Introduction
- Lead Risk Assessment Primer
- EPA 2024 Updated Residential Soil Lead Guidance
- Case Studies
- Summary/Key Takeaways

Section Overview

- EPA 2024 Updated Residential Soil Lead Guidance
    - Screening level changes
    - Screening vs. cleanup levels
    - Incorporating EPA screening levels at Navy sites
    - Supporting tools/guidance
    - Background levels
    - Bioavailability

EPA Updated Residential Soil Lead Guidance

Key Changes

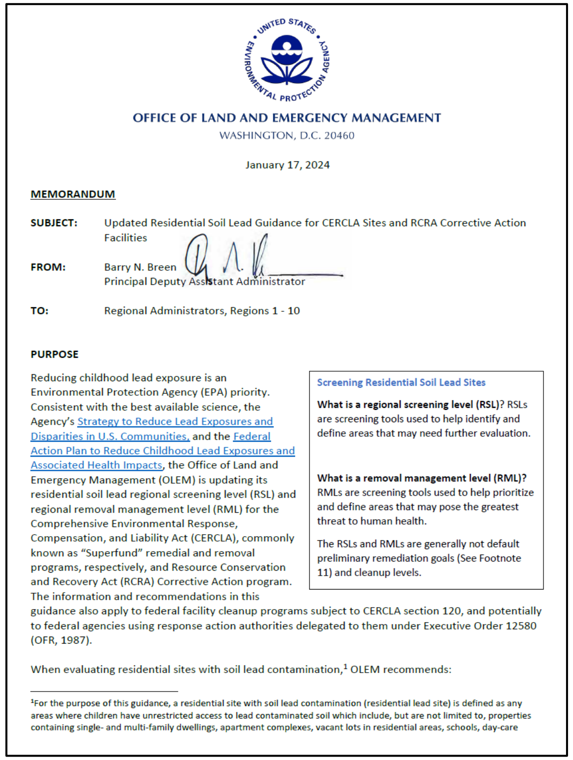
- Lower Residential RSL
    - Previous RSL = 400 ppm
    - Updated RSL = 200 ppm
    - For sites with additional sources of lead, Updated RSL = 100 ppm
        - *Use of 100 ppm RSL at DON sites requires explicit written approval from DASN*
- Applicable to <u>residential sites</u>: defined as any areas where children have unrestricted access to lead contaminated soil

KEY POINT

RSLs are just Screening Levels.

KEY POINT

No changes to industrial RSL for lead.



OFFICE OF LAND AND EMERGENCY MANAGEMENT
WASHINGTON, D.C. 20460

January 17, 2024

MEMORANDUM

SUBJECT: Updated Residential Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities

FROM: Barry N. Breen
Principal Deputy Assistant Administrator

TO: Regional Administrators, Regions 1 - 10

PURPOSE

Reducing childhood lead exposure is an Environmental Protection Agency (EPA) priority. Consistent with the best available science, the Agency's Strategy to Reduce Lead Exposures and Disparities in U.S. Communities, and the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts, the Office of Land and Emergency Management (OLEM) is updating its residential soil lead regional screening level (RSL) and regional removal management level (RML) for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as "Superfund" remedial and removal programs, respectively, and Resource Conservation and Recovery Act (RCRA) Corrective Action program. The information and recommendations in this guidance also apply to federal facility cleanup programs subject to CERCLA section 120, and potentially to federal agencies using response action authorities delegated to them under Executive Order 12580 (OFR, 1987).

Screening Residential Soil Lead Sites

What is a regional screening level (RSL)? RSLs are screening tools used to help identify and define areas that may need further evaluation.

What is a removal management level (RML)? RMLs are screening tools used to help prioritize and define areas that may pose the greatest threat to human health.

The RSLs and RMLs are generally not default preliminary remediation goals (See Footnote 11) and cleanup levels.

When evaluating residential sites with soil lead contamination,[1] OLEM recommends:

---

[1] For the purpose of this guidance, a residential site with soil lead contamination (residential lead site) is defined as any areas where children have unrestricted access to lead contaminated soil which include, but are not limited to, properties containing single- and multi-family dwellings, apartment complexes, vacant lots in residential areas, schools, day-care

(EPA 2024)

DASN: Deputy Assistant Secretary of the Navy
DON: Department of the Navy

EPA Updated Residential Soil Lead Guidance

- Purpose
  - Enhanced recommendations for investigating and cleaning up lead-contaminated soil
  - Reflects commitment to protect communities from lead, especially those facing multiple sources of lead
  - Supports EPA’s priority of recognizing the potential cumulative impacts from multiple sources of lead in a community
- Basis of updated soil screening levels
  - 200 ppm RSL: based on IEUBK Model using 5 µg/dL target BLL
  - 100 ppm RSL: based on IEUBK Model using 3.5 µg/dL target BLL

Screening Levels vs. Cleanup Levels

- RSLs
  - Tools to identify areas needing further evaluation
  - Not cleanup levels
- Site-Specific Decisions
  - Guidance does not dictate response actions or cleanup levels
  - Cleanup decisions to be made on a site-by-site basis, considering site-specific factors such as exposure and risk, bioavailability, and background lead levels
- EPA expects that lower screening levels may prompt more residential property investigations for soil lead impacts and result in more cleanup →

KEY POINT

Purple line = expanded investigation area based on 200 ppm RSL.

Silver Bow Creek/Butte Area NPL Site, MT
(EPA 2024c)

Existing BPSOU Boundary and Proposed Expansion

🟥	🟪
Existing BPSOU Boundary 4,265 acres 4,700 households	**Proposed BPSOU Expansion** 3,637 additional acres 7,253 additional households

BPSOU: Butte Priority Soils Operable Unit

Lead Cleanup Level Planning at Navy Sites

- Establishing cleanup levels
  - EPA policies still point to 10 µg/dL target BLL (OSWER 1994 and 1998)
    - Equates to 400 ppm screening level
  - 2024 EPA guidance recommends lower target BLLs of 5 µg/dL or 3.5 µg/dL
    - Equates to soil lead levels of 200 ppm or 100 ppm, respectively
  - Policy vs. Guidance: to be consistent with other chemicals, EPA policies take precedence over guidance

- Initial PRG should be based on 10 µg/dL BLL target
- If possible, also evaluate impact of a PRG based on 5 µg/dL BLL target
- If acceptable, consider using more conservative PRG, with Navy Headquarters approval
  - For example: if reasonable amounts of additional excavation or minimal LUC boundary expansion would achieve more conservative PRG
  - Use of 100 ppm requires written permission from DASN
- Check state-specific ARARs

ARAR(s): applicable or relevant and appropriate requirements
LUC: land use control

Incorporating EPA Screening Levels at Navy Sites

- Navy sites typically screen residential lead sites to 200 ppm
  - For deviations, coordinate with leadership for current best practices and approval
- Cleanup level is site-specific, not based on RSL
  - Use of IEUBK model and/or ALM
  - Site-specific inputs
  - Average soil concentration (site-wide or decision-unit-wide)
  - Predicted BLLs (e.g., >5% of children with blood lead >10 µg/dL)

KEY POINTS

RSLs are not Cleanup Levels. Changes to site lead screening levels must be approved in writing by DASN.

EPA Updated Residential Soil Lead Guidance Supporting Tools and Guidance

- Updated OLEM Residential Lead Guidance Explainer
  https://semspub.epa.gov/work/HQ/100003437.pdf

- Frequent Questions About the Updated Residential Lead Guidance
  https://www.epa.gov/superfund/frequent-questions-about-updated-residential-soil-lead-guidance

- Supplemental Framework: Selecting a Remedial Screening Level for Residential Soil Lead
  https://semspub.epa.gov/work/HQ/100003397.pdf

- Residential Lead Screening Level Checklist
  https://semspub.epa.gov/src/document/HQ/100003395

- Residential Lead GIS Screening Tool
  https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=ffe699ef7fdc4f8982d933806de179d7

- Superfund Residential Lead Sites Handbook
  https://semspub.epa.gov/work/HQ/100003401.pdf

For additional information, visit www.epa.gov/lead

OLEM: Office of Land and Emergency Management

Screening Level Selection
Residential Lead Screening Checklist

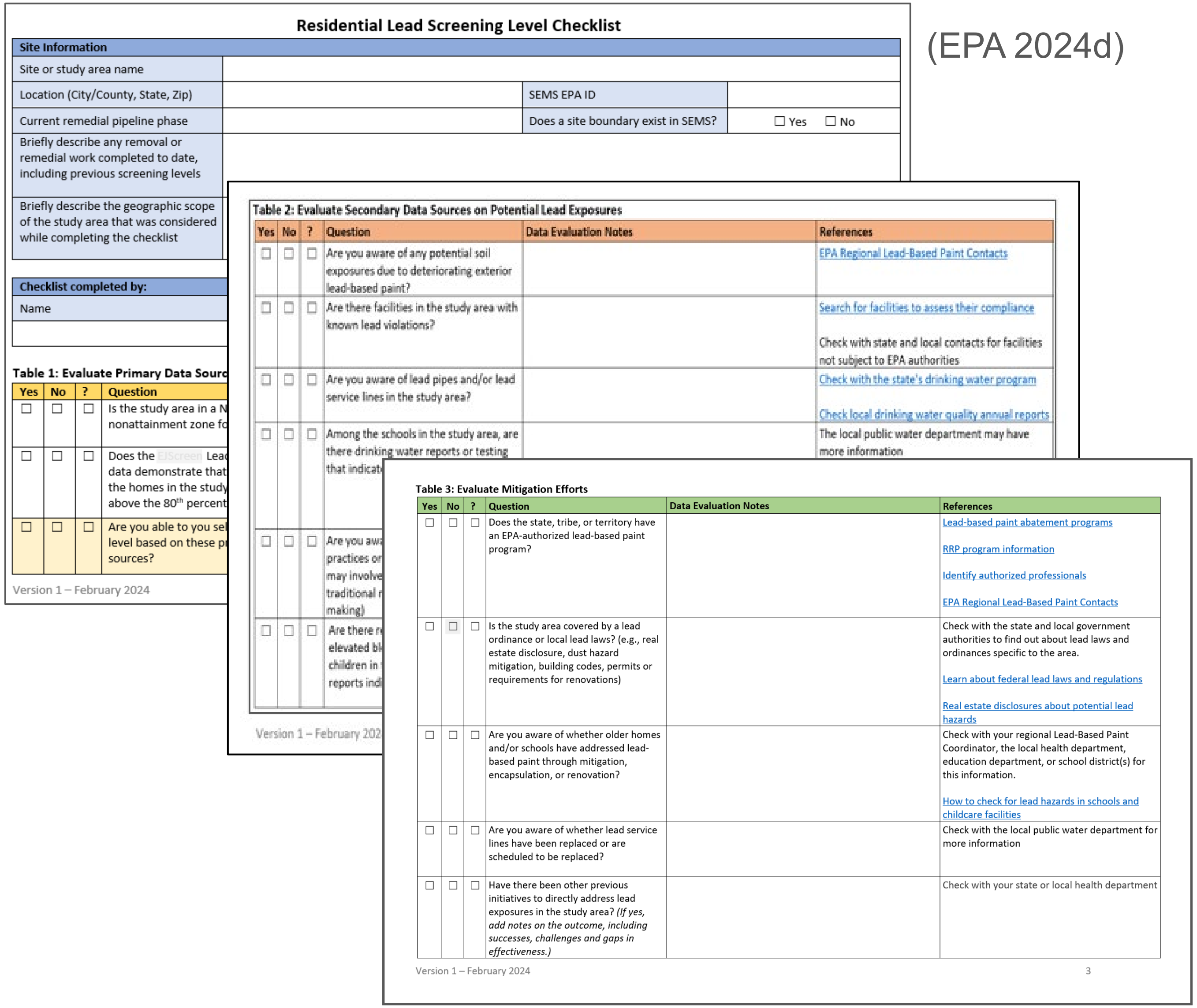
Series of three tables

Table 1: Evaluate Primary Data Sources
- NAAQS non-attainment zone for lead?
- Lead Paint Index ≥80th percentile?

Table 2: Evaluate Secondary Data Sources on Potential Lead Exposures
- Other local or site-specific information?

Table 3: Evaluate Mitigation Efforts
- Ongoing or past mitigation efforts?

NAAQS: National Ambient Air Quality Standards



(EPA 2024d)

Residential Lead Screening Level Checklist

Site Information			
Site or study area name			
Location (City/County, State, Zip)		SEMS EPA ID	
Current remedial pipeline phase		Does a site boundary exist in SEMS?	☐ Yes ☐ No
Briefly describe any removal or remedial work completed to date, including previous screening levels			
Briefly describe the geographic scope of the study area that was considered while completing the checklist			

Checklist completed by:
Name

Table 1: Evaluate Primary Data Sourc

Yes	No	?	Question
☐	☐	☐	Is the study area in a N nonattainment zone fo
☐	☐	☐	Does the EJScreen Lead data demonstrate that the homes in the study above the 80^{th} percent
☐	☐	☐	Are you able to you sel level based on these pr sources?

Version 1 – February 2024

Table 2: Evaluate Secondary Data Sources on Potential Lead Exposures

Yes	No	?	Question	Data Evaluation Notes	References
☐	☐	☐	Are you aware of any potential soil exposures due to deteriorating exterior lead-based paint?		EPA Regional Lead-Based Paint Contacts
☐	☐	☐	Are there facilities in the study area with known lead violations?		Search for facilities to assess their compliance Check with state and local contacts for facilities not subject to EPA authorities
☐	☐	☐	Are you aware of lead pipes and/or lead service lines in the study area?		Check with the state's drinking water program Check local drinking water quality annual reports
☐	☐	☐	Among the schools in the study area, are there drinking water reports or testing that indicat		The local public water department may have more information
☐	☐	☐	Are you awa practices or may involve traditional r making)		
☐	☐	☐	Are there re elevated bl children in t reports indi		

Version 1 – February 202

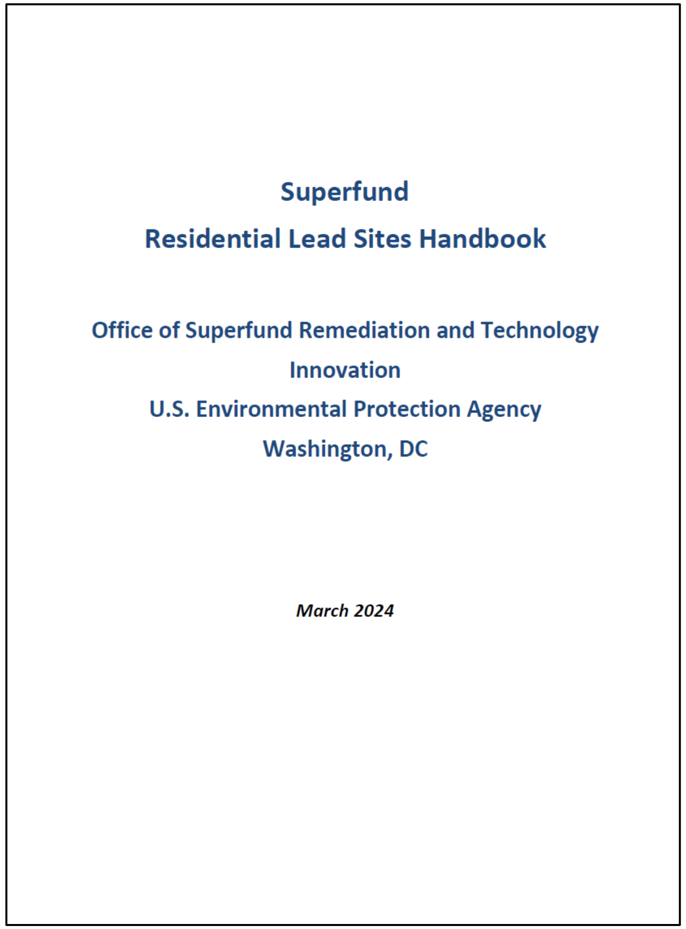
Table 3: Evaluate Mitigation Efforts

Yes	No	?	Question	Data Evaluation Notes	References
☐	☐	☐	Does the state, tribe, or territory have an EPA-authorized lead-based paint program?		Lead-based paint abatement programs RRP program information Identify authorized professionals EPA Regional Lead-Based Paint Contacts
☐	☐	☐	Is the study area covered by a lead ordinance or local lead laws? (e.g., real estate disclosure, dust hazard mitigation, building codes, permits or requirements for renovations)		Check with the state and local government authorities to find out about lead laws and ordinances specific to the area. Learn about federal lead laws and regulations Real estate disclosures about potential lead hazards
☐	☐	☐	Are you aware of whether older homes and/or schools have addressed lead-based paint through mitigation, encapsulation, or renovation?		Check with your regional Lead-Based Paint Coordinator, the local health department, education department, or school district(s) for this information. How to check for lead hazards in schools and childcare facilities
☐	☐	☐	Are you aware of whether lead service lines have been replaced or are scheduled to be replaced?		Check with the local public water department for more information
☐	☐	☐	Have there been other previous initiatives to directly address lead exposures in the study area? *(If yes, add notes on the outcome, including successes, challenges and gaps in effectiveness.)*		Check with your state or local health department

Version 1 – February 2024 3

Superfund Residential Lead Sites Handbook

- Resource guide for RPMs, OSCs, and risk assessors evaluating residential lead sites
- Identifies tools and summarizes best practices to promote consistency and provide flexibility
- Captures advances in those tools and best practices which have evolved since EPA first issued the handbook in 2003
- Moving forward, each chapter of the handbook will be a module that can be updated or modified as new information and experience are gathered



Superfund
Residential Lead Sites Handbook

Office of Superfund Remediation and Technology Innovation
U.S. Environmental Protection Agency
Washington, DC

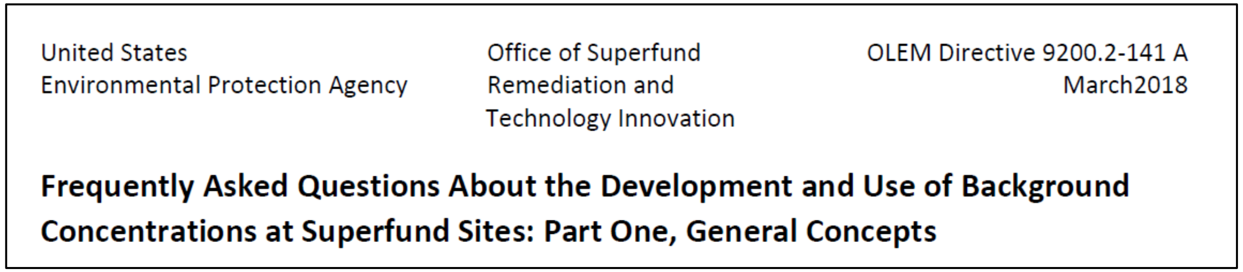
March 2024

(EPA 2024b)

OSC: On-Scene Coordinator
RPM: remedial project manager

Background Considerations for Lead

- EPA's updated residential soil lead screening levels may be below background concentrations
- Establishing statistically robust background lead levels will be important for some sites
- CERCLA generally does not clean up to concentrations below natural or anthropogenic background levels
- Cleanup levels may be set at site-specific background concentrations

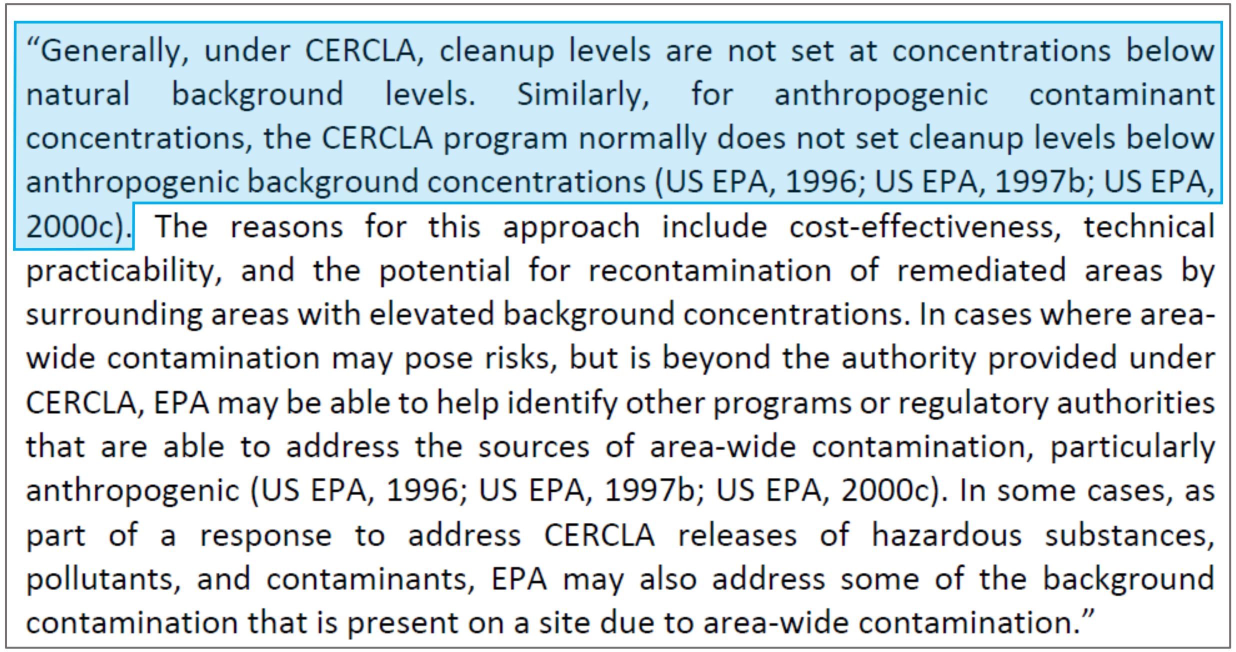


United States
Environmental Protection Agency

Office of Superfund
Remediation and
Technology Innovation

OLEM Directive 9200.2-141 A
March2018

Frequently Asked Questions About the Development and Use of Background Concentrations at Superfund Sites: Part One, General Concepts

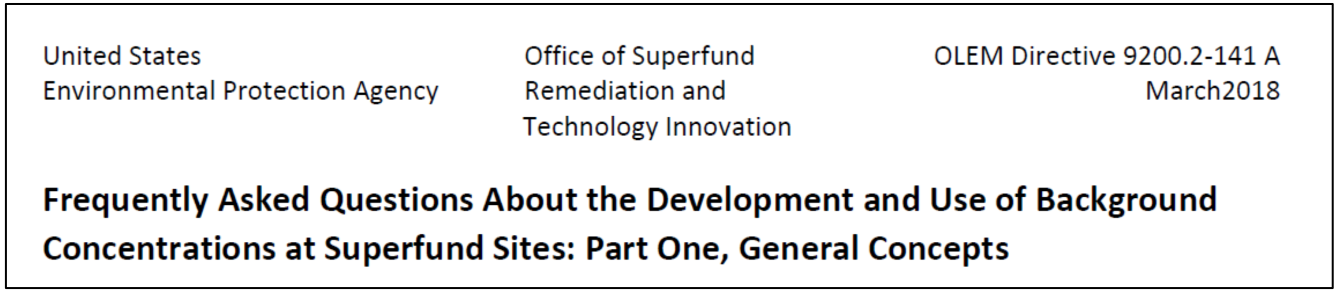


"Generally, under CERCLA, cleanup levels are not set at concentrations below natural background levels. Similarly, for anthropogenic contaminant concentrations, the CERCLA program normally does not set cleanup levels below anthropogenic background concentrations (US EPA, 1996; US EPA, 1997b; US EPA, 2000c). The reasons for this approach include cost-effectiveness, technical practicability, and the potential for recontamination of remediated areas by surrounding areas with elevated background concentrations. In cases where area-wide contamination may pose risks, but is beyond the authority provided under CERCLA, EPA may be able to help identify other programs or regulatory authorities that are able to address the sources of area-wide contamination, particularly anthropogenic (US EPA, 1996; US EPA, 1997b; US EPA, 2000c). In some cases, as part of a response to address CERCLA releases of hazardous substances, pollutants, and contaminants, EPA may also address some of the background contamination that is present on a site due to area-wide contamination."

(EPA 2018)

EPA Definition of Background

- In urban areas, it may be difficult to distinguish between anthropogenic background and site-related sources of lead



United States
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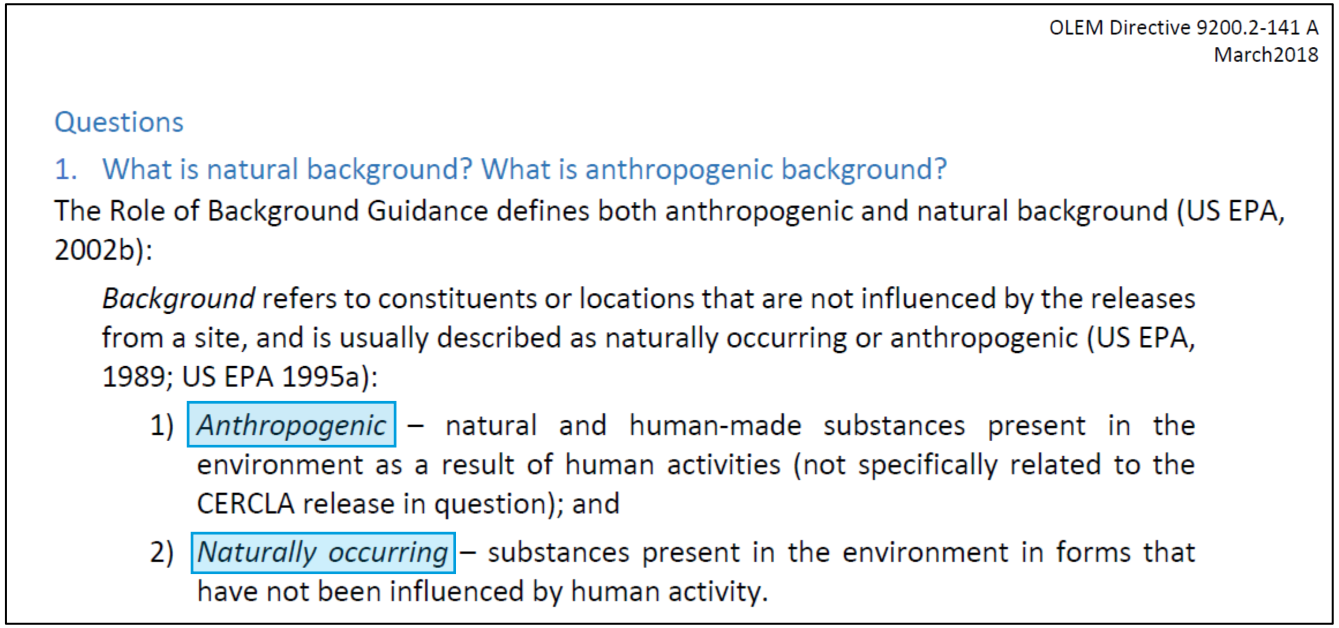


OLEM Directive 9200.2-141 A
March2018

Questions

1. What is natural background? What is anthropogenic background?

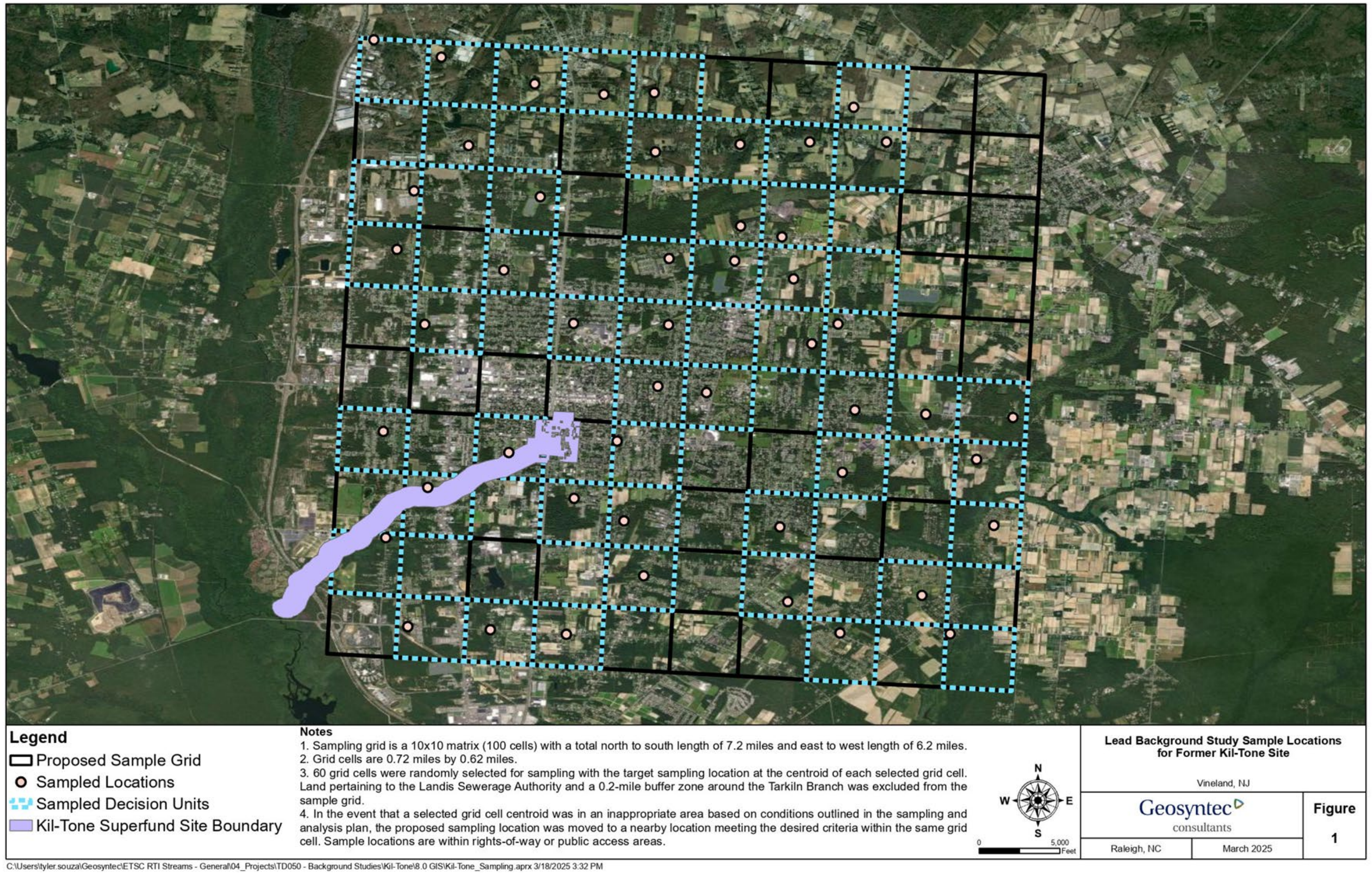
The Role of Background Guidance defines both anthropogenic and natural background (US EPA, 2002b):

> *Background* refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (US EPA, 1989; US EPA 1995a):
>
> 1) *Anthropogenic* – natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question); and
> 2) *Naturally occurring* – substances present in the environment in forms that have not been influenced by human activity.

(EPA 2018)

Superfund Background Lead Initiative

- EPA is conducting lead background studies at up to 20 Superfund sites across the United States
- Example: Former Kil-Tone Superfund Site Vineland, New Jersey
  - Sampling Grid is a 10 x 10 matrix
  - 100 grid cells of 0.6 mi by 0.7 mi each
  - 60 grid cells randomly selected for sampling (50 primary, 10 contingency)
  - Calculate UTL threshold-based background level



Notes

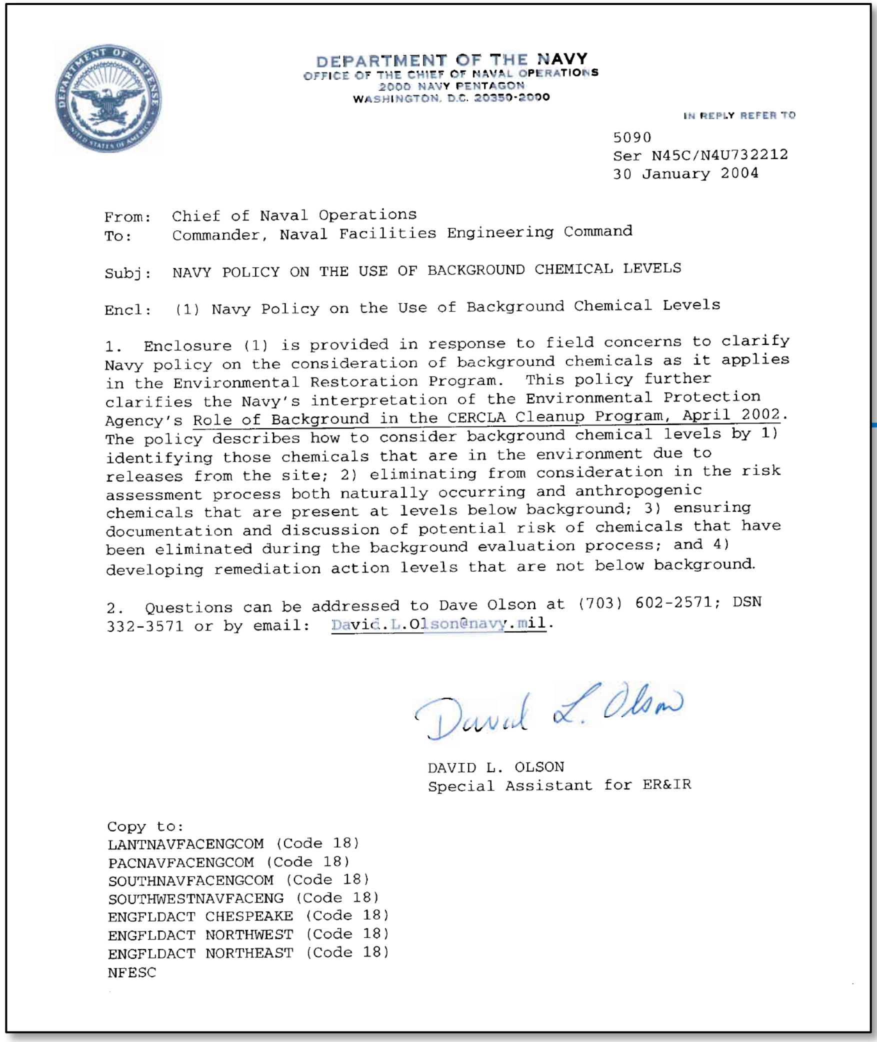
1. Sampling grid is a 10x10 matrix (100 cells) with a total north to south length of 7.2 miles and east to west length of 6.2 miles.
2. Grid cells are 0.72 miles by 0.62 miles.
3. 60 grid cells were randomly selected for sampling with the target sampling location at the centroid of each selected grid cell. Land pertaining to the Landis Sewerage Authority and a 0.2-mile buffer zone around the Tarkiln Branch was excluded from the sample grid.
4. In the event that a selected grid cell centroid was in an inappropriate area based on conditions outlined in the sampling and analysis plan, the proposed sampling location was moved to a nearby location meeting the desired criteria within the same grid cell. Sample locations are within rights-of-way or public access areas.

C:\Users\tyler.souza\Geosyntec\ETSC RTI Streams - General\04_Projects\TD050 - Background Studies\Kil-Tone\8.0 GIS\Kil-Tone_Sampling.aprx 3/18/2025 3:32 PM

(RTI International and Geosyntec Consultants 2025)

mi: miles
UTL: upper tolerance limit

Navy 2004 Background Policy



DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO
5090
Ser N45C/N4U732212
30 January 2004

From: Chief of Naval Operations
To: Commander, Naval Facilities Engineering Command

Subj: NAVY POLICY ON THE USE OF BACKGROUND CHEMICAL LEVELS

Encl: (1) Navy Policy on the Use of Background Chemical Levels

1. Enclosure (1) is provided in response to field concerns to clarify Navy policy on the consideration of background chemicals as it applies in the Environmental Restoration Program. This policy further clarifies the Navy's interpretation of the Environmental Protection Agency's Role of Background in the CERCLA Cleanup Program, April 2002. The policy describes how to consider background chemical levels by 1) identifying those chemicals that are in the environment due to releases from the site; 2) eliminating from consideration in the risk assessment process both naturally occurring and anthropogenic chemicals that are present at levels below background; 3) ensuring documentation and discussion of potential risk of chemicals that have been eliminated during the background evaluation process; and 4) developing remediation action levels that are not below background.

2. Questions can be addressed to Dave Olson at (703) 602-2571; DSN 332-3571 or by email: David.L.Olson@navy.mil.

David L. Olson

DAVID L. OLSON
Special Assistant for ER&IR

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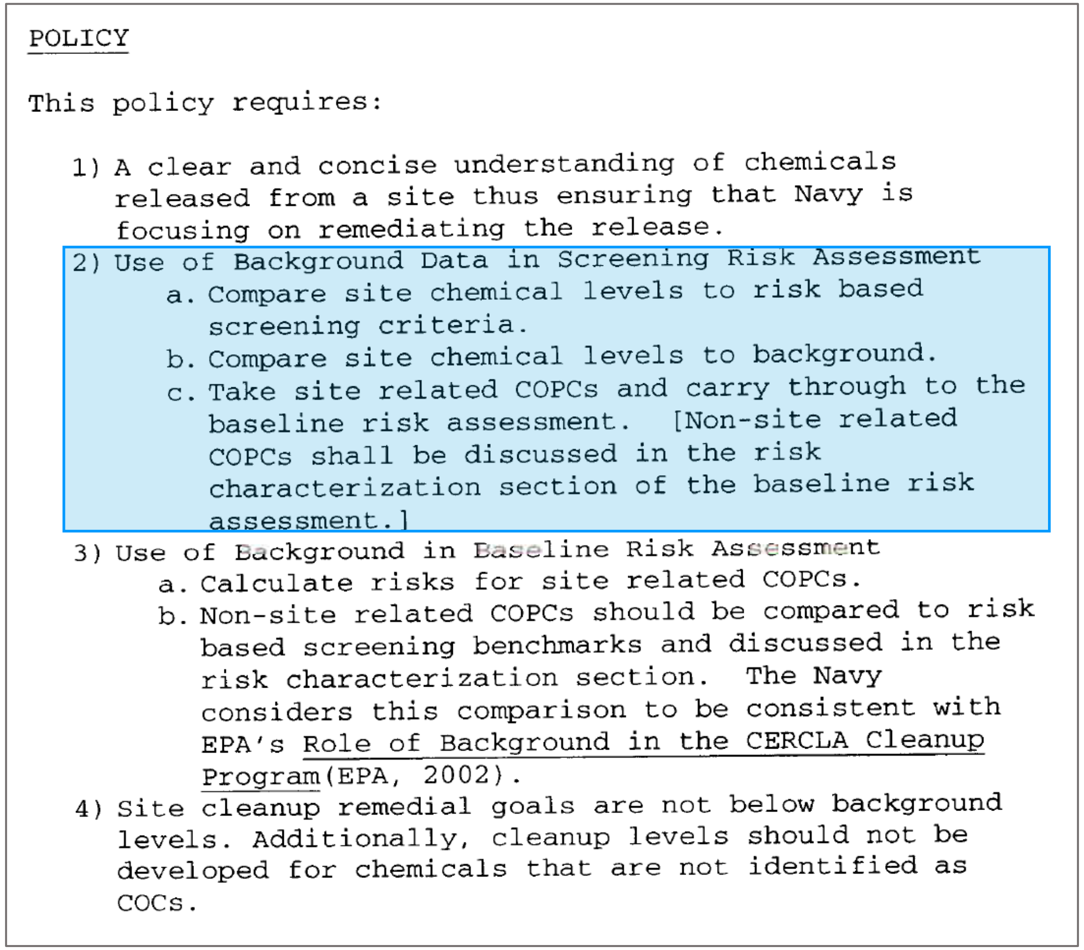


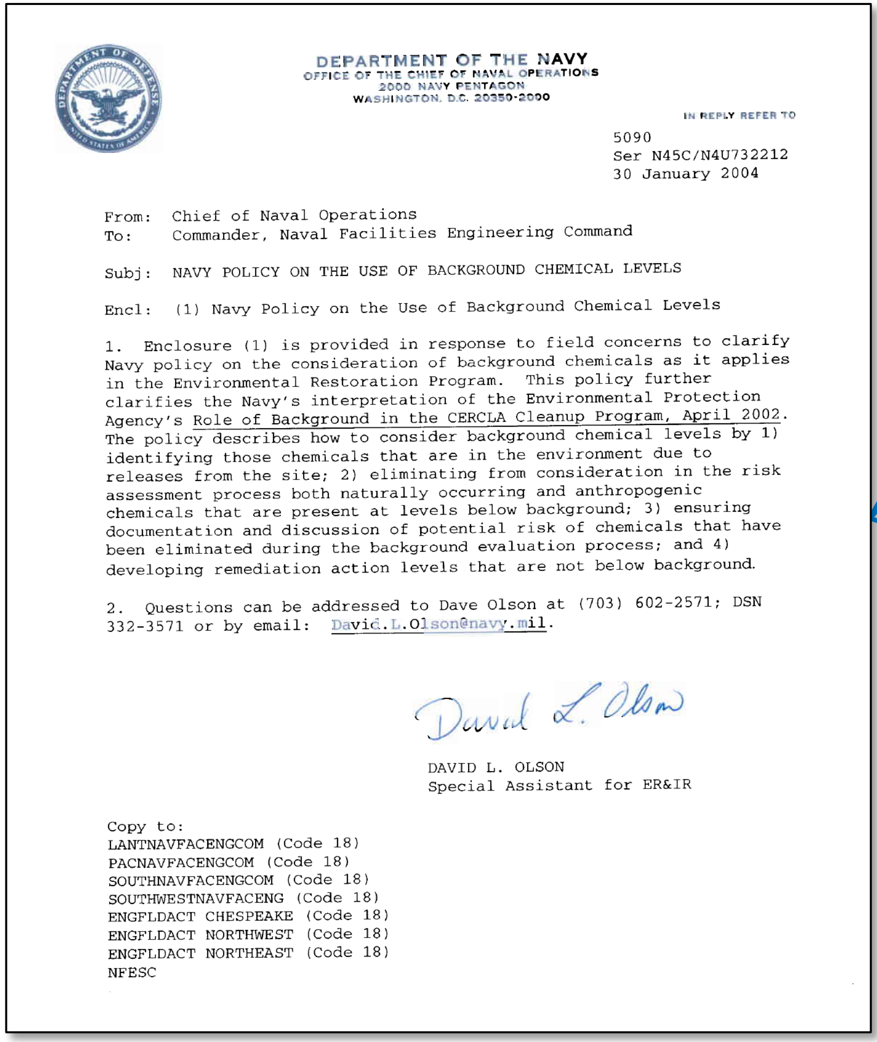
POLICY

This policy requires:

1) A clear and concise understanding of chemicals released from a site thus ensuring that Navy is focusing on remediating the release.
2) Use of Background Data in Screening Risk Assessment
    a. Compare site chemical levels to risk based screening criteria.
    b. Compare site chemical levels to background.
    c. Take site related COPCs and carry through to the baseline risk assessment. [Non-site related COPCs shall be discussed in the risk characterization section of the baseline risk assessment.]
3) Use of Background in Baseline Risk Assessment
    a. Calculate risks for site related COPCs.
    b. Non-site related COPCs should be compared to risk based screening benchmarks and discussed in the risk characterization section. The Navy considers this comparison to be consistent with EPA's Role of Background in the CERCLA Cleanup Program (EPA, 2002).
4) Site cleanup remedial goals are not below background levels. Additionally, cleanup levels should not be developed for chemicals that are not identified as COCs.

(Navy 2004)

Navy 2004 Background Policy



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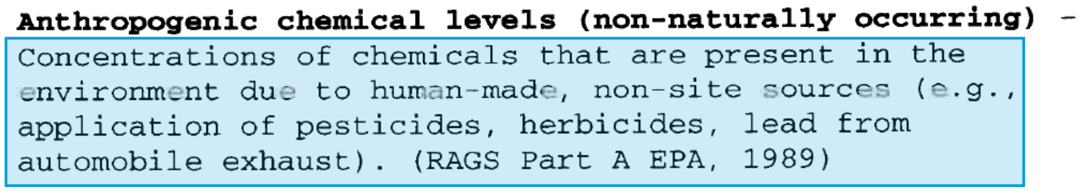
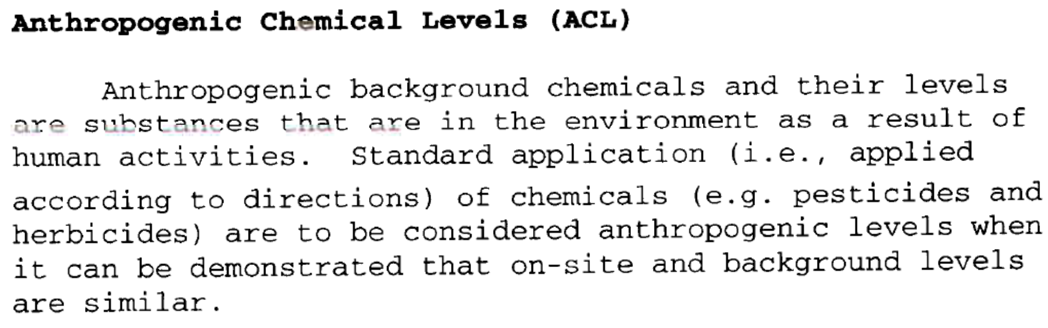
NFESC

(Navy 2004)

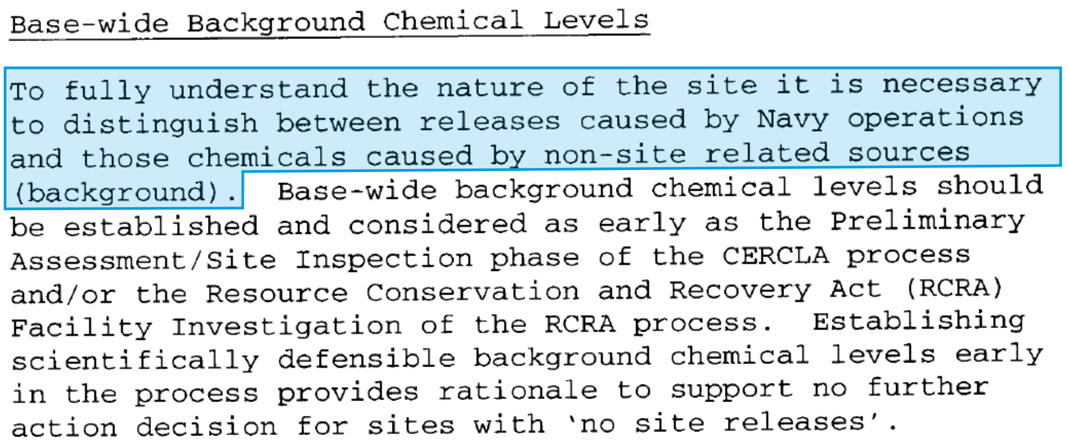


Anthropogenic chemical levels (non-naturally occurring) – Concentrations of chemicals that are present in the environment due to human-made, non-site sources (e.g., application of pesticides, herbicides, lead from automobile exhaust). (RAGS Part A EPA, 1989)



Anthropogenic Chemical Levels (ACL)

Anthropogenic background chemicals and their levels are substances that are in the environment as a result of human activities. Standard application (i.e., applied according to directions) of chemicals (e.g. pesticides and herbicides) are to be considered anthropogenic levels when it can be demonstrated that on-site and background levels are similar.

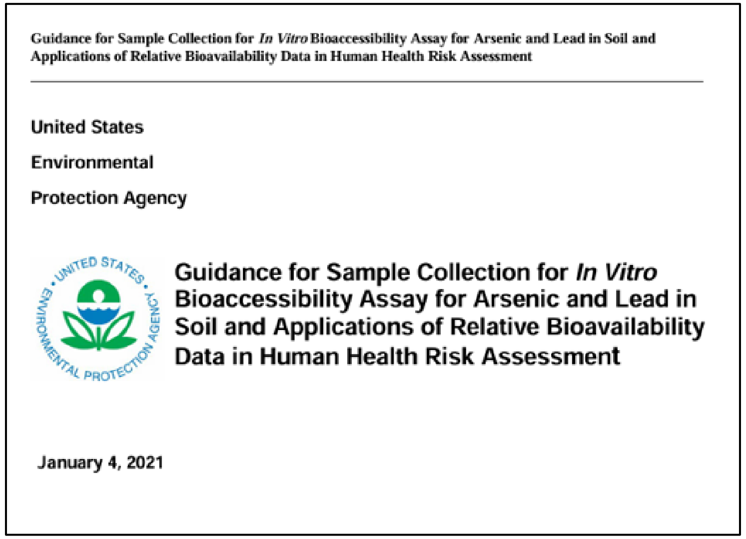


Base-wide Background Chemical Levels

To fully understand the nature of the site it is necessary to distinguish between releases caused by Navy operations and those chemicals caused by non-site related sources (background). Base-wide background chemical levels should be established and considered as early as the Preliminary Assessment/Site Inspection phase of the CERCLA process and/or the Resource Conservation and Recovery Act (RCRA) Facility Investigation of the RCRA process. Establishing scientifically defensible background chemical levels early in the process provides rationale to support no further action decision for sites with 'no site releases'.

Site-Specific Lead Bioavailability

- Bioavailability is a measure of the fraction of an ingested chemical dose that enters the bloodstream
- Lead is present in different chemical forms in soils, with some forms more bioavailable than others
- Lower bioavailability indicates a smaller fraction of lead in soil that can be absorbed by the body
- EPA generally recommends that site-specific relative bioavailability data be collected at lead-contaminated sites using validated *in vitro* methods



Guidance for Sample Collection for *In Vitro* Bioaccessibility Assay for Arsenic and Lead in Soil and Applications of Relative Bioavailability Data in Human Health Risk Assessment

United States
Environmental
Protection Agency

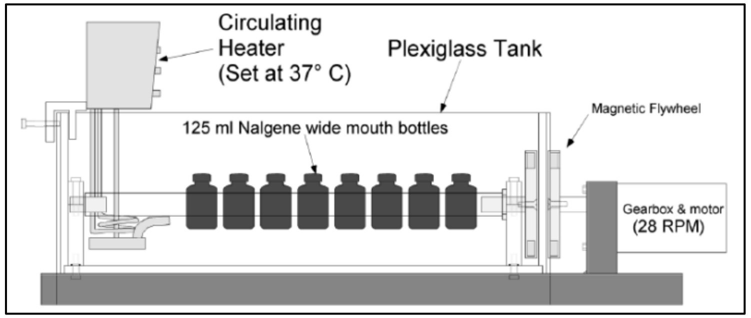
Guidance for Sample Collection for *In Vitro* Bioaccessibility Assay for Arsenic and Lead in Soil and Applications of Relative Bioavailability Data in Human Health Risk Assessment

January 4, 2021

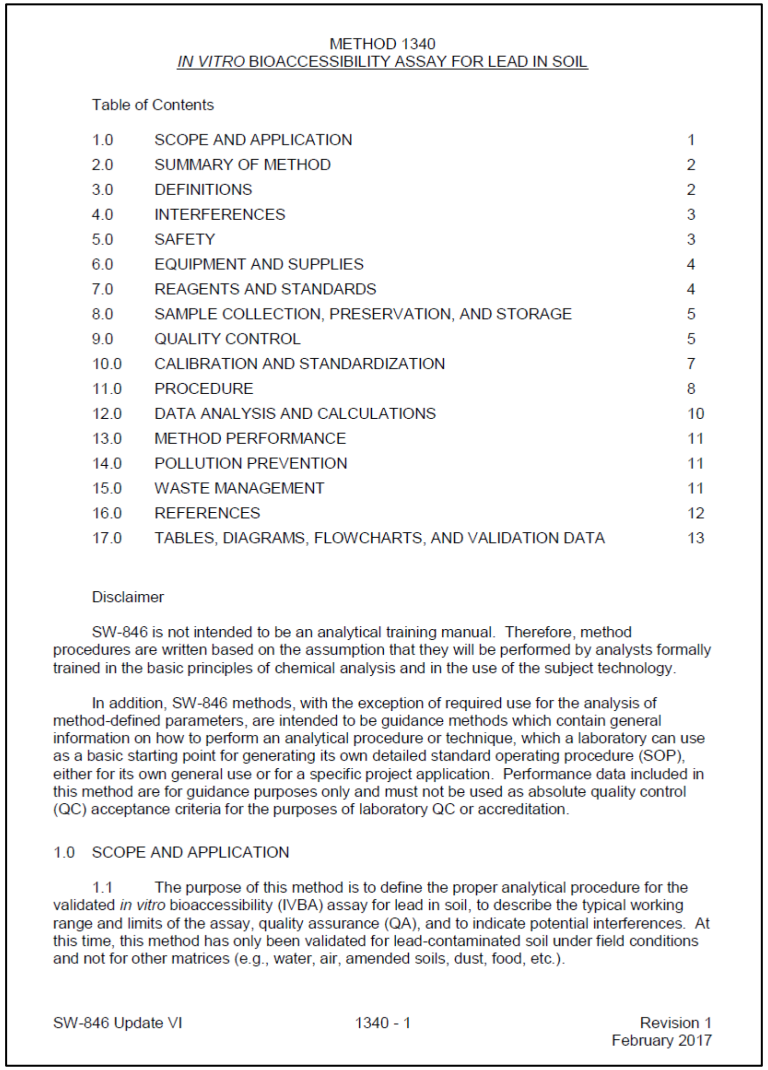
(EPA 2021)

FIGURE 1

EXAMPLE OF AN *IN VITRO* BIOACCESSIBILITY EXTRACTION APPARATUS WITH WATER BATH



(EPA 2017)



METHOD 1340
IN VITRO BIOACCESSIBILITY ASSAY FOR LEAD IN SOIL

Table of Contents

Disclaimer

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts formally trained in the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique, which a laboratory can use as a basic starting point for generating its own detailed standard operating procedure (SOP), either for its own general use or for a specific project application. Performance data included in this method are for guidance purposes only and must not be used as absolute quality control (QC) acceptance criteria for the purposes of laboratory QC or accreditation.

1.0 SCOPE AND APPLICATION

1.1 The purpose of this method is to define the proper analytical procedure for the validated *in vitro* bioaccessibility (IVBA) assay for lead in soil, to describe the typical working range and limits of the assay, quality assurance (QA), and to indicate potential interferences. At this time, this method has only been validated for lead-contaminated soil under field conditions and not for other matrices (e.g., water, air, amended soils, dust, food, etc.).

SW-846 Update VI 1340 - 1 Revision 1
February 2017

(EPA 2017)

Presentation Overview

- Introduction
- Lead Risk Assessment Primer
- EPA 2024 Updated Residential Soil Lead Guidance
- Case Studies
- Summary/Key Takeaways

Section Overview

- **Case Studies**
  - Westside Lead Site: Atlanta, Georgia
  - Site 78A: Andersen AFB, Guam
  - Sites 21A and 63A: Andersen AFB, Guam

From S. Alexander, J. Jefferies, and B. Martin, 2025. *EPA Updated Residential Soil Lead Policy and Guidance – Case Studies*. Georgia Environmental Conference, Aug. 22, 2024.

From A. Miyamoto, 2025. *Case Studies of Managing Changing Lead RSLs*, Navy 2025 Environmental Restoration Conference, Feb. 2025.

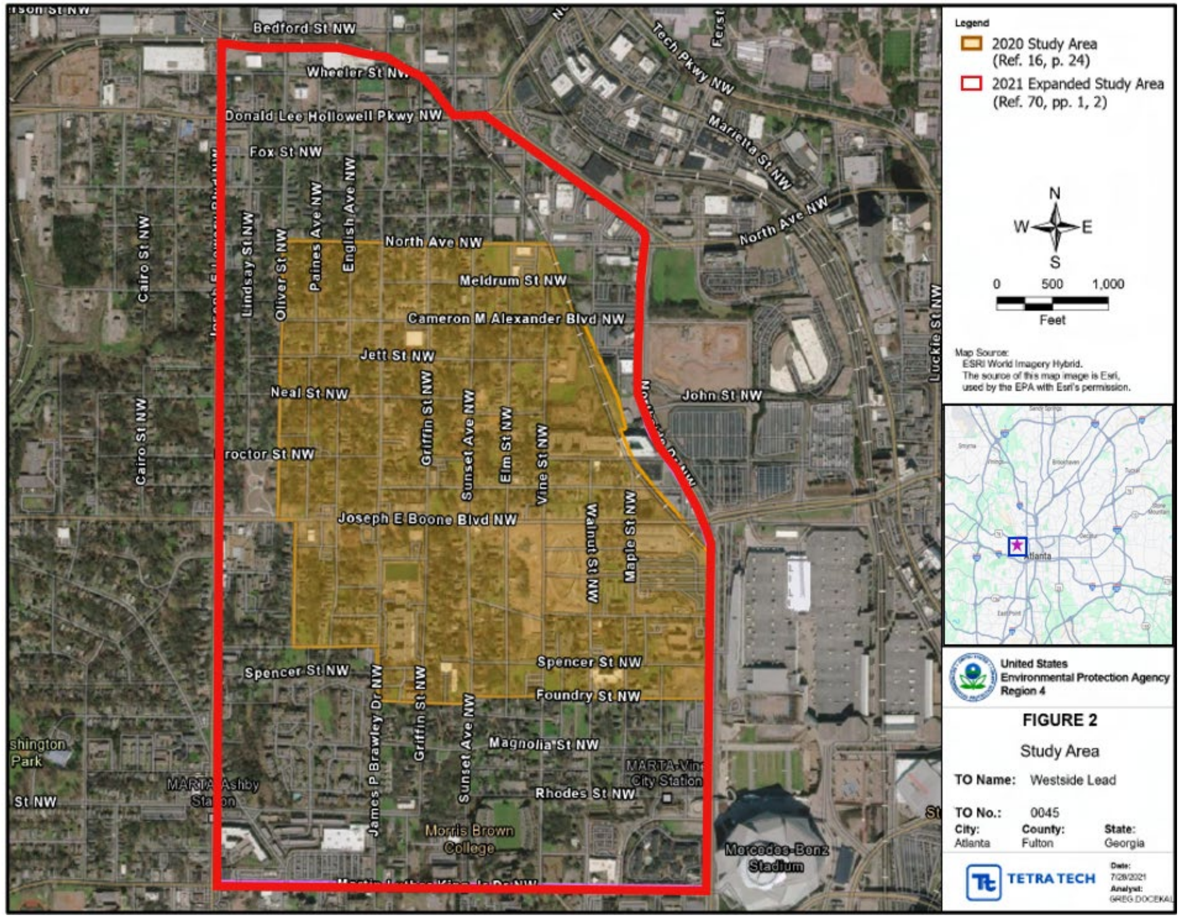
AFB: Air Force Base

Case Study 1
Westside Lead Site: Atlanta, Georgia

- Emory University grad student studying lead in urban gardens found slag in a west Atlanta neighborhoods
- Historically, many foundries operated in Atlanta
- Slag is suspected of being used as fill during neighborhood development, circa 1900–1940s
- This slag enriched with lead and slightly high in arsenic

Figure 1 - Atlanta's Westside slag can appear as a dark layer of sandy grit just below the soil or as gravelly pieces often described as "lava rocks" or "moon rocks."

(EPA 2024a)



(EPA 2021b)

Case Study 1
Westside Lead Site: Atlanta, Georgia

Project Timeline

Action	Date
NPL Proposed Listing	September 2021
NPL Final Listing	March 2022
RI/FS Report	August 2022
Record of Decision	November 2022
Remedial Design	January 2023
Remedial Action Start	August 2023
Updated Residential Soil Lead Guidance	January 2024
Lead Background Study Work Plan	September 2024
Lead Background Study Implementation	November 2024

FS: feasibility study
NPL: National Priorities List
RI: remedial investigation

(Alexander et al. 2025)

Case Study 1
Westside Lead Site: Atlanta, Georgia

Westside Lead Status Update
As of April 10, 2025

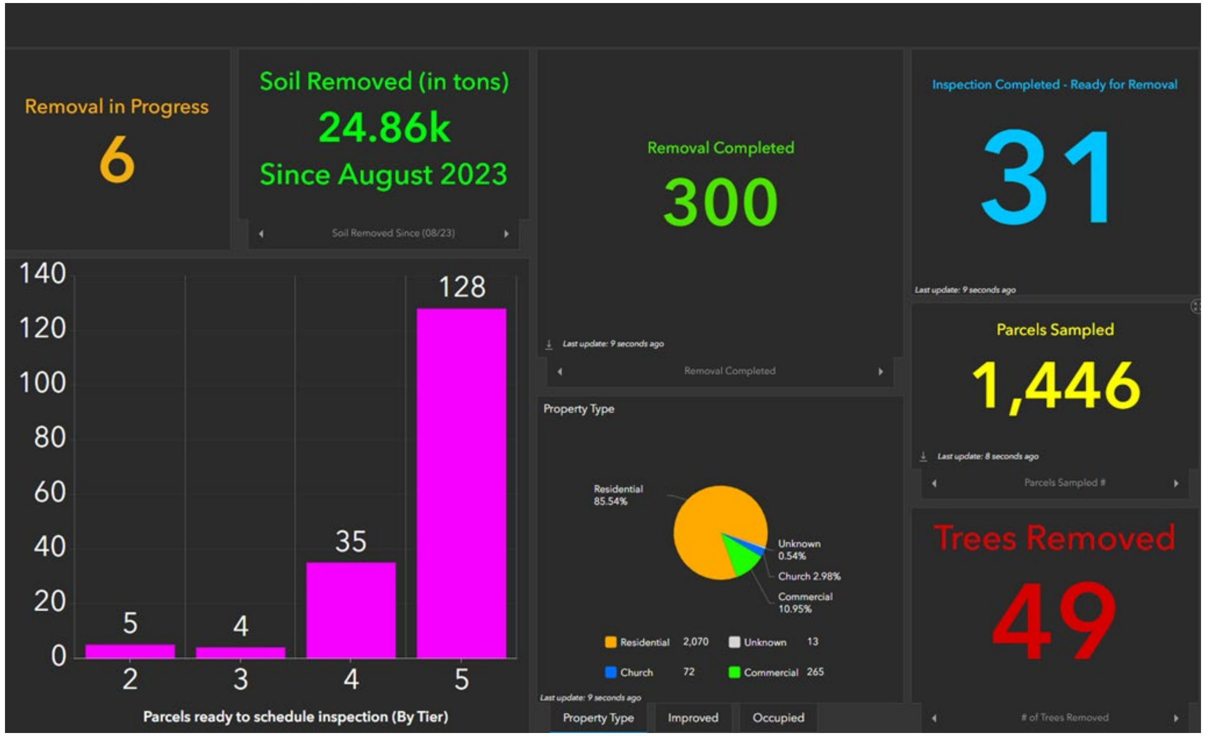
Sampling Metrics

- Total Properties (estimated): 2,097
- Access Granted: 1,680
- Properties Sampled: 1,624
- Properties Requiring Remediation (>400 ppm): 606

Remediation Metrics

- Properties Completed: 300
- Properties Remaining: 254
- Properties in Progress: 10
- Nonhazardous Soil Removed (Tons): 89,130

Westside Lead Site: Removal Statistics Dashboard



(Alexander et al. 2025)

Case Study 1
Westside Lead Site: Atlanta, Georgia

Updated Residential Lead Guidance Implications

- Assuming a Cleanup Level of 200 ppm, ~71% of parcels sampled will require remediation
    - An additional ~828 parcels will need to be addressed (total 1,500 parcels in OU-1)
    - ~$100,000,000 remedial cost estimate
    - Establishing a new site-specific cleanup level
    - Background study
    - Other lead sources evaluation
    - Amended/new decision document development (ESD with comments or AROD)

(Google Earth 2024)

AROD: administrative record of decision   ESD: explanation of significant differences   OU: operable unit

Case Study 2
Marine Corps Base Camp Blaz, Guam (Pre-ROD)

- RI/FS completed in 2014
  - Draft ROD selected UU/UE remedy
- Conducted Removal Action based on a tentative agreement from EPA to sign ROD
- Removal action completed in 2016
- New EPA PM disagreed with IEUBK model inputs and lead remedial goal (551 mg/kg)

Four Categories of AOC Lead Identified
1. Soil removed, confirmed lead conc. <400 ppm
2. Soil removed, no confirmation results for lead
3. No removal, AOC average lead conc. <400 ppm
4. No removal, AOC average lead conc. >400 ppm

- Insufficient data to define LUC boundaries to 400 ppm

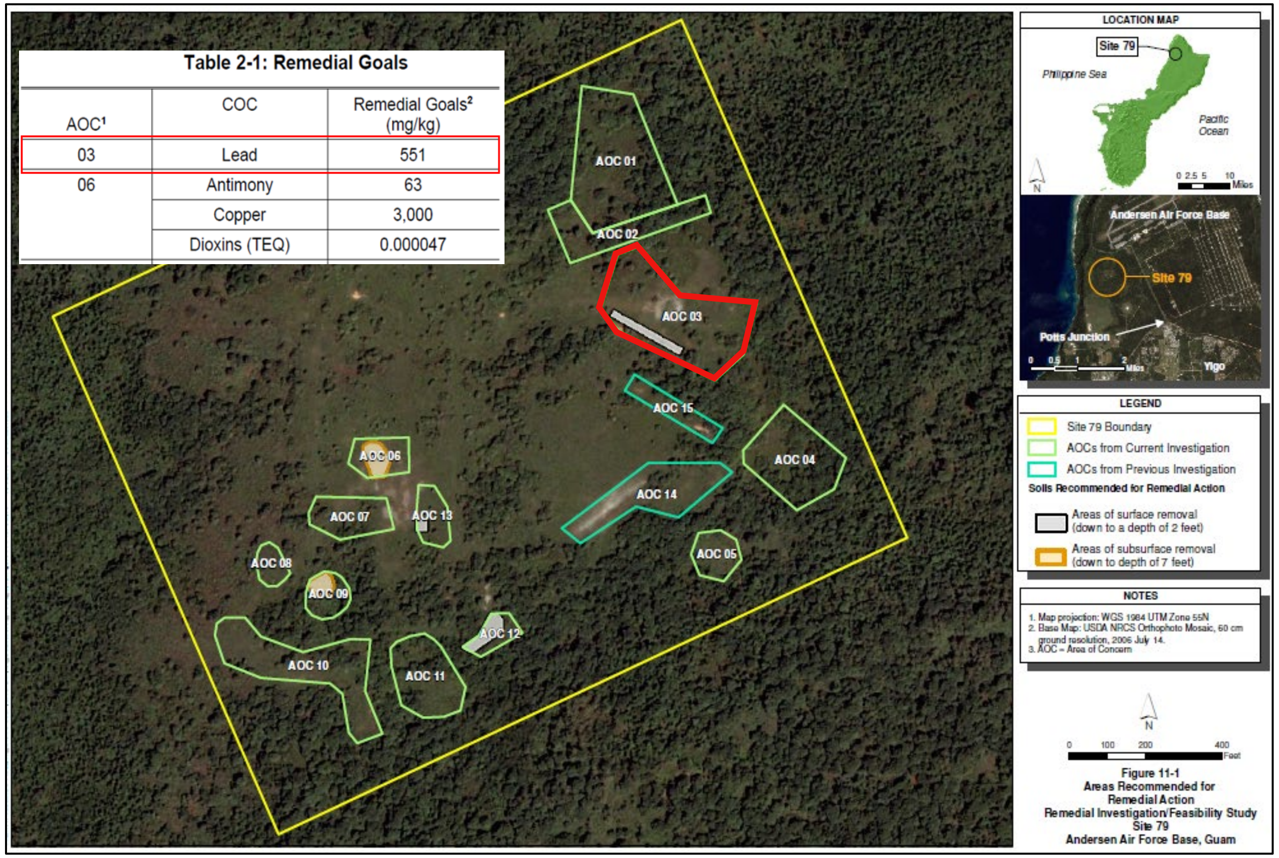


Table 2-1: Remedial Goals

AOC[1]	COC	Remedial Goals[2] (mg/kg)
03	Lead	551
06	Antimony	63
	Copper	3,000
	Dioxins (TEQ)	0.000047

NOTES
1. Map projection: WGS 1984 UTM Zone 55N
2. Base Map: USDA NRCS Orthophoto Mosaic, 60 cm ground resolution, 2006 July 14.
3. AOC = Area of Concern

Figure 11-1
Areas Recommended for Remedial Action
Remedial Investigation/Feasibility Study
Site 79
Andersen Air Force Base, Guam

(AECOM 2014)

AOC: area of concern UU/UE: unlimited use/unrestricted exposure PM: project manager

Case Study 2
Marine Corps Base Camp Blaz, Guam (Pre-ROD)

- Because more assessment work was needed, project team elected to delineate to 200 ppm to evaluate effects of screening level change
  - XRF was used to assist with selecting locations of samples sent to fixed-base lab
- Possible Outcomes
  - AOC with average concentration <200 ppm
  - AOC with average concentration >200 ppm but <400 ppm
  - AOC with average concentration >400 ppm

Most difficult scenario

XRF: x-ray fluorescence

- Possible Problems
  - EPA Position 1: Point value of lead needs to be addressed, regardless of AOC average
  - EPA Position 2: Need to clean up to average concentration ≤200 ppm
- Potential Resolutions
  - Educate regulator
  - Agree to disagree? (consider involving risk assessor and/or legal)
  - Potentially consider cleaning up to <400 ppm based on site-specific conditions (**NEED HEADQUARTERS APPROVAL**)

Case Study 3
Andersen AFB Sites 21A and 63A (Post-ROD)

- RODs finalized in 2009 (21A) and 2011 (63A)
  - Both selected UU/UE remedy
  - Due to various delays, remedial action did not commence until 2023
- Remedial Action Work Plan stage
  - EPA disagreed with remediation goals, which were based on a BLL of 10 µg/dL
  - EPA PM identified point concentrations >400 ppm

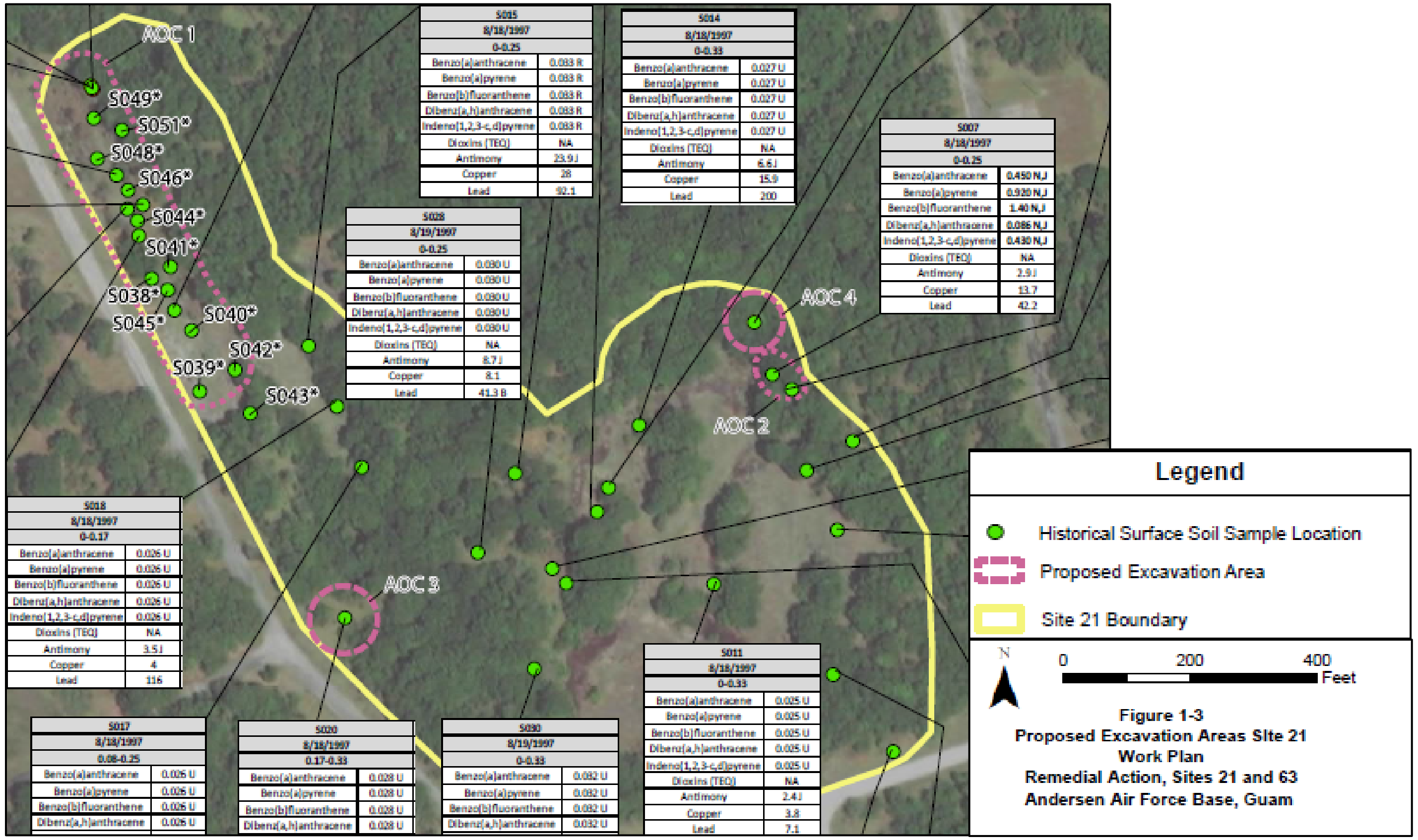
(Google Maps 2025)

(AECOM 2011)

Case Study 3
Andersen AFB Sites 21A and 63A (Post-ROD)

Site 21A

- **Headquarters approved** cleanup to 200 ppm
- Due to MEC regulation, could not complete remedial action
  - In remediated areas, used XRF to delineate to either PRG (200 mg/kg) or background (166 mg/kg)



S015	
8/18/1997	
0-0.25	
Benzo(a)anthracene	0.083 R
Benzo(a)pyrene	0.083 R
Benzo(b)fluoranthene	0.083 R
Dibenz(a,h)anthracene	0.083 R
Indeno(1,2,3-c,d)pyrene	0.083 R
Dioxins (TEQ)	NA
Antimony	23.9 J
Copper	28
Lead	92.1

S014	
8/18/1997	
0-0.33	
Benzo(a)anthracene	0.027 U
Benzo(a)pyrene	0.027 U
Benzo(b)fluoranthene	0.027 U
Dibenz(a,h)anthracene	0.027 U
Indeno(1,2,3-c,d)pyrene	0.027 U
Dioxins (TEQ)	NA
Antimony	6.6 J
Copper	15.9
Lead	200

S007	
8/18/1997	
0-0.25	
Benzo(a)anthracene	0.450 N,J
Benzo(a)pyrene	0.920 N,J
Benzo(b)fluoranthene	1.40 N,J
Dibenz(a,h)anthracene	0.086 N,J
Indeno(1,2,3-c,d)pyrene	0.430 N,J
Dioxins (TEQ)	NA
Antimony	2.9 J
Copper	13.7
Lead	42.2

S028	
8/19/1997	
0-0.25	
Benzo(a)anthracene	0.030 U
Benzo(a)pyrene	0.030 U
Benzo(b)fluoranthene	0.030 U
Dibenz(a,h)anthracene	0.030 U
Indeno(1,2,3-c,d)pyrene	0.030 U
Dioxins (TEQ)	NA
Antimony	8.7 J
Copper	8.1
Lead	41.3 B

S018	
8/18/1997	
0-0.17	
Benzo(a)anthracene	0.026 U
Benzo(a)pyrene	0.026 U
Benzo(b)fluoranthene	0.026 U
Dibenz(a,h)anthracene	0.026 U
Indeno(1,2,3-c,d)pyrene	0.026 U
Dioxins (TEQ)	NA
Antimony	3.5 J
Copper	4
Lead	116

S017	
8/18/1997	
0.08-0.25	
Benzo(a)anthracene	0.026 U
Benzo(a)pyrene	0.026 U
Benzo(b)fluoranthene	0.026 U
Dibenz(a,h)anthracene	0.026 U

S020	
8/18/1997	
0.17-0.33	
Benzo(a)anthracene	0.028 U
Benzo(a)pyrene	0.028 U
Benzo(b)fluoranthene	0.028 U
Dibenz(a,h)anthracene	0.028 U

S030	
8/19/1997	
0-0.33	
Benzo(a)anthracene	0.032 U
Benzo(a)pyrene	0.032 U
Benzo(b)fluoranthene	0.032 U
Dibenz(a,h)anthracene	0.032 U

S011	
8/18/1997	
0-0.33	
Benzo(a)anthracene	0.025 U
Benzo(a)pyrene	0.025 U
Benzo(b)fluoranthene	0.025 U
Dibenz(a,h)anthracene	0.025 U
Indeno(1,2,3-c,d)pyrene	0.025 U
Dioxins (TEQ)	NA
Antimony	2.4 J
Copper	3.8
Lead	7.1

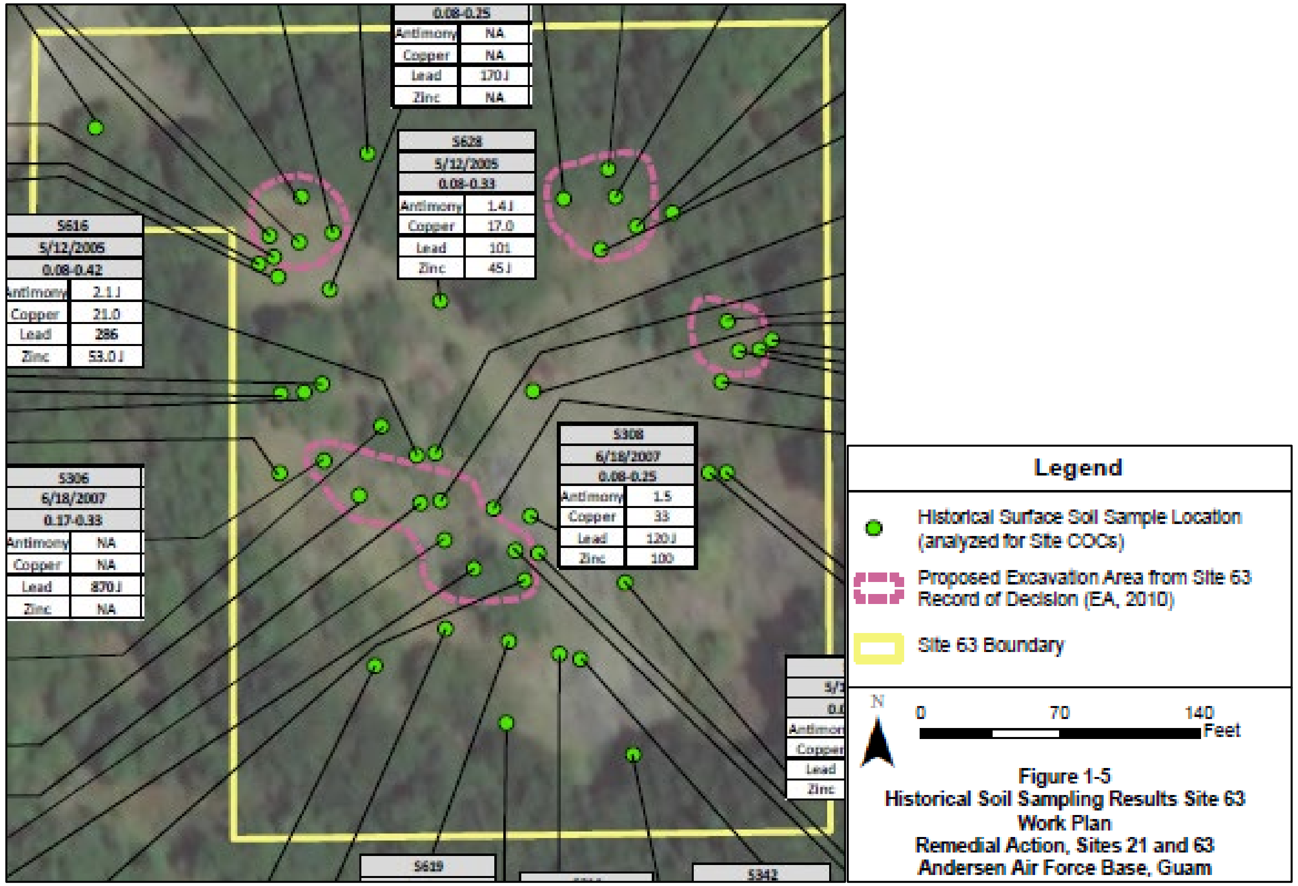
(Modified from Cape Environmental Management 2023a)

MEC: munitions and explosives of concern

Case Study 3
Andersen AFB Sites 21A and 63A (Post-ROD)

Site 63A

- **Headquarters approved** evaluation of cleanup to 200 ppm
- RI data were insufficient to develop robust cost estimate for cleanup to 200 ppm
- Conducted additional delineation/confirmation sampling (XRF)



(Modified from Cape Environmental Management 2023a)

Case Study 3
Andersen AFB Sites 21A and 63A (Post-ROD)

Site 63A

- Successfully delineated to 200 ppm
- Additional cost for cleanup to 200 ppm was deemed acceptable
- With **Headquarters approval**, will proceed with cleanup to 200 ppm

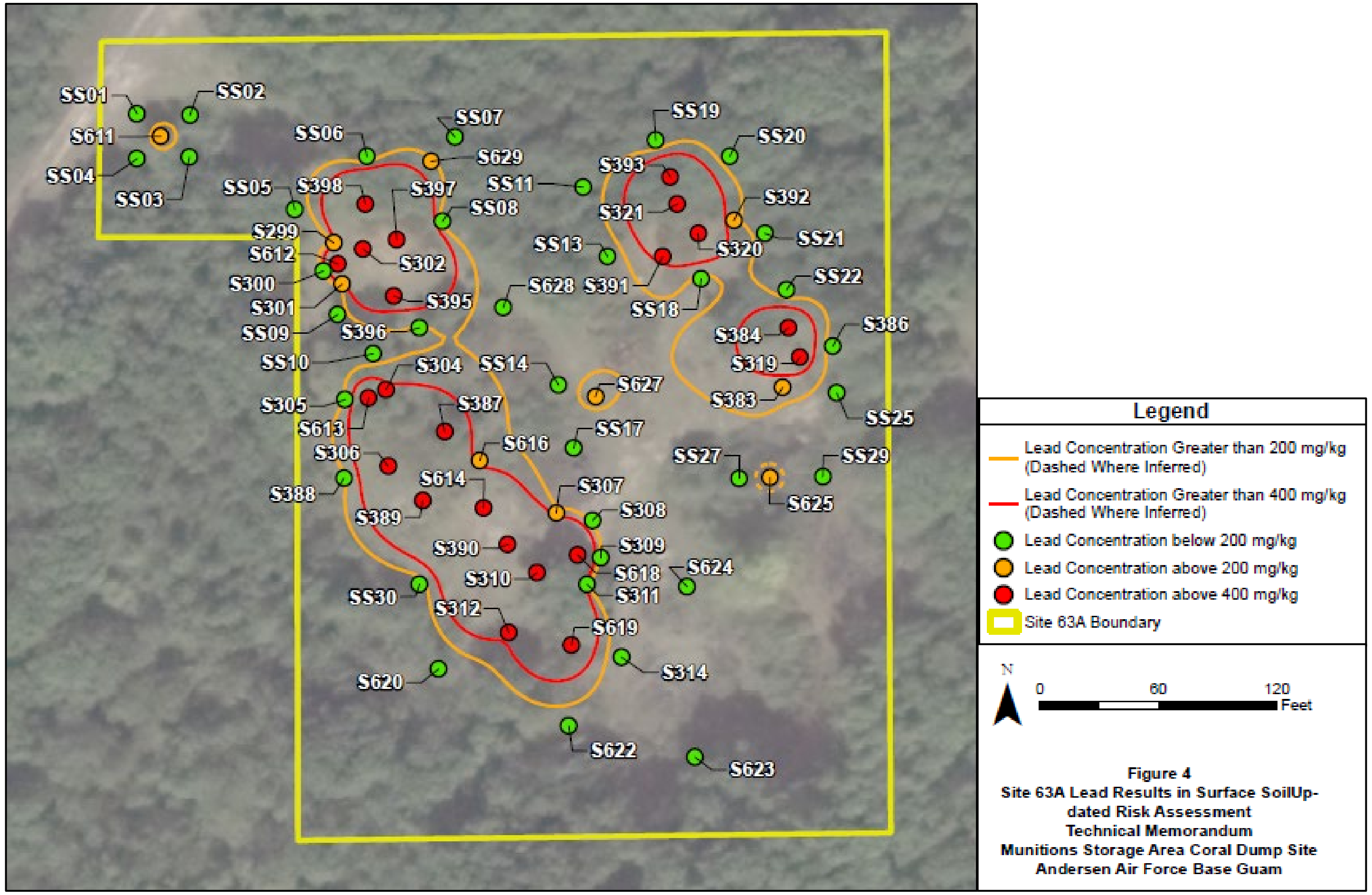


Figure 4
Site 63A Lead Results in Surface SoilUp-dated Risk Assessment
Technical Memorandum
Munitions Storage Area Coral Dump Site
Andersen Air Force Base Guam

(Modified from Cape Environmental Management 2023b)

Presentation Overview

- Introduction
- Lead Risk Assessment Primer
- EPA 2024 Updated Residential Soil Lead Guidance
- Case Studies
- Summary/Key Takeaways

Summary/Key Takeaways

- Lead risk assessment is unique
- EPA 2024 Updated Residential Soil Lead Guidance substantially lowers default screening levels for lead in soil
  - Based on lower BLL target: 10 μg/dL → 5 μg/dL

    400 ppm → 200 ppm
- Use of lower BLL targets in calculation of cleanup levels could increase cost to achieve closure
- Developing site-specific background levels may be more important at some sites

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Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Questions

Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Preliminary Assessment and Site Inspection (PA/SI) Process for Sites with General Radioactive Material (G-RAM)

Rion Marcinko, Certified Health Physicist (CHP)
Jacobs

RITS 2025

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Information in this presentation is current as of May 22, 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Rion Marcinko
CHP, RRPT
Health Physicist
Jacobs

Navy: Department of the Navy

- Bachelor of Science, Nuclear Energy Engineering Technology, Thomas Edison State College, Trenton, NJ
- Master of Science, Radiological Health Sciences Colorado State University, Fort Collins, CO
- CHP with over 12 years of experience in environmental assessment and remediation, licensing and regulatory requirements, decommissioning, shielding design, and operation and maintenance of military and civilian nuclear reactors
- Community of practice lead for the Jacobs Radiation Services group
- Former enlisted Navy “nuke” (Nuclear Propulsion Program), served on board the USS Kentucky, SSBN-737 in Silverdale (Bangor), WA

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Section Overview

- Introduction
  - Previous RITS Presentations
  - Purpose
  - Applicability
  - Radiation 101
  - General Radioactive Material
  - Brief History of Radioactive Material and Regulators
  - Regulatory Authority and Responsibility

Previous RITS Presentations

2014	Rad 101: Everything you have been Curie-ous about…
2015	Multi-Agency Radiological Survey and Site Investigation Manual

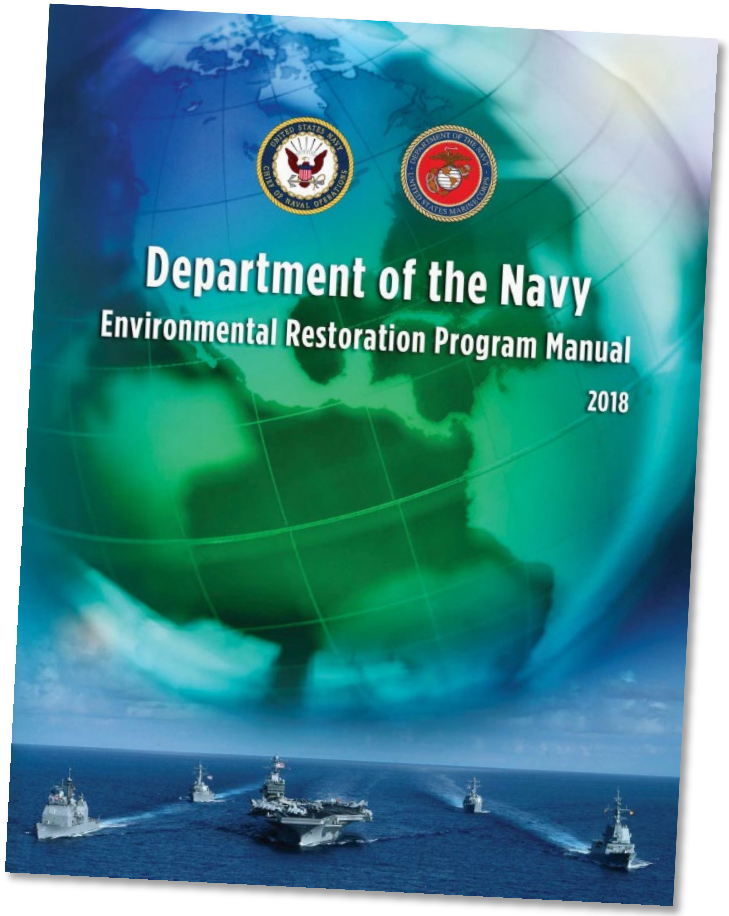
Purpose

- This presentation introduces G-RAM, its evaluation, and methodologies for investigation in the environment
- PA/SIs are commonplace for many COCs; however, G-RAM is a contaminant that presents unique challenges for investigation
- RPMs may be unfamiliar with G-RAM terminology and processes to evaluate environmental media
- Recently developed *Framework for Preliminary Assessments and Site Inspections at Radiological Sites* promulgated under EXWC for use by RPMs (Navy 2025)

CLEAN: Comprehensive Long-term Environmental Action—Navy
COC: contaminant of concern
RPM: Remedial Project Manager

Applicability

- Sites and areas identified with a suspicion or confirmed presence of G-RAM must meet eligibility criteria under NERP or ER,N (Navy 2018)
- G-RAM present within buildings are typically not ER,N eligible; however, releases to the environment from buildings (without an active source of contamination) or from foundations or piping remaining following building demolition are eligible

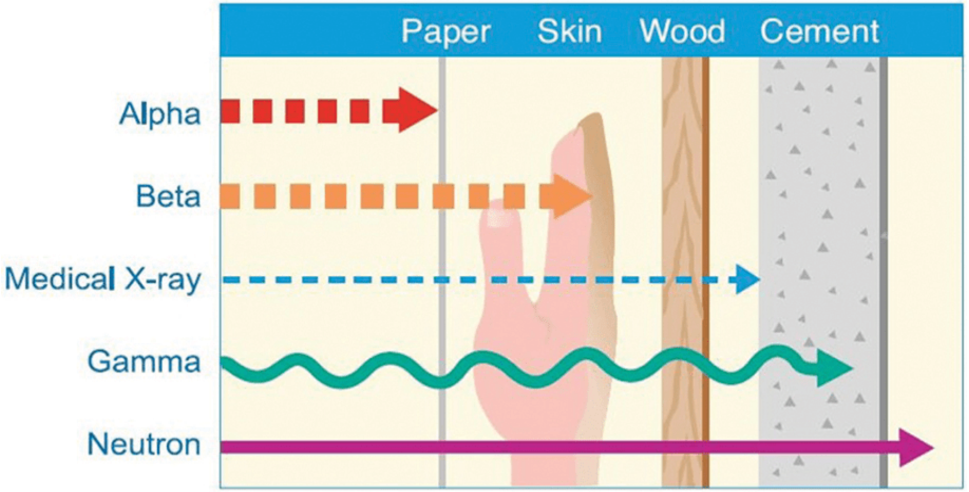


(Navy 2018)

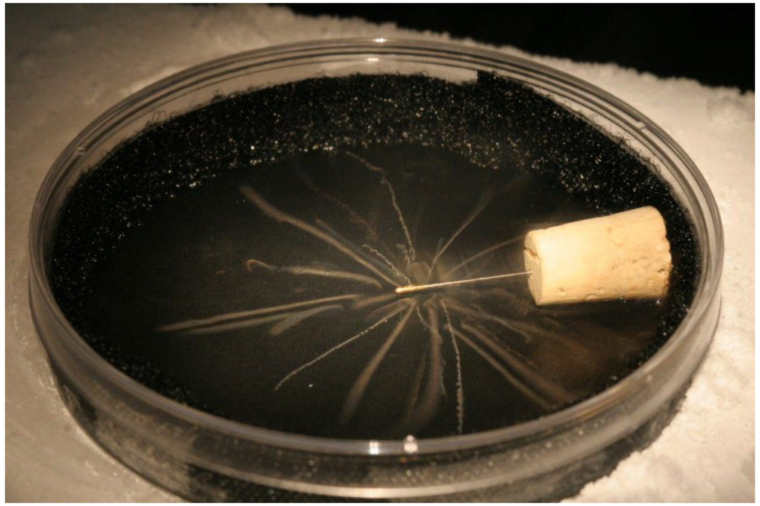
ER,N: Environmental Restoration, Navy
NERP: Navy Environmental Restoration Program

Radiation 101

- Key concept: Difference between *radiation* and *radioactive material*
- Radiation is all around us (cosmic, terrestrial sources)
- Three **primary** radiation types applicable to G-RAM:
  - Alpha (α)
  - Beta (β)
  - Gamma (γ)
- Hazards associated with different radiation types vary (e.g., external versus internal)



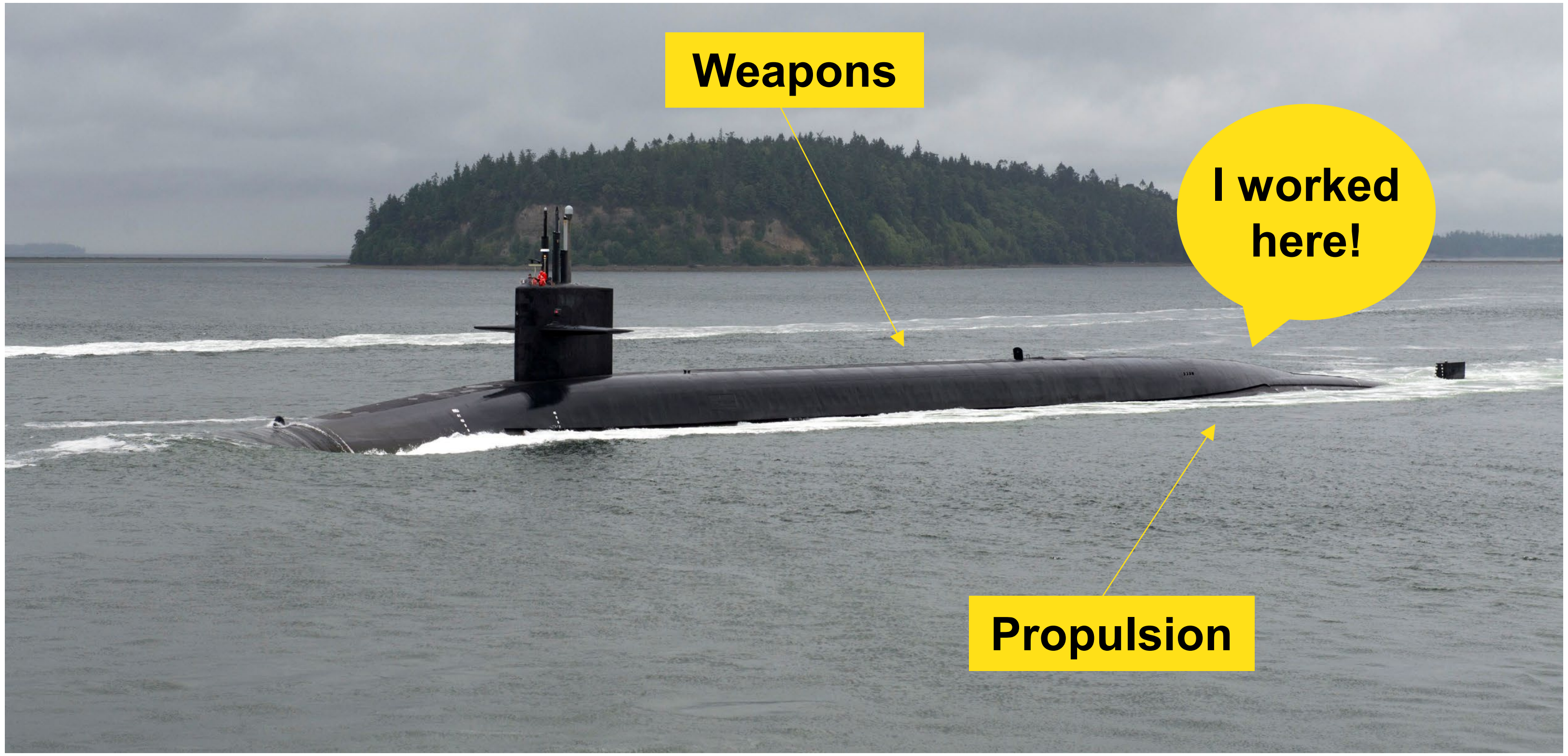
(NRC 2020)



(Jefferson Lab Resources 2025)

General Radioactive Material

*Term that describes Navy radioactive materials **excluding** Naval Nuclear Propulsion Program or Naval Nuclear Weapons Program radioactive materials*



(STRATCOM 2017)

General Radioactive Material

- **Includes**
  - Byproduct, source, and special nuclear materials
  - NORM
  - TENORM
  - NARM

KEY POINT

If radioactive material in question is not related to weapons or nuclear propulsion, it may be considered G-RAM!

Are x-ray machines considered G-RAM?

NARM: Naturally Occurring and Accelerator-produced Radioactive Material
NORM: Naturally Occurring Radioactive Material
TENORM: Technologically Enhanced Naturally Occurring Radioactive Material

Brief History of Radioactive Material and Regulators

- 1914: United States Radium Corporation founded
- 1946: AEA, AEC established
- 1954: AEA Revision (licensing and regulation of civilian use)
- 1963: Navy Bureau of Ships issues Instruction 5100.15, *Control of Contamination from Radioactive Luminescent Materials* (responsibilities eventually assigned to Naval Sea Systems Command)
- 1975: NRC established
- 1980: CERCLA and Superfund Program administered by EPA
- 1987: NRC grants Navy Master Materials License, NRMP established

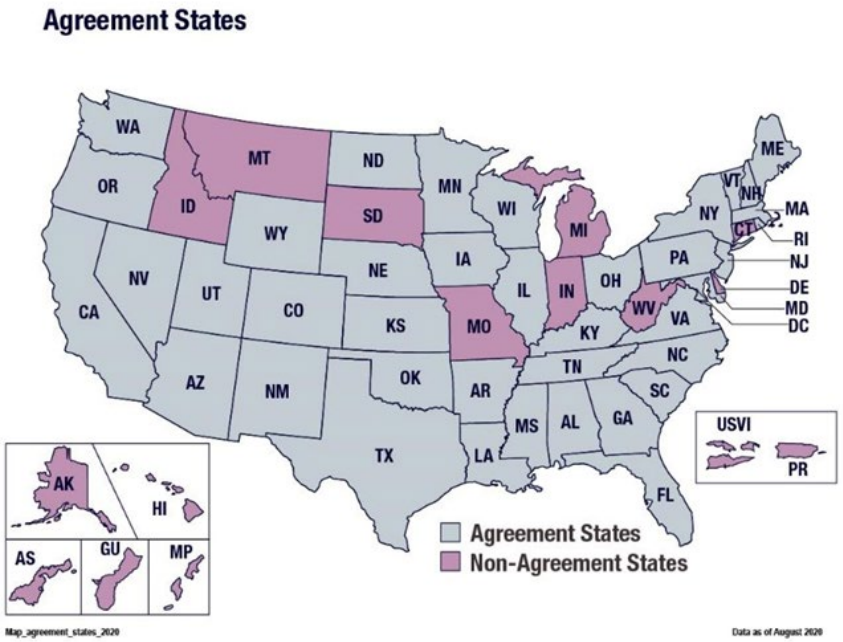
(DOE 1946)

(NRC 2024)

AEA: Atomic Energy Act
AEC: Atomic Energy Commission
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
EPA: United States Environmental Protection Agency
NRC: Nuclear Regulatory Commission
NRMP: Naval Radioactive Materials Permit Program

Regulatory Authority and Responsibility

- Regulatory authority is specific to each Installation and may differ for nearby properties
  (e.g., outlying fields or annexes)
- Installations listed under NPL will include EPA regional regulatory authority
- DoD maintains Memorandum of Understanding with NRC to avoid duplicative regulation and ensure responsibilities satisfied
- Non-NPL sites may include agreements with NRC or state environmental agencies (NRC Agreement States)
  - State may be engaged for NPL sites, too
- Consult your real estate or regulatory specialist for installation specific jurisdiction



(NRC 2020)

NPL: National Priorities List

Regulatory Authority and Responsibility

- The RPM is responsible for overall management and execution of work at DON ERP radiological sites
- RASO is the DON technical authority with cognizance for administering and enforcing G-RAM policies and requirements
- RASO will assign an individual EPM for PA/SI activities
- EPM will coordinate with NAVFAC on technical oversight and discussions with regulators (e.g., EPA, NRC, and State) and the public

(Navy 2020)

KEY POINT

Coordinate with your EPM *early* and *often* during the PA and SI process!

DON: Department of the Navy
EPM: Environmental Protection Manager
RASO: Radiological Affairs Support Office

(Navy 2010)

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Section Overview

- Preliminary Assessment Development
  - Purpose of the Preliminary Assessment
  - Current Navywide Preliminary Assessment Status
  - Historical Radiological Assessments
  - Identifying Sites with General Radioactive Materials
  - Radionuclides of Potential Concern
  - Development of the Conceptual Site Model
  - Example Migration Pathways
  - Initial Site Classification
  - Preliminary Assessment Recommendations
  - Report Preparation

Preliminary Assessment Development

- Historical use of G-RAM through use of commodities, research radionuclides, and other military projects
- Commodities are most common form of G-RAM
  - Examples: Radioluminescent devices such as compasses, deck markers, signs, dials, and gauges; aircraft components such as engine exciters, structural metal alloys, and electronics systems; munitions; weaponry sights; and radar systems
- Many items were unregulated or permitted disposal by burial
- Regulations applicable to low-level radioactive waste were not implemented until early 1980s
- Legacy commodities (or residual radioactive material as the result of their use) may be present in environment

(US Army 2018)

Purpose of the Preliminary Assessment

- The PA team will gather information, evaluate environmental conditions, and provide recommendations to sites that warrant further investigation
- Accomplished through the following steps

1

IDENTIFY SITES WITH G-RAM

(Or potential to contain)

2

DEVELOP CSM

3

ASSIGN PRELIMINARY CLASSIFICATION

4

PREPARE PA REPORT

(Making recommendations)

- Methodology for completing each step is unique for sites with G-RAM

CSM: conceptual site model

(EPA 1991, Navy 2025)

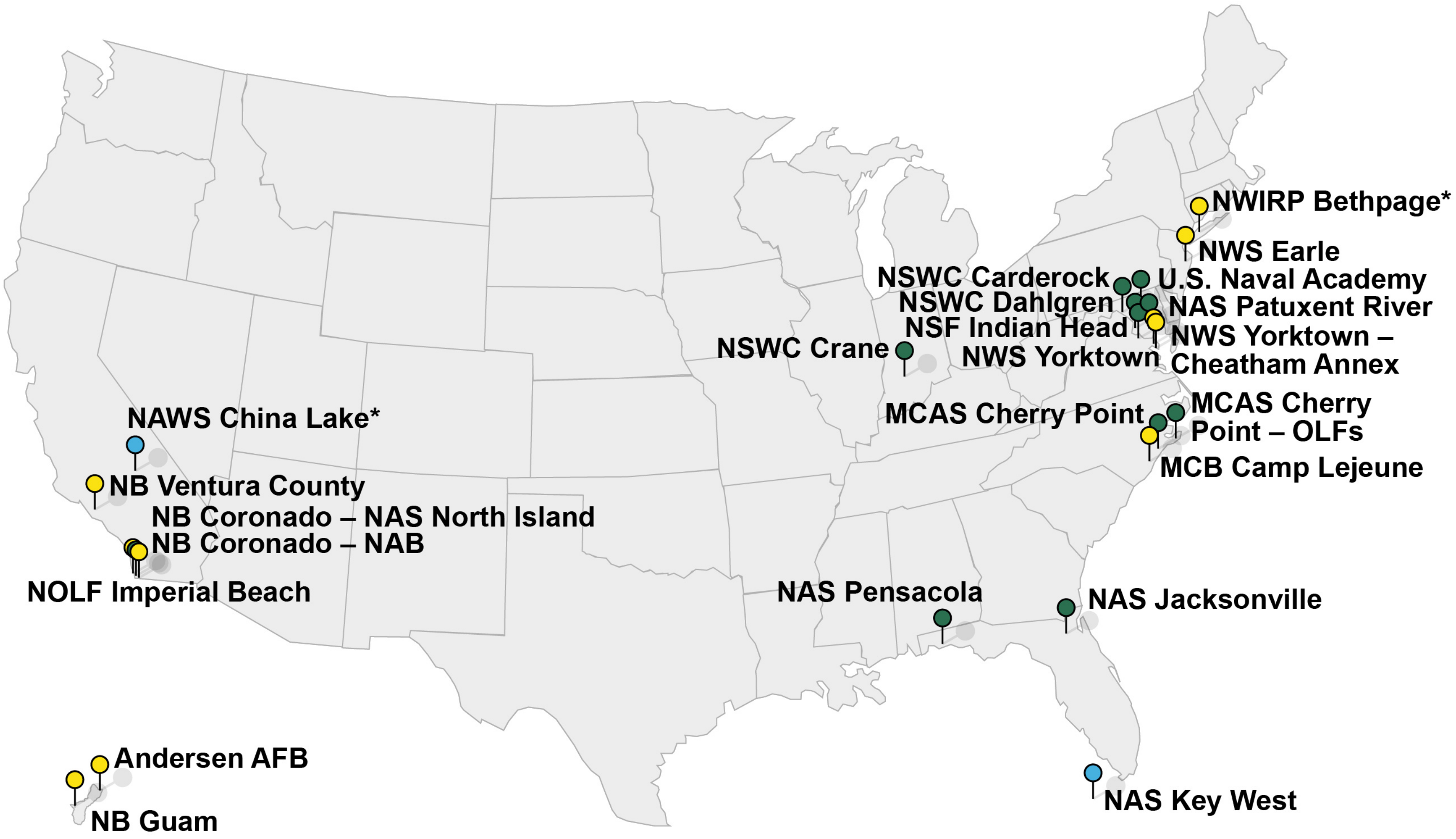
Historical Radiological Assessments

- What is an HRA, and was it completed at my installation?
  - Analog of CERCLA PA
  - Management tool developed by RASO to identify areas with radiological liabilities
  - In fiscal year 2015, RASO initiated series of modern HRAs
    - Shifted execution and support to NAVFAC and established consistency standards
  - Includes areas not ER,N eligible and materials or areas currently managed or regulated under NRMP
  - RPMs participate in performance and review
  - Includes same site classifications as PA
  - **Internal document – not added to administrative record**
  - <u>Should not reference HRA directly in PA</u>

HRA: Historical Radiological Assessment

(Navy 2022)

Current Navywide PA Status



LEGEND

🟡 In progress

🟢 Complete

🔵 Planned

* No HRA

AFB: Air Force Base
MCAS: Marine Corps Air Station
MCB: Marine Corps Base
NAB: Naval Amphibious Base
NAS: Naval Air Station
NAWS: Naval Air Weapons Station
NB: Naval Base
NOLF: Naval Outlying Landing Field
NSF: Naval Support Facility
NSWC: Naval Surface Warfare Center
NWIRP: Naval Weapons Industrial Reserve Plant
NWS: Naval Weapons Station

(Navy 2025)

Historical Radiological Assessments

Locations where modern HRA was completed

Installation	Year HRA Completed	Installation	Year HRA Completed
NAS Jacksonville	2016	NAS Key West	2020
NAS Pensacola	2016	Joint Region Marianas – Navy Base Guam	2021
NOLF Imperial Beach	2016	Joint Region Marianas – Andersen Air Force Base	2021
NRL Washington DC	2016	NAS Patuxent River	2020
NB Coronado; NAS North Island, NAB Silver Stand Training Complex	2019	MCAS Cherry Point	2021
NSA Crane	2018	NWS Earle	2022
NSWC Carderock	2018	NWS Yorktown	2022
NSF Dahlgren	2018	MCB Camp Lejeune	2023
US Naval Academy	2020	NB Ventura County	2018
NSF Indian Head	2018	NPGS, Monterey, CA	2017

(Navy 2022)

Identifying Sites with G-RAM

- If HRA is available, use information applicable to ER,N-eligible sites
  - Should not reference HRA directly
  - Download and review, applicable HRA references
- If HRA is not available
  - Compile comprehensive list of ER,N-eligible areas
  - Determine which sites have potential for G-RAM
- Conduct historical research
  - Desktop review
  - Site visit
  - Interviews
- Determine potential for G-RAM release to environment

(National Archives and Records Administration 2019)

(Navy 2025)

Identifying Sites with G-RAM

- Examples of sites with potential for G-RAM
  - Disposal sites (e.g., dumps, borrow pits, burn pits, and landfills)
  - DRMOs
  - Storage yards
  - Demolished aircraft hangars and aircraft rework shops
  - Aircraft boneyards
  - Aircraft crash sites
  - Former firefighting training areas where derelict aircraft were used for fire training exercises
  - Former ranges with use of aircraft, vehicle, or tank targets
  - Former radium paint shops (and surrounding areas)

(University of Guam 2017)

DRMO: Defense Reutilization and Marketing Office

(Navy 2025)

Radionuclides of Potential Concern

Radionuclide	Principal Radiation	Half-Life (years)	Common Uses
Cs-137	Beta	30	• Aircraft components (exciters: exciter boxes, engine exciters, and exciter assemblies) • Commodities
Ra-226	Alpha	1660	• Aircraft components (circuit breakers, numerous assorted gauges, and switches) • Radioluminescent devices (radioluminescent paint) • Commodities • Combat vehicle components (numerous assorted dials and switches) • Ground control approach radar units
Sr-90	Beta	29	• Aircraft components • Commodities
Th-232	Alpha	1.4×10^{10}	• Aircraft components (engine inlet frames, engine gear cases, gun sights, control pedals, and magnesium-Th coated structural pieces) • Thoriated glass optics (night vision lenses) • Commodities
U-238	Alpha	4.5×10^{9}	• DU ammunition • Aircraft components (DU counterweights)

What about gamma radiation?

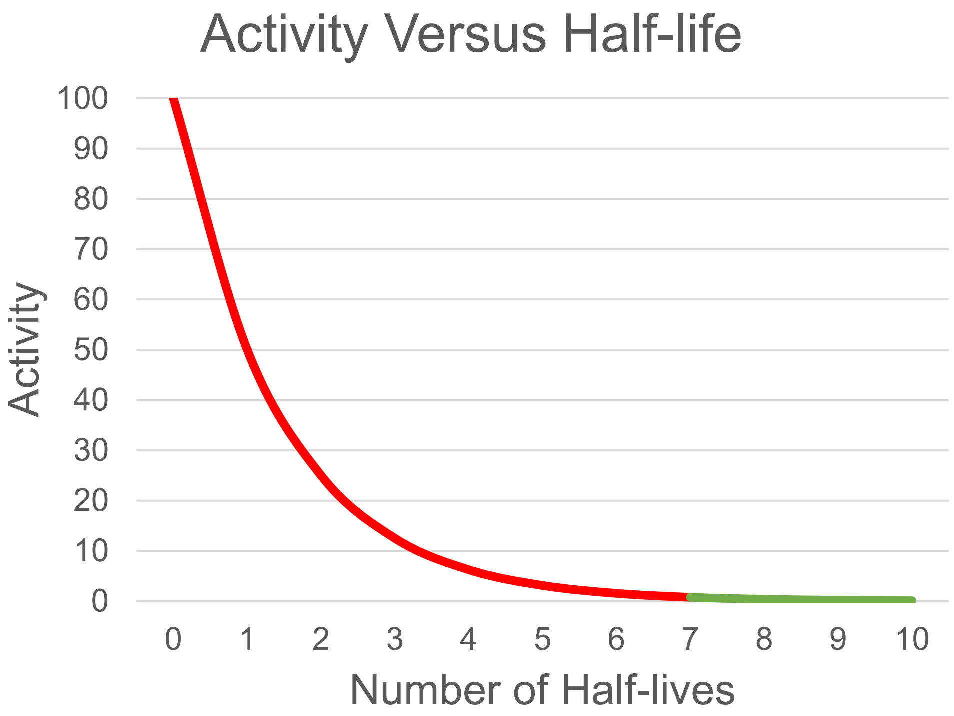
CS: cesium
DU: depleted uranium
Ra: radium

Sr: strontium
Th: thorium
U: uranium

(Navy 2025)

Radionuclides of Potential Concern

- What radionuclides are not typically added to our ROPC list, and why
    - Co-60
    - Pm-147
    - Tl-204
    - H-3 (tritium)
- Commercially regulated commodities may not be included as ROPCs
    - Th-232 in thoriated welding electrodes
    - U-238 in coal fly and bottom ash



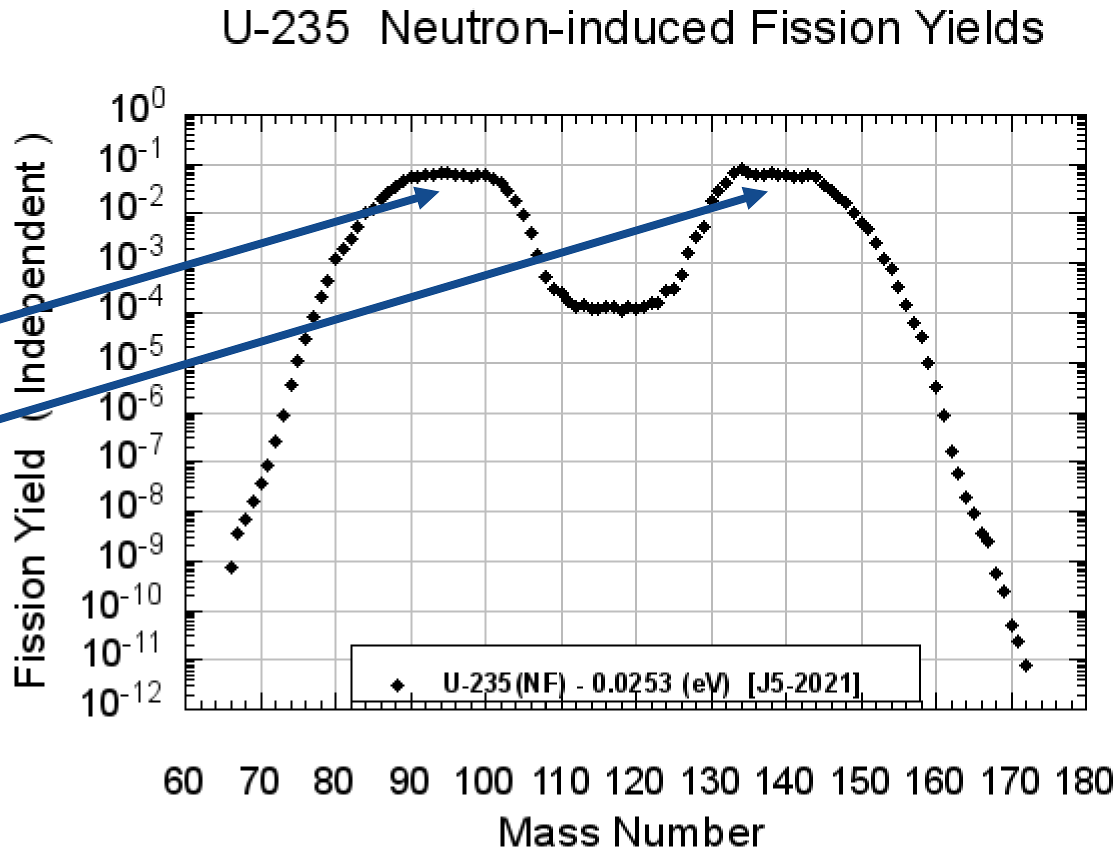
Co: cobalt
H: hydrogen
Pm: promethium
ROPC: Radionuclide of Potential Concern
Tl: thallium

KEY POINT

ROPCs do not pose a significant risk after decaying beyond 7-10 half-lives

Radionuclides of Potential Concern

- ROPCs present in background
  - U-238 (natural)
  - Ra-226 (natural)
  - Th-232 (natural)
  - Sr-90 (anthropogenic)
  - Cs-137 (anthropogenic)

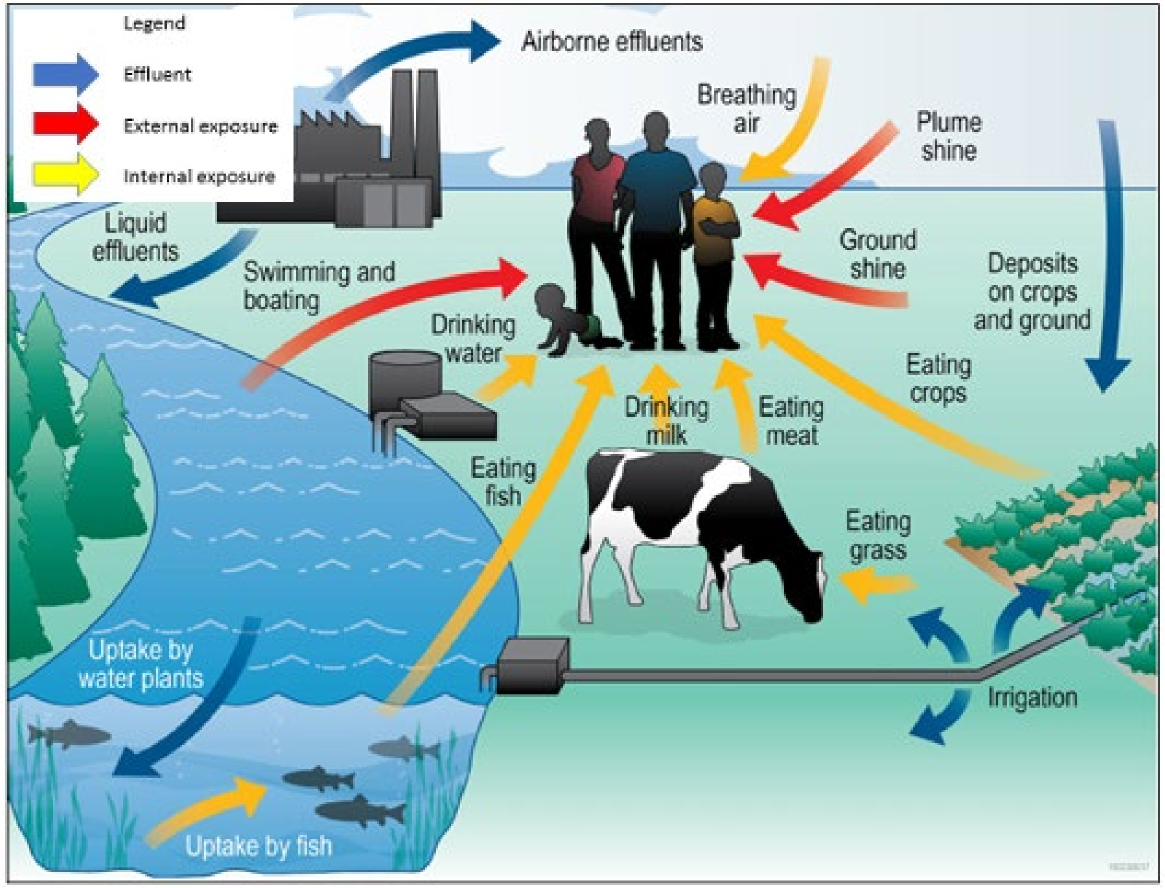


(Japan Atomic Energy Agency 2023)

(Oak Ridge Associated Universities 2025)

Development of Conceptual Site Model

- Common CSM elements
  - Site operational and investigation history
  - Site-specific geology and hydrology
  - Current site status
  - Historical radiological investigations
  - Potential or former historical radiological use and ROPCs
  - Identifying migration pathways and receptors
- How does CSM vary for sites with potential for G-RAM?

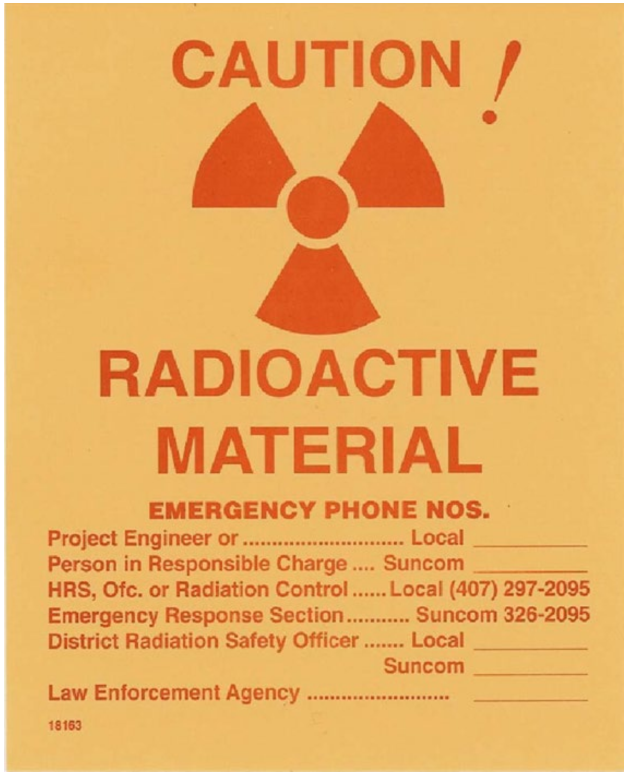


(Savannah River National Laboratory 2021)

(Navy 2025)

Example Migration Pathways

Media with G-RAM	Potential Migration Pathways
Debris on ground surface (e.g., disposal sites or crash sites)	• Surface soil • Subsurface soil (localized) • Surface water and sediment
Ash on ground surface (e.g., burn pits or crash sites)	• Surface soil • Subsurface soil (localized) • Surface water and sediment • Air (fugitive dust)
Buried debris (e.g., trench disposal sites and landfills)	• Subsurface soil • Groundwater (shallow leaching through infiltration)
Liquid G-RAM disposed onto ground surface (e.g., radium paint shop)	• Surface soil • Subsurface soil • Groundwater • Surface water and sediment



CAUTION !

RADIOACTIVE MATERIAL

EMERGENCY PHONE NOS.

Project Engineer or .... Local ________
Person in Responsible Charge .... Suncom ________
HRS, Ofc. or Radiation Control ...... Local (407) 297-2095
Emergency Response Section .... Suncom 326-2095
District Radiation Safety Officer .... Local ________
Suncom ________
Law Enforcement Agency .... ________
18163

(Florida Department of Transportation 2008)

(Navy 2025)

Initial Site Classification

- Four site classifications are provided in HRA, based on MARSSIM and Navy definitions
  - Note: These classifications may dictate level of effort required in SI phase and should be carefully selected and agreed upon by all stakeholders

1. **Non-Impacted**
2. **Impacted**
3. **AOI**
4. **Previously Impacted**

Can a site classification change from HRA to PA?

AOI: Area of Interest
MARSSIM: Multi-Agency Radiation Survey and Site Investigation Manual

(Navy 2025)

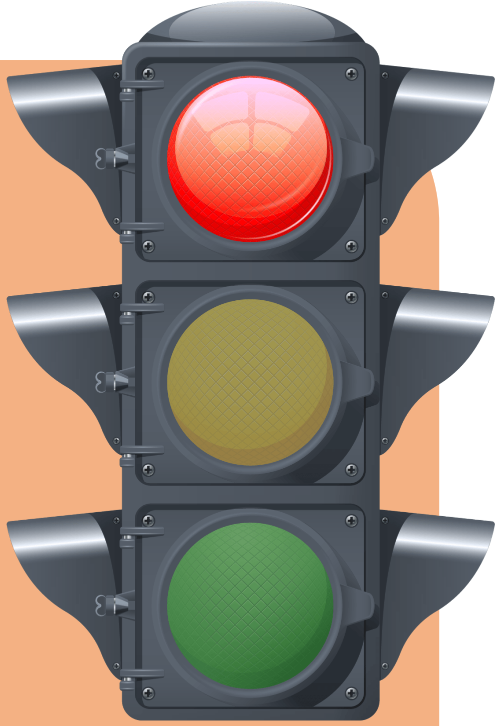
Initial Site Classification

1. Non-Impacted: “Sites with **no reasonable possibility** or an **extremely low probability** for residual radioactive material based on area history, process knowledge, or survey information are determined to be non-impacted. They are identified through historical knowledge or previous survey information as areas where there is no reasonable possibility or extremely low probability for residual radioactive contamination.”

- Should later information identify radiological operations associated with a non-impacted area, the area can be reclassified as impacted
- Discovery of minimal radioactivity attributable to anthropogenic background radiation is not, in itself, cause for designation of an area as impacted

(Navy 2025)

Initial Site Classification



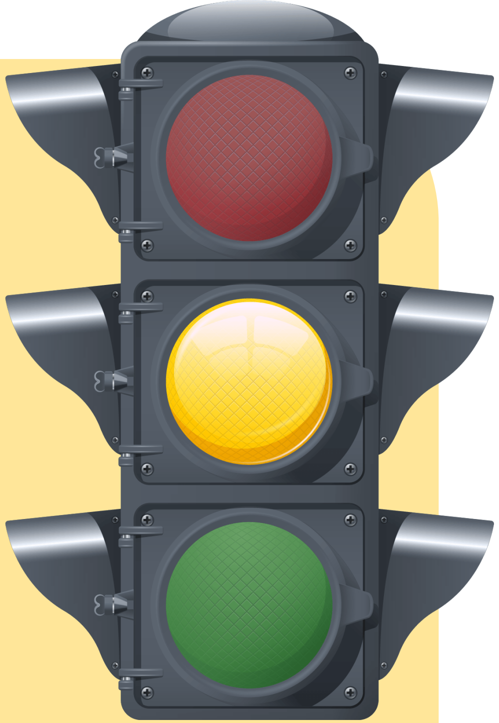
2. Impacted: "Site is either **known** to contain residual radioactive material based on radiological surveys or other documented evidence **or suspected with a high probability** to contain residual radioactive material based on historical information."

Evidence of an impacted area includes waste disposal areas likely to have received waste from a radioactive materials area, documented contamination or remediation, historically posted radioactivity areas, areas with specific descriptive names, or through sampling data.

(Navy 2025)

Initial Site Classification

3. AOI: “Sites that **cannot be classified as impacted or non-impacted** based on existing information are classified as AOIs. Following further evaluations, such as discovering new or additional information, performing investigations, or conducting interviews, AOIs are classified as impacted or are recommended for NFA for G-RAM because of the PA/SI. Areas initially identified as AOIs have a potential to contain residual radioactive materials from past operations that may have involved radioactive materials, but records may be unavailable to corroborate non-impacted status.”

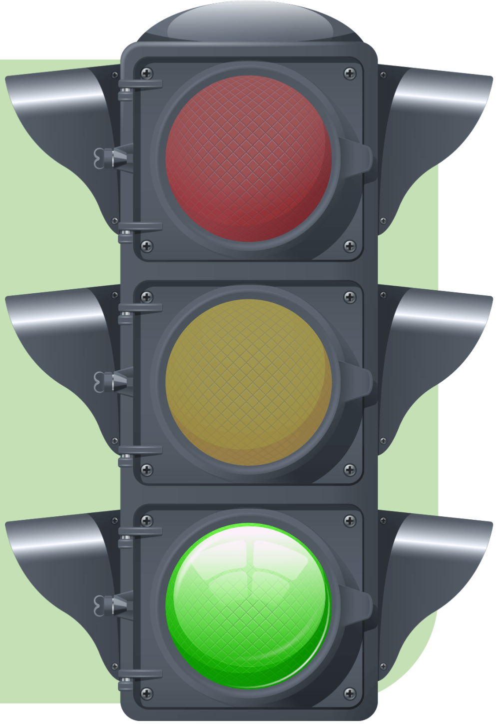


NFA: No Further Action

(Navy 2025)

Initial Site Classification

4. Previously Impacted: "Sites that were impacted, remediated, and surveyed, and adequate documentation exists supporting the area's **release for unrestricted use**." The area could also be categorized as non-impacted; however, it is given this specific designation, so the area's historical past is not overlooked.



- Release for unrestricted use is an official term that means the site has met all safety standards and has demonstrated through measurements that residual radiation levels are below the applicable, acceptable limits
- Equivalent to Unrestricted Use/Unlimited Exposure

(Navy 2025)

PA Recommendations

Proceed to the SI

- Sites where sufficient evidence of a potential release is identified

Recommend a TCRA

- Sites where a known release occurred, risks to human health or ecological receptors have been identified, and time-sensitive actions may be recommended to stabilize or mitigate the threat from release

Recommend NFA for G-RAM

- Sites meeting the definition of Non-Impacted or Previously Impacted

FS: Feasibility Study
RI: Remedial Investigation
TCRA: Time-Critical Removal Action

(Navy 2025)

Report Preparation

- Report sections
  - Introduction
  - Regulatory Involvement
  - Installation Background and Environmental Setting
  - Radiological History of the Installation
  - Assessment Methodology
  - Findings and Recommendations
  - Conclusions

- Review stages
  - Preliminary Draft Report
    - Reviewers: NAVFAC RPM, RASO EPM, Installation Environmental Point of Contact
  - Draft Report
    - Reviewers: Regulatory agencies (e.g., EPA, State)
  - Draft Final Report
    - Reviewers: All prior reviewers (includes responses to comments)
  - Final Report
    - Reviewers: NAVFAC RPM, RASO EPM

(Navy 2025)

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Section Overview

- Site Inspection Process
  - Purpose
  - Current Navy-wide Site Inspection Status
  - MARSSIM Overview
  - Survey Basics
  - MARSSIM Survey Elements
  - Evaluation of Subsurface Soils
  - Evaluation of Groundwater
  - Planning Process
  - Data Quality Objectives
  - Data Quality Objective Example
  - Laboratory Analysis of Samples for G-RAM
  - Other Planning Documents
  - Report Preparation

Site Inspection Process

- Initiation based on recommendations presented in the PA
- SI does not involve a determination of nature or extent of contamination spread through migration pathways or site boundaries (EPA 1992)
- Instead, a strategic sampling approach and comparison to PSLs is performed
- Includes site specific DQOs; surveying, sampling, and laboratory analysis methods; evaluation of ROPCs present in background; and current and future anticipated use of the site
- Includes concurrence from all stakeholders

DQO: Data Quality Objective
PSL: Project Screening Level

Purpose

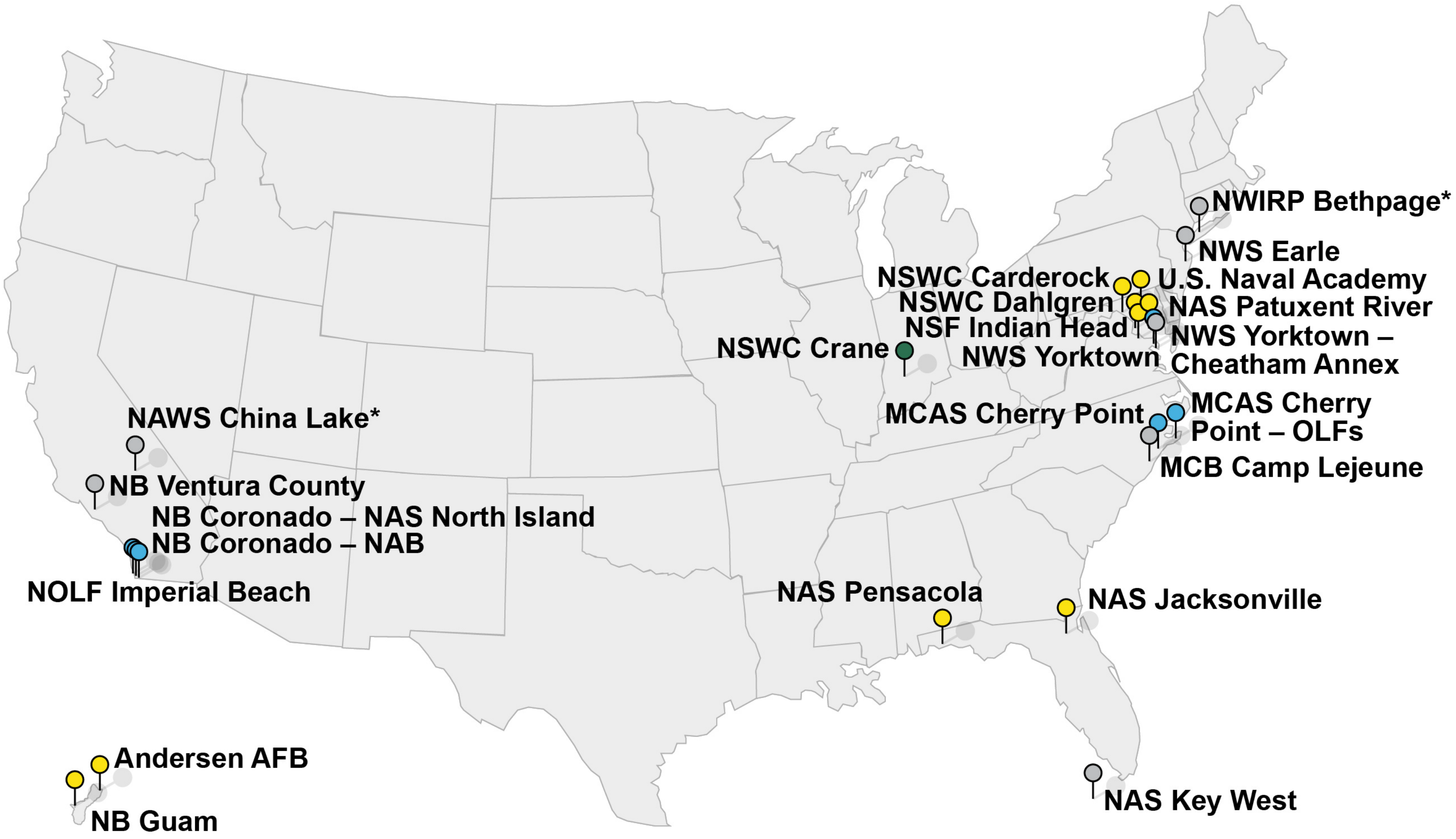
- Purpose of SI is to answer the following question

  Does G-RAM potentially pose an unacceptable risk to human health and the environment?

- Question is answered through
  - Use of standardized methods to evaluate ROPCs in environment
  - Development of **DQOs** to resolve SI question
  - Proposed recommendations including release for unrestricted use, NFA, or further evaluation in CERCLA process

(Navy 2025)

Current Navy-wide SI Status



LEGEND

- 🟡 In progress
- 🟢 Complete
- 🔵 Planned
- ⚪ To be determined
- * No HRA

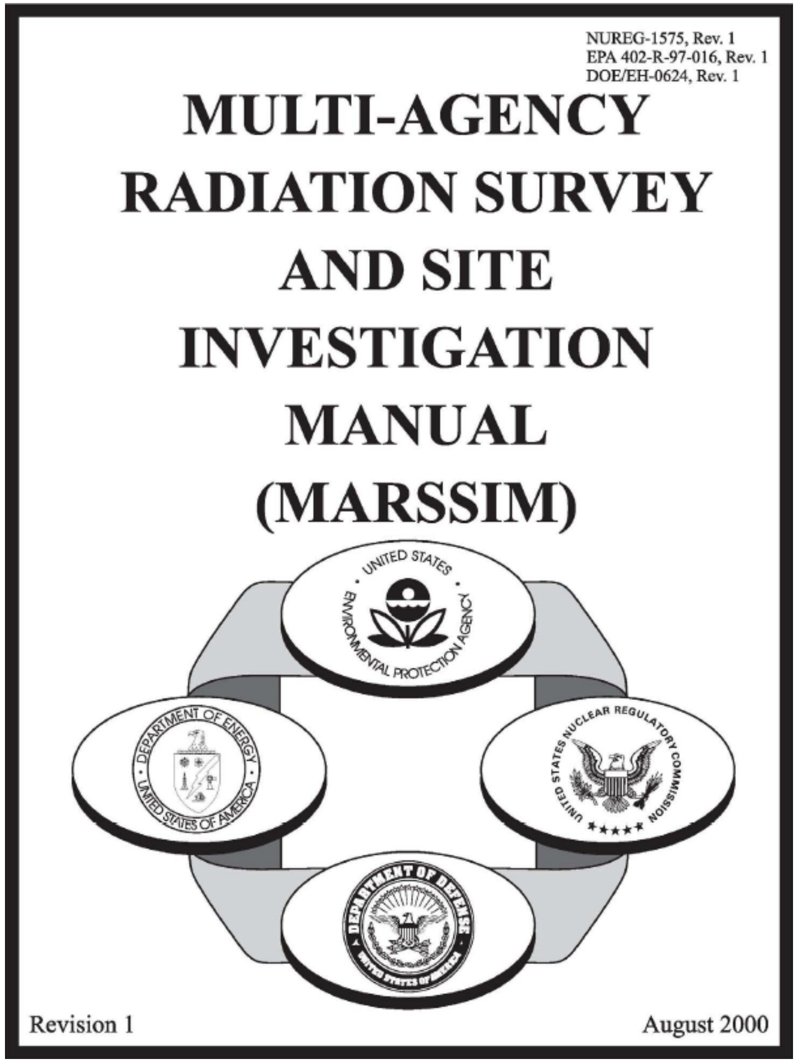
AFB: Air Force Base
MCAS: Marine Corps Air Station
MCB: Marine Corps Base
NAB: Naval Amphibious Base
NAS: Naval Air Station
NAWS: Naval Air Weapons Station
NB: Naval Base
NOLF: Naval Outlying Landing Field
NSF: Naval Support Facility
NSWC: Naval Surface Warfare Center
NWIRP: Naval Weapons Industrial Reserve Plant
NWS: Naval Weapons Station

(Navy 2025)

MARSSIM Overview

- MARSSIM Revision 1 (August 2000)
- Agency consensus document developed collaboratively by four federal agencies having authority and control over radioactive materials
  - DoD
  - DOE
  - EPA
  - NRC
- Objective to describe consistent approach for surveys and sampling while encouraging effective use of resources
- Basis for Radiological Site Management Toolkit for Navy Installations (Navy 2021), also known as EPM standards document

Guidance only!



NUREG-1575, Rev. 1
EPA 402-R-97-016, Rev. 1
DOE/EH-0624, Rev. 1

MULTI-AGENCY RADIATION SURVEY AND SITE INVESTIGATION MANUAL (MARSSIM)

United States Environmental Protection Agency

United States Nuclear Regulatory Commission

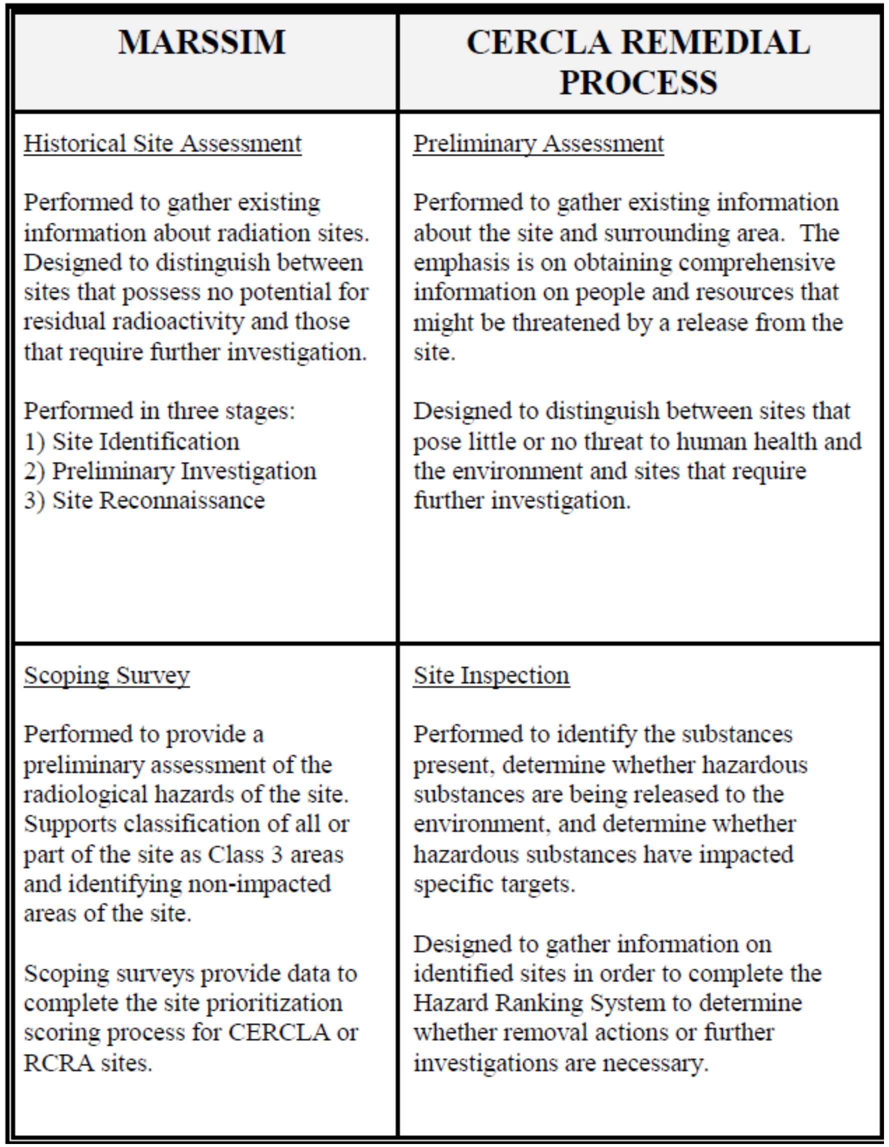
Revision 1
August 2000

(DoD et al. 2000)

DoD: Department of Defense
DOE: Department of Energy

MARSSIM Overview

- Widely accepted; gold standard for radiological surveys
- Approach is only applied to surface soils and foundations (paved surfaces)
  - **Defined as top 15 centimeters (6 inches) of soils**
- Program comparison to CERCLA SI Process shows equivalency to a **Scoping Survey** (DoD et al. 2000)
- Other MARSSIM surveys defined as **FSS** which increase complexity (and cost)

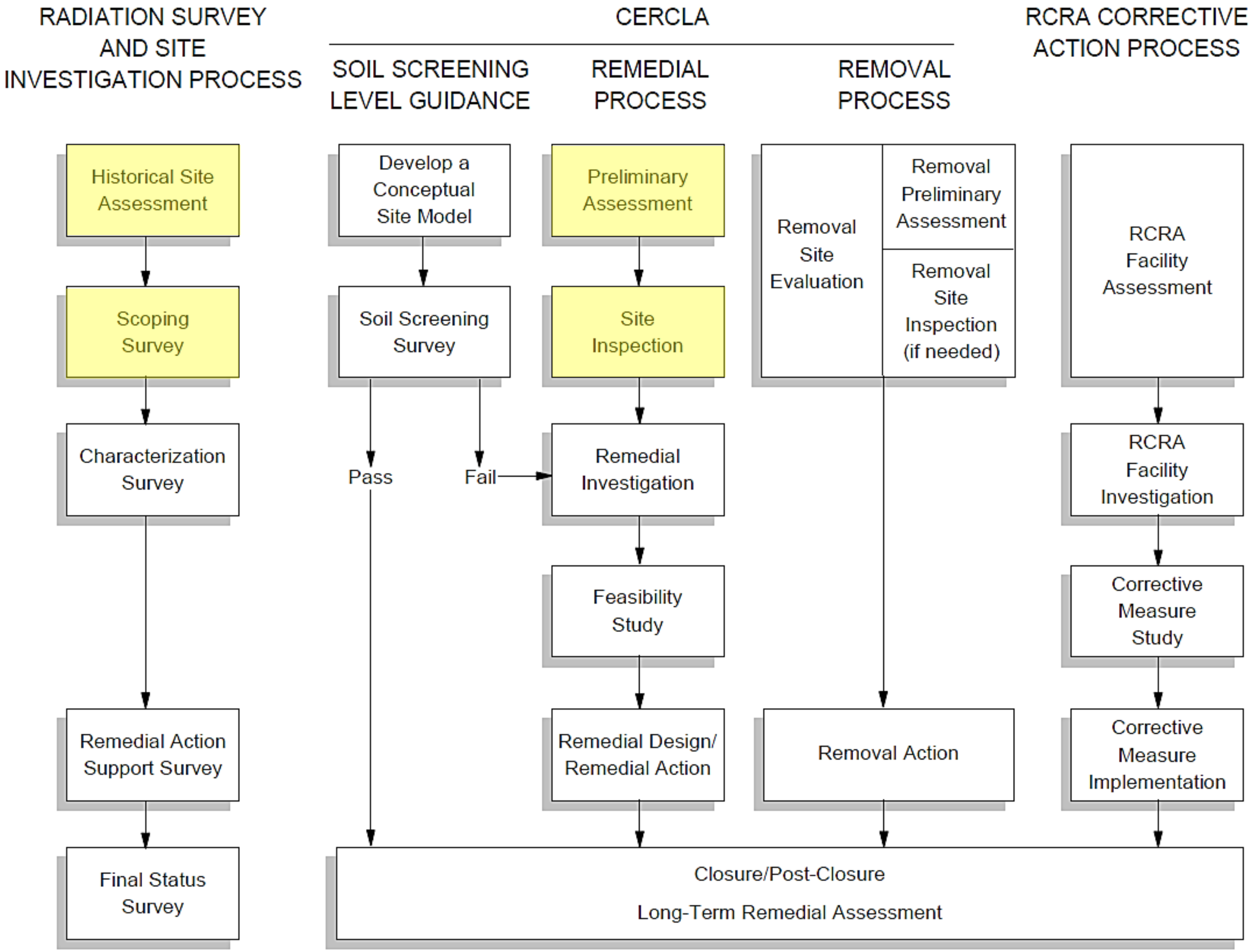


MARSSIM	CERCLA REMEDIAL PROCESS
Historical Site Assessment Performed to gather existing information about radiation sites. Designed to distinguish between sites that possess no potential for residual radioactivity and those that require further investigation. Performed in three stages: 1) Site Identification 2) Preliminary Investigation 3) Site Reconnaissance	Preliminary Assessment Performed to gather existing information about the site and surrounding area. The emphasis is on obtaining comprehensive information on people and resources that might be threatened by a release from the site. Designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.
Scoping Survey Performed to provide a preliminary assessment of the radiological hazards of the site. Supports classification of all or part of the site as Class 3 areas and identifying non-impacted areas of the site. Scoping surveys provide data to complete the site prioritization scoring process for CERCLA or RCRA sites.	Site Inspection Performed to identify the substances present, determine whether hazardous substances are being released to the environment, and determine whether hazardous substances have impacted specific targets. Designed to gather information on identified sites in order to complete the Hazard Ranking System to determine whether removal actions or further investigations are necessary.

(DoD et al. 2000)

FSS: Final Status Survey(s)

MARSSIM Overview



(DoD et al. 2000)

RCRA: Resource Conservation and Recovery Act

Survey Basics

- Radiation detection instrumentation or “detectors” are used to survey or scan media to determine whether quantity of radiation exists above natural background range
- Typically, one of two types of detectors are used
  1. Gamma Detector (e.g., Ludlum Model 44-10) for soils
  2. Alpha-Beta Detector (e.g., Ludlum Model 43-93) for paved surfaces (e.g., building foundations)
- These detector types are simple counters, they cannot decipher between ROPCs
  - Instrumentation that can identify ROPCs (gamma spectroscopy) exists; however, it is typically impractical for use at this stage

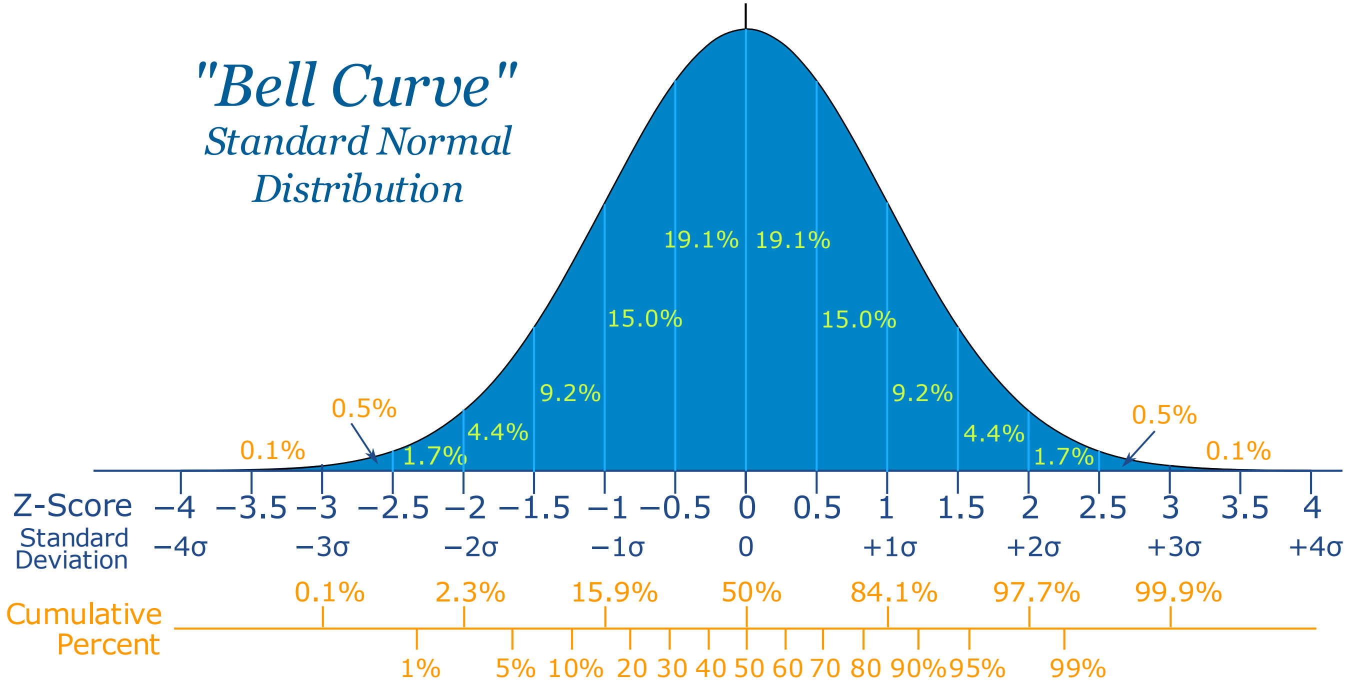
1, (γ)

2, (α-β)

(Ludlum Measurements 2024)

Survey Basics

- Before evaluation of radiation levels at site, a BRA survey is typically performed to establish IL
- IL is typically included as a count rate (e.g., counts per minute) and is instrument specific
- IL is applied to a survey of the site to identify locations for sampling



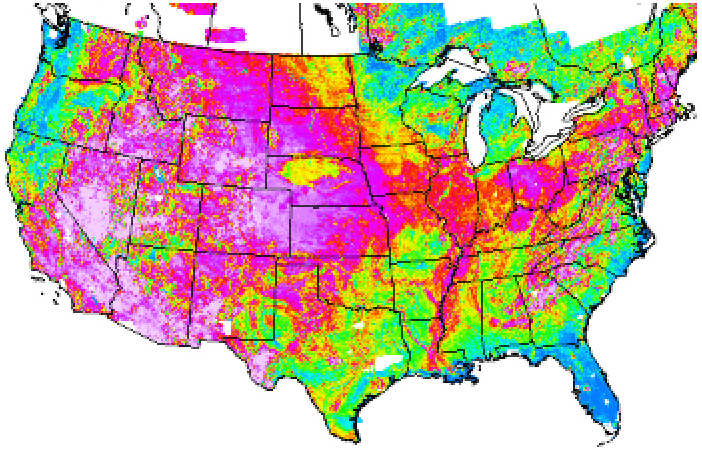
(Math is Fun 2025)

- Background radiation is assumed to follow normal distribution; therefore, IL may be selected at a value above the mean (e.g., +2 to 3σ)

σ: standard deviation
BRA: Background Reference Area
IL: Investigation Level

Survey Basics

- BRA
  - *"Area with similar physical, chemical, radiological, and biological characteristics as the site area but has not been contaminated by historical site activities. The distribution and concentration of background radiation in the BRA should be the same as that which would be expected on the site if that site had never been contaminated"* (DoD et al. 2000)
- May apply one BRA for multiple sites; however, proceed with caution because radiation levels can vary over short distances
- Recommended to use nearby, adjacent area
- Large enough to collect data for IL
- Depending on survey goals, may collect samples for comparison to site data and PSLs



(USGS 2005)

PSL: Project Screening Level

Survey Basics

- Surveys using a Gamma Detector (Instrument 1) may be coupled to a GPS device and additional software to create a precise heat map
  - Referred to as GWS
- Locations which exceed IL are easily identified and flagged for sampling
- Survey results **only** determine sampling locations, they do not make decisions on clearance
- May be applied during test pitting or to paved surfaces (conditions apply)

(ERG 2021)

RadScout GPS Gamma Survey System

GPS: Global Positioning System
GWS: Gamma Walkover Survey

Survey Basics

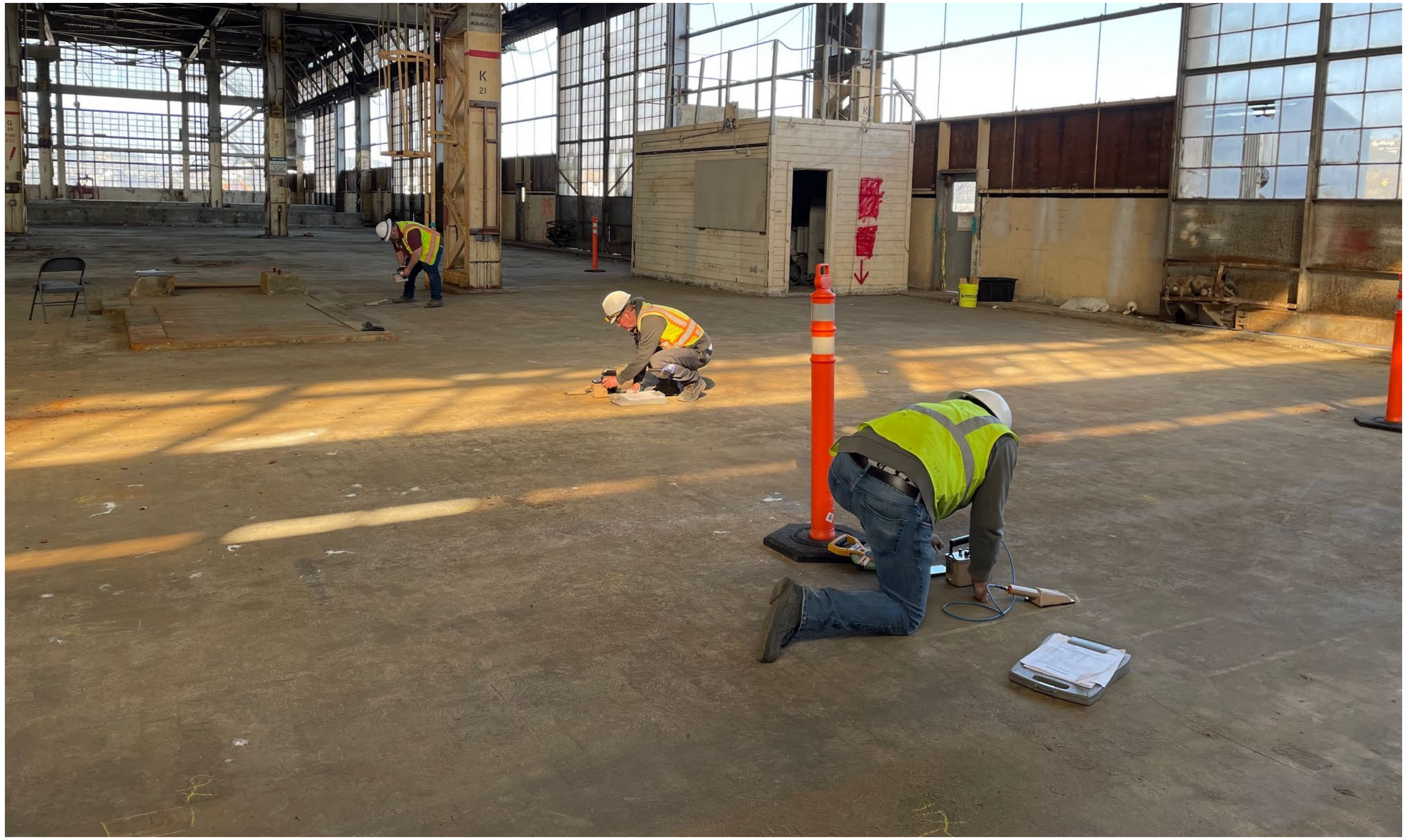
- Surveys using an Alpha-Beta detector (Instrument 2) may be used for scanning and, in lieu of sampling, for paved surfaces
- PSLs are typically expressed in values of surface activity (e.g., dpm per 100 square centimeters) and are separate for alpha and beta
- Since detector cannot decipher between ROPCs, the most limiting alpha or beta value is typically applied as the PSL

(Ludlum Measurements 2024)

dpm: Disintegrations Per Minute

Survey Basics


(Jacobs 2024)


(Jacobs/Perma-Fix 2022)

MARSSIM Survey Elements

- **Scoping Survey**
  - If one or more ROPC present in background
    - BRA determination and survey
    - Collection of background data (e.g., GWS) and background soil samples
  - Determination of IL (e.g., 2 to 3σ above the mean background value)
  - Site survey (e.g., GWS)
  - Locations that exceed IL are flagged for **judgmental sampling** (soils) *or evaluation of paved surfaces*
    - Some sites may add random sampling, depending on objectives
  - Collection of samples for laboratory analysis
  - Evaluation of sample data against PSLs

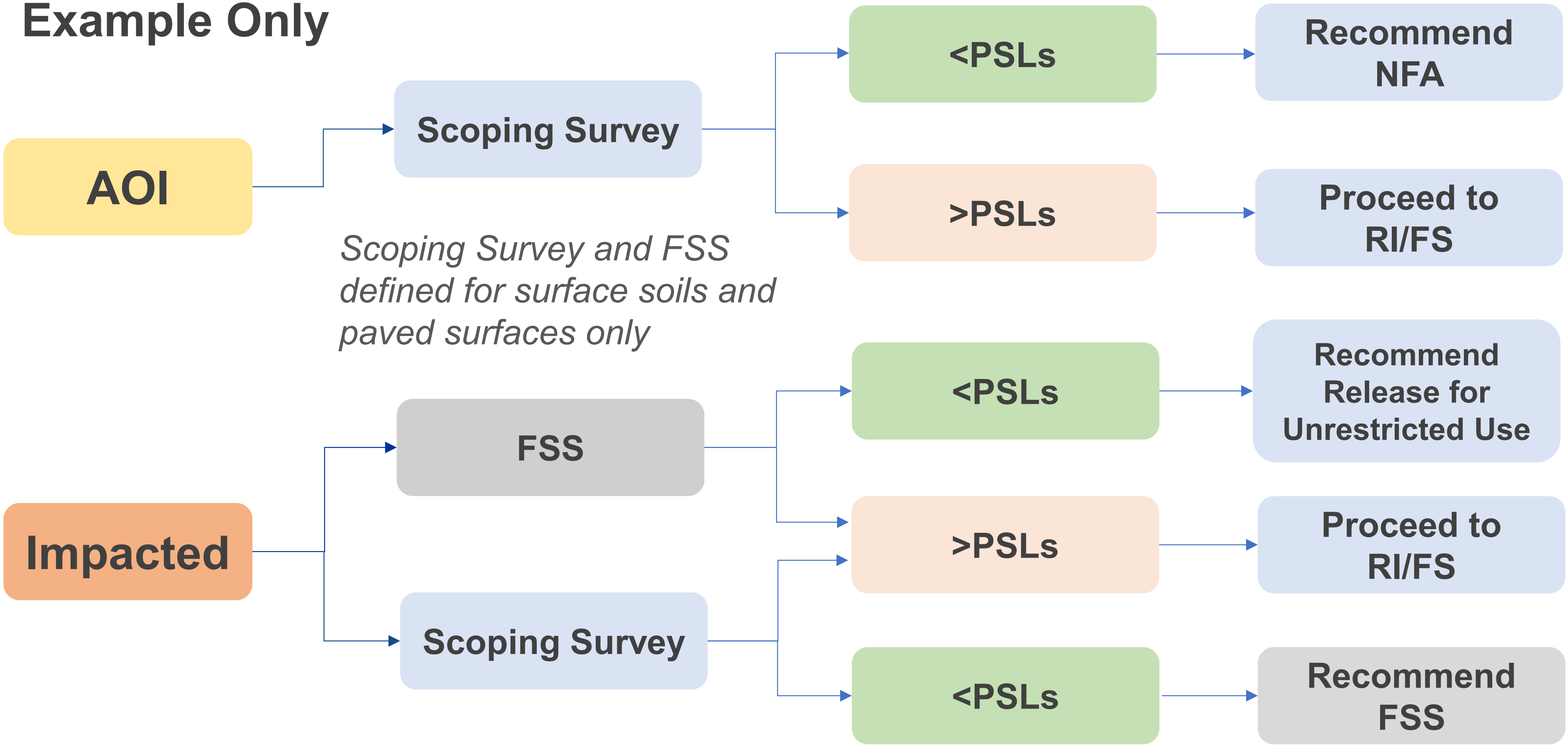
(DoD et al. 2000)

MARSSIM Survey Elements

- **Final Status Survey**
  - Different FSS classes based on expected contamination levels or previous surveys documenting ROPCs
  - Same general methodology as a Scoping Survey, plus
  - Determination of a specific number of **random** or **systematic measurements**
    - Calculated based on differences between background and PSL
    - Problem: Large number of samples calculated when differences are small
  - May be performed in lieu of a Scoping Survey, or
  - May be performed following a Scoping Survey, depending on the results (after SI phase)
  - Provides official "*release for unrestricted use*" for surface soils or paved surfaces

MARSSIM Survey Elements

Example Only



AOI

Scoping Survey

<PSLs

Recommend NFA

>PSLs

Proceed to RI/FS

Scoping Survey and FSS defined for surface soils and paved surfaces only

Impacted

FSS

<PSLs

Recommend Release for Unrestricted Use

>PSLs

Proceed to RI/FS

Scoping Survey

<PSLs

Recommend FSS

Evaluation of Subsurface Soils

- Subsurface investigations are outside of the scope of MARSSIM
- Limited guidance exists for subsurface investigations of G-RAM
  - *Soil Screening Guidance for Radionuclides: User's Guide* (EPA 2000)
    - Includes simple soil boring approach to determine if homogenous contamination exists
  - *Guidance on Surveys for Subsurface Radiological Contaminants, Draft Technical Letter Report* (SC&A 2021)
    - Draft not made final, many contractors still reference this information
  - NUREG 1757, Volume 2, Revision 2. *Consolidated Decommissioning Guidance. Characterization, Survey, and Determination of Radiological Criteria* (NRC 2022)
    - Recommends use of modeling for radiation dose

Evaluation of Subsurface Soils

- Soil borings
  - Problem: Depth and number of borings may not be enough to make conclusions regarding absence or presence of contamination, or to conclude site status
- Test pitting or excavation
  - Problem: Disposal areas may contain numerous COCs, unexploded ordnance, and other hazards
  - Digging into waste should be carefully planned
- Considerations for ROPCs suspected in subsurface waste
  - LUCs already in place to limit intrusive activities for other contaminants
  - Navy’s anticipated future use for site
  - Possibility of simply removing and replacing waste
  - Investigation-derived waste concerns (additional, costly sampling)
  - Problems if large-scale contamination is unearthed

LUC: land use control

Evaluation of Groundwater

- No difference from sampling of GW for other contaminants
- Background (unaffected) GW sample should be collected
  - Upgradient of the site
- Site sample collection
  - Downgradient of the site

Tip: Laboratory analysis of GW samples may be accomplished by measuring gross alpha and beta activity and comparing to background sample. If consistent with background, no additional ROPC specific sampling may be needed (pending stakeholder concurrence).

KEY POINT

GW sampling preferably completed from previously installed wells. May also be able to install temporary wells based on scope and budget.

GW: groundwater

Planning Process

COLLABORATIONS

NAVFAC
RASO
Installation
Stakeholders

DOCUMENTS

Sampling and Analysis Plan

- Review Historical Records and PA Recommendations
- Refine Conceptual Site Model
- Prepare Sampling Plan
  - Prepare Worksheets (37)
    - Laboratory and Method Selection
    - Waste Management
    - Data Quality Objectives
      - **STEP 1:** State problem
      - **STEP 2:** Identify goal of SI
      - **STEP 3:** Identify information inputs
      - **STEP 4:** Define boundaries
      - **STEP 5:** Develop analytical approach
      - **STEP 6:** Screening criteria

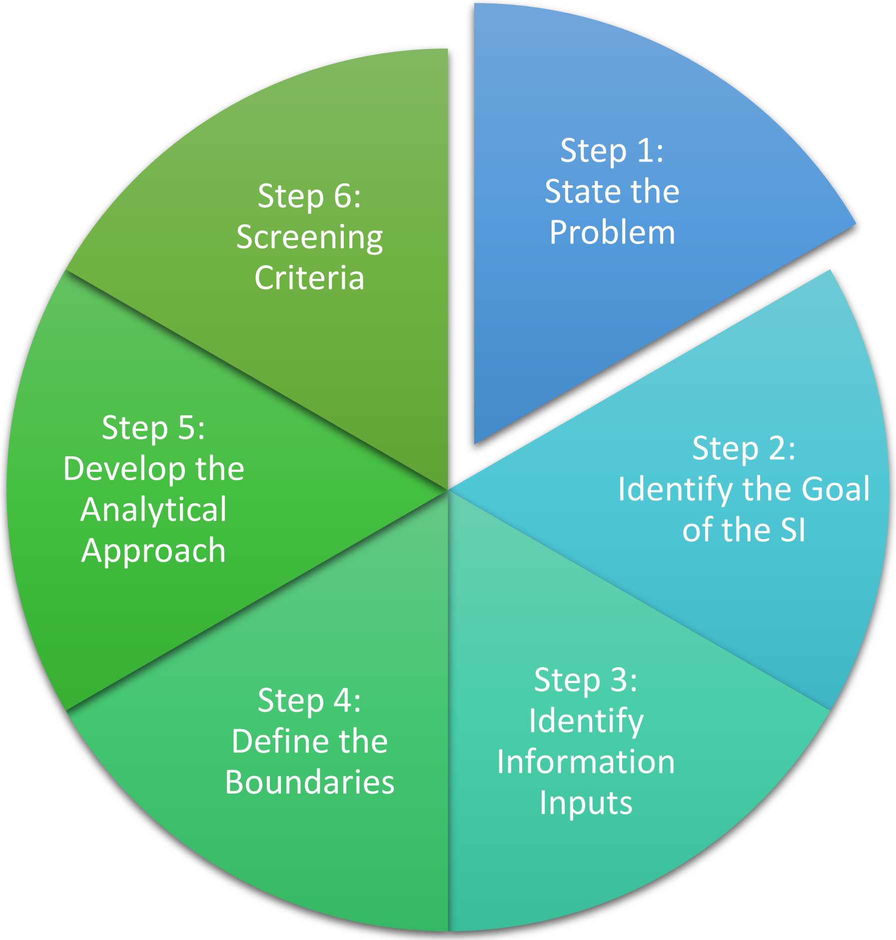
Health and Safety Plan

- Site-Specific Health and Safety Plan, Accident Prevention Plan, Radiological Protection Plan
- Radiological Management Plan
- Radioactive Materials License (if needed)

(Navy 2025)

Data Quality Objectives

- DQOs are site specific and must be developed separately for each site identified in PA
- Roadmap to completion of SI
- Define the type and number of measurements to collect, performance criteria, and decision points
- Seven dissimilar DQO steps developed by EPA (EPA 2006), MARSSIM (DoD et al. 2000), and the Toolkit (Navy 2021); harmonized within *Framework* to a total of six steps


Step 1: State the Problem

Step 2: Identify the Goal of the SI

Step 3: Identify Information Inputs

Step 4: Define the Boundaries

Step 5: Develop the Analytical Approach

Step 6: Screening Criteria

(Navy 2025)

DQO Step 1: State Problem

- Statement may be taken directly from the CSM and recommendations from the PA
- Common problem for all sites with G-RAM
- ROPCs exist or have a potential to exist that may pose threat to human health and environment
- Knowledge of source of contamination is important to determine whether it is contained within the site or exists as a continuous release that may require a TCRA

KEY POINT

The problem statement should be simple enough such that the SI will provide a sufficient answer!

(Navy 2025)

DQO Step 2: Identify Goal of SI

- In determining goal, must collect enough data to sufficiently answer problem in Step 1
- Example goals include the following
    - Release site or a portion of the site for unrestricted use
    - Determine whether ROPCs are present and if there is an unacceptable risk to human health and environment
    - Determine whether a removal action is needed
    - Determine whether the ROPC(s) exist as a continuous or isolated source
- Other considerations include anticipated future land use and potentially affected populations

(Navy 2025)

DQO Step 3: Identify Information Inputs

- General data collection includes two methods
  - **Field Screening (Survey)**
    - Ensure detector can measure specific type or energy of radiation
    - Generally, does not distinguish between ROPCs
  - **Sampling (Laboratory Analysis)**
    - Can distinguish between ROPCs
    - Laboratory MDC must be less than PSL values for each ROPC
    - Minimum volume requirements
    - Samples should not require preservatives, may include in-growth of ROPC decay progeny at laboratory, typical turn around time of approximately 30 days

MDC: Minimum Detectable Concentration

(Navy 2025)

DQO Step 4: Define Boundaries

- Scope, range, and delimitation of environmental media or conditions to be represented by the information inputs from Step 3
  - Water bodies (oceans, bays, and rivers) typically excluded from the scope of SI (also true for the HRA and PA)
- Lateral and vertical distribution determined by migration pathways in the CSM and other historical information, including where non-radiological COCs have been found
- General site boundaries (if not previously established) may be found using historic aerial photography
- Define BRA

DQO Step 5: Develop Analytical Approach

- Needs to answer the following
  - Type of survey (e.g., Scoping Survey or FSS)
  - Determination of ILs (e.g., 2 to 3σ above background)
  - Number of samples to be collected
    - Scoping Survey: Consider setting minimum and maximum number of samples to be collected
    - FSS: Determine decision error rates, PSLs, and background ROPC concentrations to determine minimum number of samples.
  - Evaluation of subsurface soils (if applicable)
  - Evaluation of GW (if applicable)
  - Decisions and recommendations based on the results of sampling

(Navy 2025)

DQO Step 5: Develop Analytical Approach

- Example scenarios presented based on site classification and survey type
- **Impacted sites:** If the site is Impacted in the PA and a Scoping Survey is performed, the following decisions **may be options**
    - a) NFA with release of site for unrestricted use *(Unlimited Use/ Unrestricted Exposure)* for G-RAM based on completion of FSS
    - b) Conduct removal action and FSS, then request release of site for unrestricted use for G-RAM
    - c) Proceed to an RI/FS
- **AOIs:** If site is AOI in PA and a Scoping Survey is performed, the following decisions may be options
    - a) NFA for G-RAM
    - b) Proceed to an RI/FS

(Navy 2025)

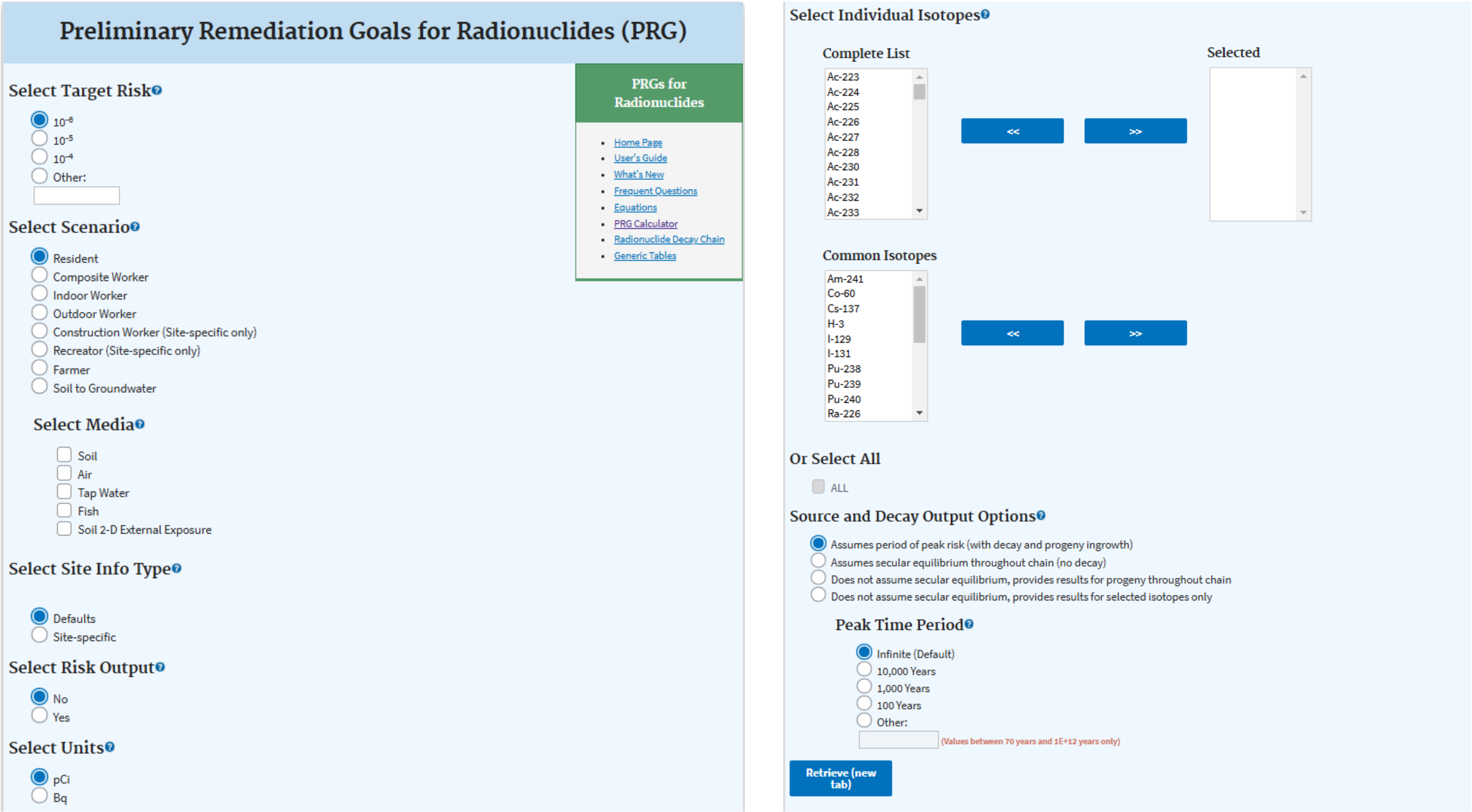
DQO Step 6: Specify Performance or Acceptance Criteria

- Cleanup and release criteria for radionuclides is complex and is not streamlined between regulatory agencies
- At NPL sites, a **risk-based** approach to screening criteria is typically used
- At non-NPL sites, a **dose-based** approach may be used (except in California)
- Example risk levels: 1×10^{-4} to 1×10^{-6}
- Conversion of risk to maximum activity concentration used for PSLs is most commonly accomplished through EPA PRG calculator or DOE (Argonne National Laboratory) RESRAD-ONSITE modeling tools
- Models use select exposure scenarios based on future site use (e.g., residential, industrial, farming, and recreation) over a set time period
- Exposure typically based on external radiation exposure, inhalation, and ingestion

PRG: Preliminary Remediation Goals for Radionuclides

(Navy 2025)

DQO Step 6: Specify Performance or Acceptance Criteria



Preliminary Remediation Goals for Radionuclides (PRG)

Select Target Risk

● 10^{-6}
○ 10^{-5}
○ 10^{-4}
○ Other:

Select Scenario

● Resident
○ Composite Worker
○ Indoor Worker
○ Outdoor Worker
○ Construction Worker (Site-specific only)
○ Recreator (Site-specific only)
○ Farmer
○ Soil to Groundwater

Select Media

☐ Soil
☐ Air
☐ Tap Water
☐ Fish
☐ Soil 2-D External Exposure

Select Site Info Type

● Defaults
○ Site-specific

Select Risk Output

● No
○ Yes

Select Units

● pCi
○ Bq

PRGs for Radionuclides

- Home Page
- User's Guide
- What's New
- Frequent Questions
- Equations
- PRG Calculator
- Radionuclide Decay Chain
- Generic Tables

Select Individual Isotopes

Complete List

Ac-223
Ac-224
Ac-225
Ac-226
Ac-227
Ac-228
Ac-230
Ac-231
Ac-232
Ac-233

Selected

Common Isotopes

Am-241
Co-60
Cs-137
H-3
I-129
I-131
Pu-238
Pu-239
Pu-240
Ra-226

Or Select All

☐ ALL

Source and Decay Output Options

● Assumes period of peak risk (with decay and progeny ingrowth)
○ Assumes secular equilibrium throughout chain (no decay)
○ Does not assume secular equilibrium, provides results for progeny throughout chain
○ Does not assume secular equilibrium, provides results for selected isotopes only

Peak Time Period

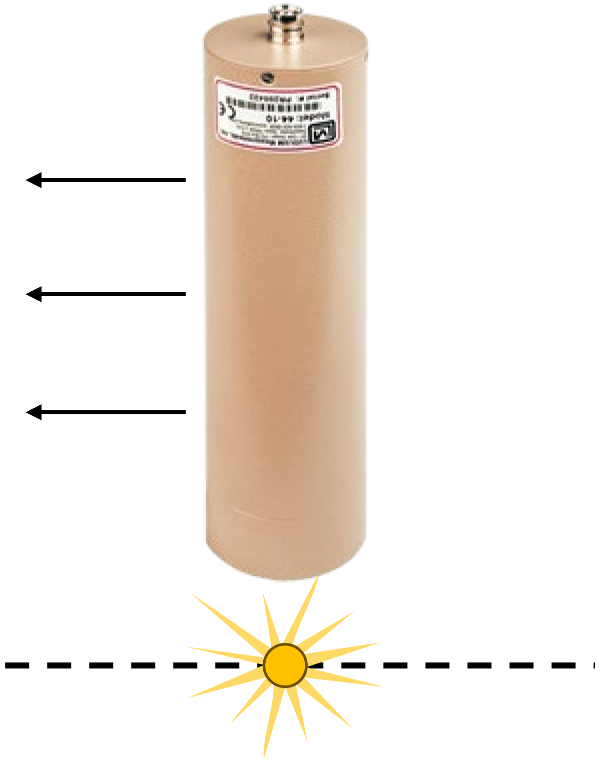
● Infinite (Default)
○ 10,000 Years
○ 1,000 Years
○ 100 Years
○ Other:

(Values between 70 years and 1E+12 years only)

(EPA 2020)

DQO Step 6: Specify Performance or Acceptance Criteria

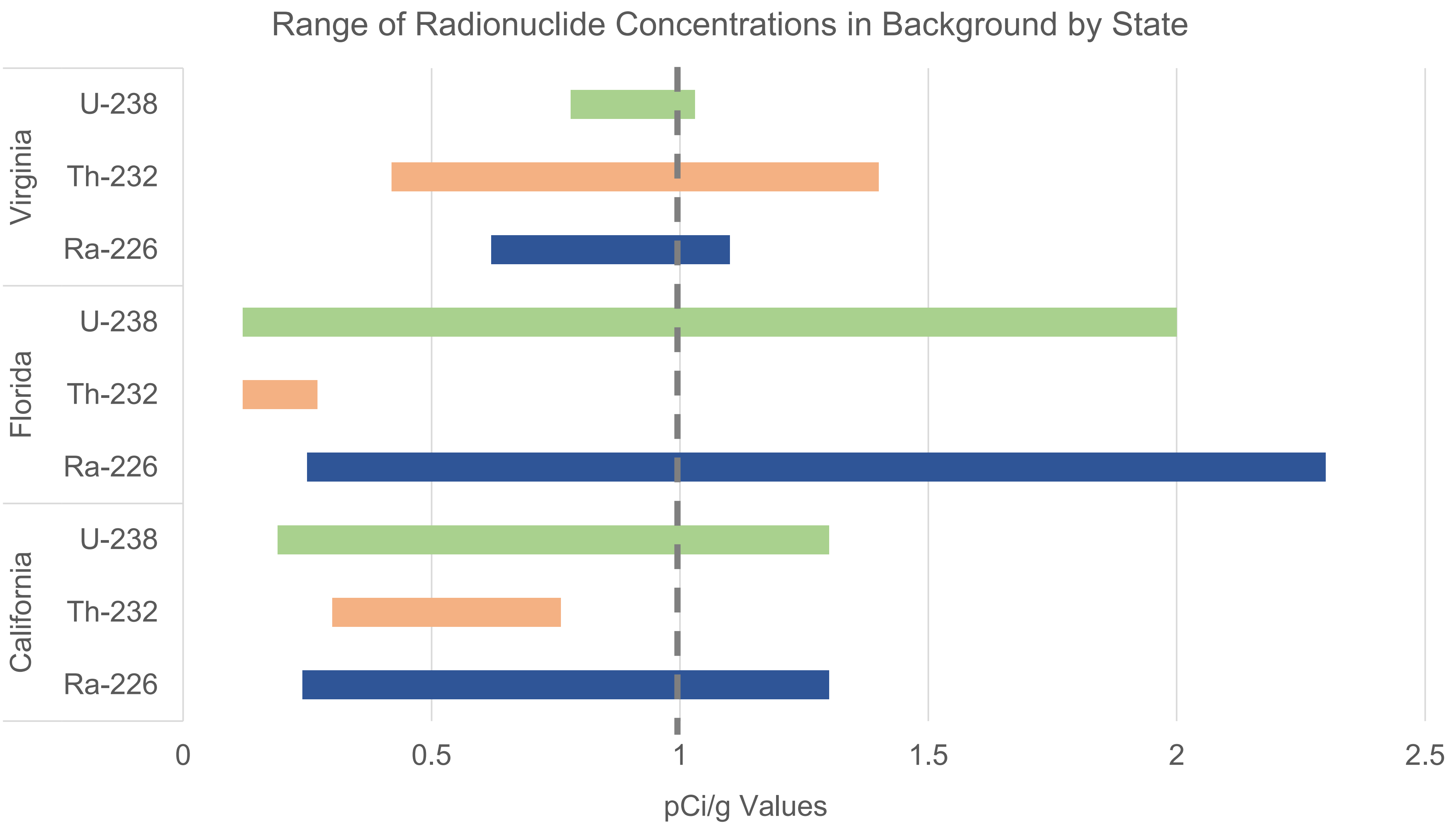
- Using multiple EPA PRG Calculator risk and scenario types, output PSL values for multiple radionuclides (e.g., Ra-226, Th-232) are typically **less than 1 pCi/g**
  - 1 pCi/g is equivalent to 2.22 dpm
  - Radiation emitted isotopically, losses >50%
  - Results in detector efficiency <20%
  - Detector is in motion, scan speed major variable
- Values include total concentration measured in soil and are *inclusive of background radionuclides*
- These values may be multiple orders of magnitude less than background
- Should be identified and rectified before initiation of SI activities



(Ludlum Measurements 2024)

pCi/g: picocurie(s) per gram

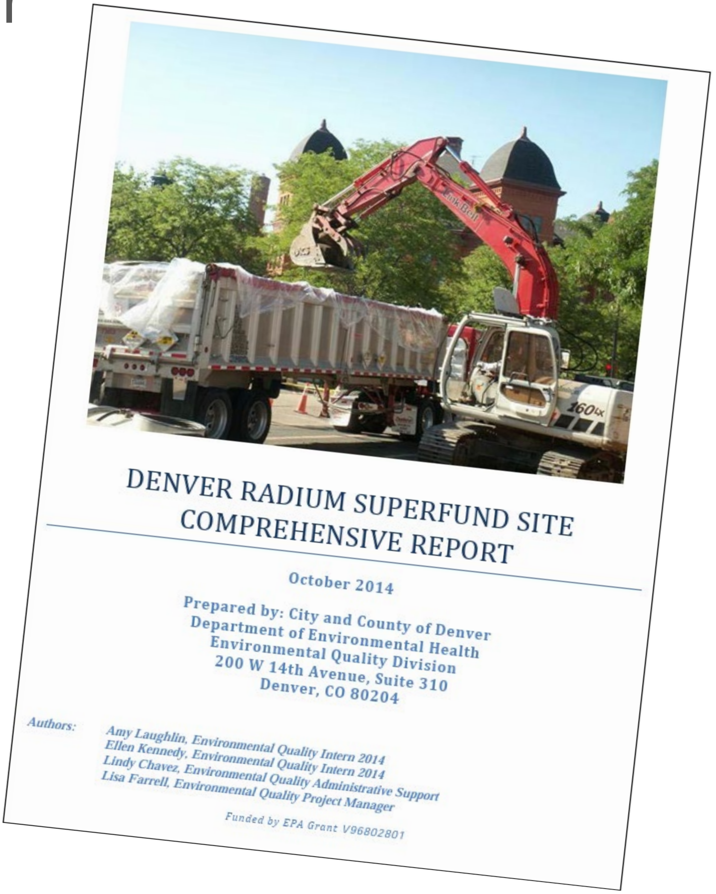
DQO Step 6: Specify Performance or Acceptance Criteria



(Oak Ridge National Laboratory 1981)

DQO Step 6: Specify Performance or Acceptance Criteria

- Summary of potential problems with EPA PRG Calculator
  - Assumes site is contaminated and needs remediated
  - Does not account for site-specific background
  - Sets extremely low screening criteria for some ROPCs
- Potential solutions
  - Title 40 CFR Part 192
    - Potentially applicable to CERCLA/Superfund sites
    - Limits surface soils to **5 pCi/g** (Ra-226 and Th-232)
  - Increase acceptable risk or use dose-based criteria
  - Change model parameters or modeling software
  - Discuss alternate solutions with RASO



DENVER RADIUM SUPERFUND SITE
COMPREHENSIVE REPORT

October 2014

Prepared by: City and County of Denver
Department of Environmental Health
Environmental Quality Division
200 W 14th Avenue, Suite 310
Denver, CO 80204

Authors:

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Lindy Chavez, Environmental Quality Administrative Support
Lisa Farrell, Environmental Quality Project Manager

Funded by EPA Grant V96802801

(Denver Department of Environmental Quality 2014)

CFR: *Code of Federal Regulations*

DQO Step 6: Specify Performance or Acceptance Criteria

- Consider detector performance in preparation for field screening
- Gamma Detector (Instrument 1) variants shown
- Example: FIDLER detector is best suited for U-238 (DU), but not remaining ROPCs

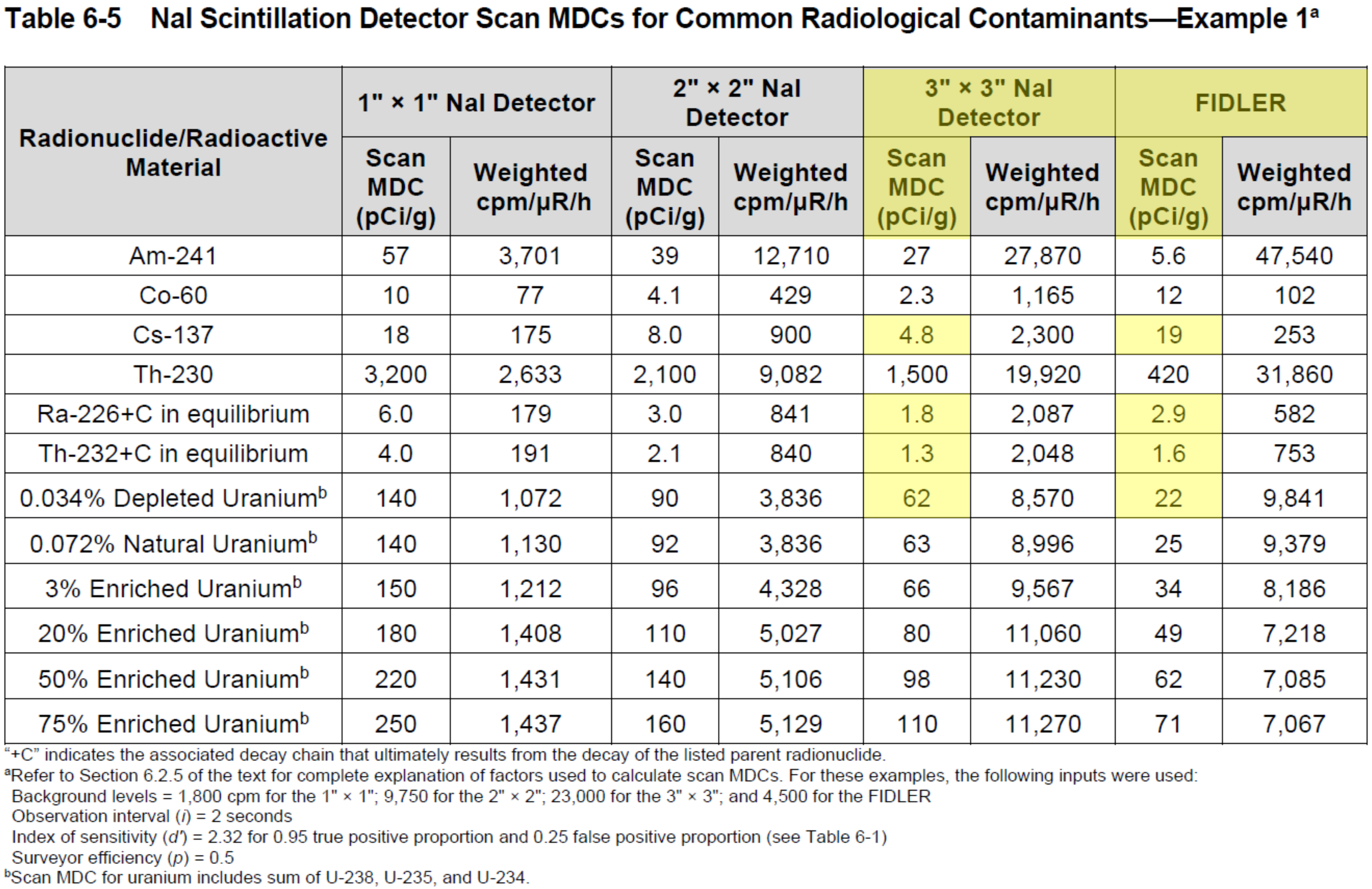


Table 6-5 NaI Scintillation Detector Scan MDCs for Common Radiological Contaminants—Example 1[a]

Radionuclide/Radioactive Material	1" × 1" NaI Detector		2" × 2" NaI Detector		3" × 3" NaI Detector		FIDLER	
	Scan MDC (pCi/g)	Weighted cpm/μR/h	Scan MDC (pCi/g)	Weighted cpm/μR/h	Scan MDC (pCi/g)	Weighted cpm/μR/h	Scan MDC (pCi/g)	Weighted cpm/μR/h
Am-241	57	3,701	39	12,710	27	27,870	5.6	47,540
Co-60	10	77	4.1	429	2.3	1,165	12	102
Cs-137	18	175	8.0	900	4.8	2,300	19	253
Th-230	3,200	2,633	2,100	9,082	1,500	19,920	420	31,860
Ra-226+C in equilibrium	6.0	179	3.0	841	1.8	2,087	2.9	582
Th-232+C in equilibrium	4.0	191	2.1	840	1.3	2,048	1.6	753
0.034% Depleted Uranium[b]	140	1,072	90	3,836	62	8,570	22	9,841
0.072% Natural Uranium[b]	140	1,130	92	3,836	63	8,996	25	9,379
3% Enriched Uranium[b]	150	1,212	96	4,328	66	9,567	34	8,186
20% Enriched Uranium[b]	180	1,408	110	5,027	80	11,060	49	7,218
50% Enriched Uranium[b]	220	1,431	140	5,106	98	11,230	62	7,085
75% Enriched Uranium[b]	250	1,437	160	5,129	110	11,270	71	7,067

"+C" indicates the associated decay chain that ultimately results from the decay of the listed parent radionuclide.

[a] Refer to Section 6.2.5 of the text for complete explanation of factors used to calculate scan MDCs. For these examples, the following inputs were used:
Background levels = 1,800 cpm for the 1" × 1"; 9,750 for the 2" × 2"; 23,000 for the 3" × 3"; and 4,500 for the FIDLER
Observation interval (*i*) = 2 seconds
Index of sensitivity (*d′*) = 2.32 for 0.95 true positive proportion and 0.25 false positive proportion (see Table 6-1)
Surveyor efficiency (*p*) = 0.5

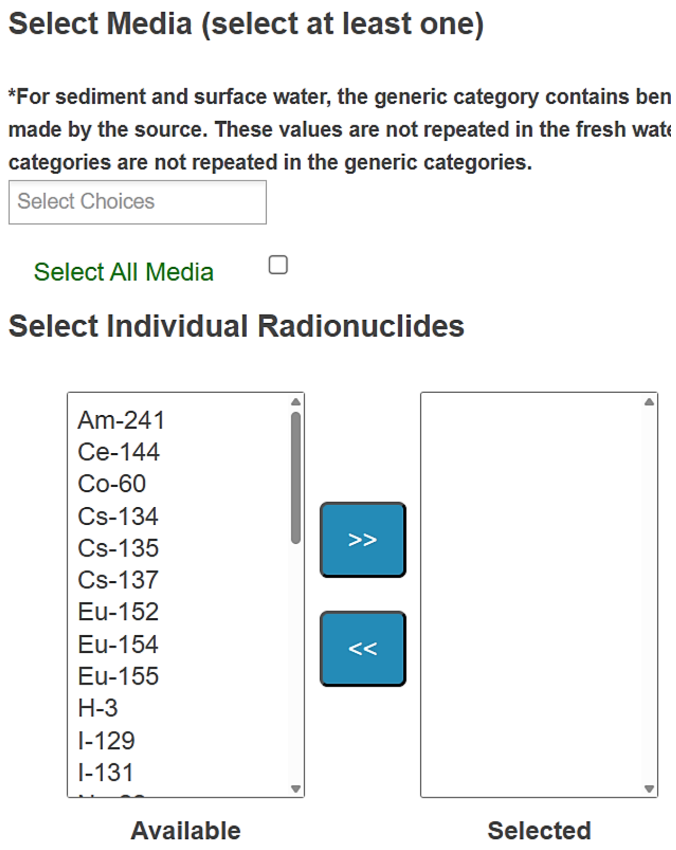
[b] Scan MDC for uranium includes sum of U-238, U-235, and U-234.

NaI: Sodium Iodide

(NRC 2020)

DQO Step 6: Specify Performance or Acceptance Criteria

- Groundwater limits
  - Gross alpha/beta comparison
  - Determine groundwater use, consider drinking water limits for radionuclides
- Surface contamination limits
  - Applies to paved surfaces (e.g., storage lots and building foundations)
  - Also calculated using EPA PRG Calculator
  - Limits expressed as dpm per 100 square centimeters
- What about risks to the environment (biota)?
  - Los Alamos National Laboratory ECORISK Database (Release 4.4)
  - Selection of radionuclide and media type
  - Screening criteria likely exceeds risk or dose-based PSLs



Select Media (select at least one)

***For sediment and surface water, the generic category contains ben made by the source. These values are not repeated in the fresh wat categories are not repeated in the generic categories.**

Select Choices

Select All Media ☐

Select Individual Radionuclides

Am-241
Ce-144
Co-60
Cs-134
Cs-135
Cs-137
Eu-152
Eu-154
Eu-155
H-3
I-129
I-131

(Oak Ridge National Laboratory 2024)

DQO Example

Step 1

STATE PROBLEM

Surface Dump Site 1
Dumping and disposal of hazardous materials, including potential (unconfirmed) radioluminescent devices documented from 1970 until 1985. Exact quantities and locations of dumped or disposed material are unknown. Various debris is assumed to be collocated within the top 15 centimeters of soils. The ROPC is Ra-226.

Step 2

IDENTIFY GOAL OF SI

Site is currently classified as an AOI. Based on future anticipated land use, the goal of the SI is to evaluate whether ROPCs are present in soil from historical activities exceeding the PSLs. Future anticipated land use includes development of a new military training facility.

Step 3

IDENTIFY INFORMATION INPUTS

Field screening will use a 2-inch by 2-inch gamma detector with positional correlation to perform a scan of professional judgment and accessible areas of the site. Laboratory MDC value is 1 pCi/g and is less than the PSL.

DQO Example

Step 4

DEFINE BOUNDARIES

Surveys will be performed within pre-established site boundaries based on a review of historical aerial photography of disturbed areas during site's estimated period of use.

Step 5

DEVELOP ANALYTICAL APPROACH

- Field screening will be completed in an adjacent BRA with the IL developed at 3 standard deviations above the mean background value
- At site, field screening exceeding the IL will be marked for judgmental sampling to a maximum of 10 samples
- If results of sampling do not indicate G-RAM is present exceeding screening criteria, site will be recommended for NFA for G-RAM
- If results of sampling indicate G-RAM is present and screening criteria is exceeded, site will proceed to RI
- No subsurface or groundwater sampling is recommended; sampling of subsurface soil may be recommended if elevated activity is identified in surface soil samples indicating a potential release that would impact subsurface or groundwater

Step 6

SCREENING CRITERIA

Screening criteria for Ra-226 is 3.96 pCi/g and are based on the EPA PRG Calculator using the Outdoor Worker scenario and an excess lifetime cancer risk of 1×10^{-4}

Laboratory Analysis of Samples for G-RAM

- EPA laboratory analysis methods, timelines, minimum sample volumes, and packaging requirements should be known and agreed upon before execution of SI
- Example analysis methods
  - Liquid scintillation counting
  - Gamma spectroscopy
  - Alpha spectroscopy
  - Gas flow proportional counting
- Laboratory MDCs should not exceed PSLs
  - MDCs are typically laboratory and contract specific
  - May reduce MDC by increasing sample count time (increases cost)
  - Most analysis methods should be ≤1 pCi/g

(Oak Ridge National Laboratory 2025)

(Navy 2025)

Other Planning Documents

- Radiological Protection Plan and Management Plans
  - Calibration and use of radiation detection instrumentation
  - Task-specific plans
  - Worker safety (personal protective equipment and stop points)
  - Training requirements
  - Handling requirements
  - Notification requirements
- Radioactive Materials License
  - If radioactive materials are unearthed, contractor shall be responsible for handling, storage, and disposal of those materials
  - Invocation of an NRC or Agreement State radioactive materials license, with reciprocity filed as appropriate, may be required (and should be verified prior to execution of the SI)

Report Preparation

- Report Sections
  - Introduction
  - Installation background and environmental setting
  - Field activities
  - Site-specific sections (including data review)
  - Conclusions and recommendations

- Review Stages
  - Same as PA
  - During review of SI report, any site that has a confirmed presence of G-RAM exceeding PSLs must include official RASO notification
  - These sites will be added to the IRP by applicable NAVFAC or installation procedures unless site has been recommended for NFA for G-RAM or released for unrestricted use

(Navy 2025)

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- **Case Studies**
- Summary and Closing Statements

Case Studies

- Example 1 (2022)
  - First SI executed (before completion of Framework)
  - 28 sites evaluated
  - Initially used **dose-based** PSLs (in conflict with EPA Region 4)
  - Re-evaluation of data against risk-based PSLs
  - **Nearly all ROPCs sampled exceeded new PSLs**
  - SI report not yet finalized

Case Studies

- Example 2 (2023, internal draft only)
  - 15 sites evaluated (all AOIs)
  - Risk based PSLs at 1×10^{-6} with residential and composite worker scenarios
  - Additional action levels set at 1×10^{-4} or 3×10^{-4}
  - **Nearly all ROPCs sampled exceeded PSLs for soil**
  - Background subtraction applied to site samples, sum of fractions applied to sites with multiple ROPCs, and results did not exceed action levels
  - Two sites recommended for further investigation, including a data gap SI, RI, or LUCs
  - Other areas not recommended for further investigation
  - SI report not yet finalized

Presentation Overview

- Introduction
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- Summary and Closing Statements

Summary and Closing Statements

- G-RAM and its identification and evaluation in the environment is relatively new for many RPMs
- The PA compiles evidence needed to both classify a site and make recommendations for further action
- The SI is a complex process for evaluating ROPCs using field screening and laboratory sampling
- A harmonized DQO process allows for proper planning of SI and maintains a consistent approach; however, PSL development is site specific and needs to be carefully explored
- Recent PA/SI Framework should help RPMs and contractors succeed in efficiently evaluating sites with G-RAM

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Questions