NAVFAC
Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

Open Environmental Restoration Resource (OER2) Webinar

Managing the Navy's Complex Groundwater Sites: Alternative Endpoints and Approaches

Presented by:
NAVFAC Environmental Restoration Program

Webinar: 5

Points of Contact

POCs

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- tara.meyers@navy.mil — **Moderator**

Logistics

- **Submit all questions via chat box throughout the presentation**
- **Presentation is being recorded**
- **Complete the webinar survey (main feedback mechanism)**

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OER2 Webinar Series

- **Why Attend?**
  - **Obtain and hear about the latest DOD and DON's policies/guidance, tools, technologies and practices to improve the ERP's efficiency**
  - **Promote innovation and share lessons learned**
  - **FEEDBACK to the ERP Leadership**
- **Who Should Attend?**
  - **ERP Community Members: RPMs, RTMs, Contractors, and other remediation practitioners who support and execute the ERP**
  - **Voluntary participation**
- **Schedule and Registration:**
  - **Every other month, 4th Wed (can be rescheduled due to holidays)**
  - **Registration link for each topic (announced via ER T2 email)**
- **Topics and Presenters:**
  - **ERP community members to submit topics (non-marketing and DON ERP-relevant) to POCs (Gunarti Coghlan – gunarti.coghlan@navy.mil or Josh Fortenberry – josh.fortenberry@navy.mil)**
  - **Selected topic will be assigned Champion to work with presenter**

Speaker Introduction

Mike Singletary, P.E., is a senior engineer and technical manager in the Environmental Restoration (ER) program at NAVFAC Southeast, where he provides expert advice and optimization support to remedial project managers (RPMs); program managers; contractors; and environmental legal counsel on issues related to the ER and Base Realignment and Closure (BRAC) cleanup programs. Mike specializes in groundwater hydrology, the fate and transport of contaminants in subsurface environments, bioremediation technologies, the development of risk management strategies for complex contaminated sites, and the strategic planning and optimization of site investigation and remediation approaches. Mike earned a Bachelor's degree in Civil Engineering and a Master of Science degree in Environmental Engineering from Georgia Tech.

Speaker Introduction

Rula Deeb, Ph.D., BCEEM, PMP, is a principal civil and environmental engineer based in California. She has more than 25 years of experience in private practice and academia addressing the cross-media fate and transport of contaminants and the remediation of complex soil and groundwater sites impacted by non-aqueous phase liquids. Rula earned her doctorate in civil and environmental engineering at the University of California, Berkeley, where her research focused on substrate interactions of gasoline aromatics and oxygenates. As a post-doctoral fellow at UC Berkeley, she developed and implemented research programs in collaboration with scientists and engineers at other universities, consulting firms, and the U.S. Air Force on the remediation of sites impacted with contaminant mixtures. Rula was selected as a National Science Foundation Engineering Education Scholar for Excellence in Engineering Education.

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Managing the Navy's Complex Groundwater Sites: Alternative Endpoints and Approaches

Mike Singletary, P.E., NAVFAC Southeast
Rula Deeb, Ph.D., BCEEM, Geosyntec Consultants

Presentation Outline

- Introduction to current challenges at Navy's complex groundwater sites
- Snapshot of the ER,N program with respect to 2021 RC goals
- Use of alternative endpoints at complex groundwater sites
  - Discussion of "complex" sites
  - ARAR waivers
  - Groundwater management and containment
  - MNA with extended timeframes
  - Other approaches
- National efforts and technical resources

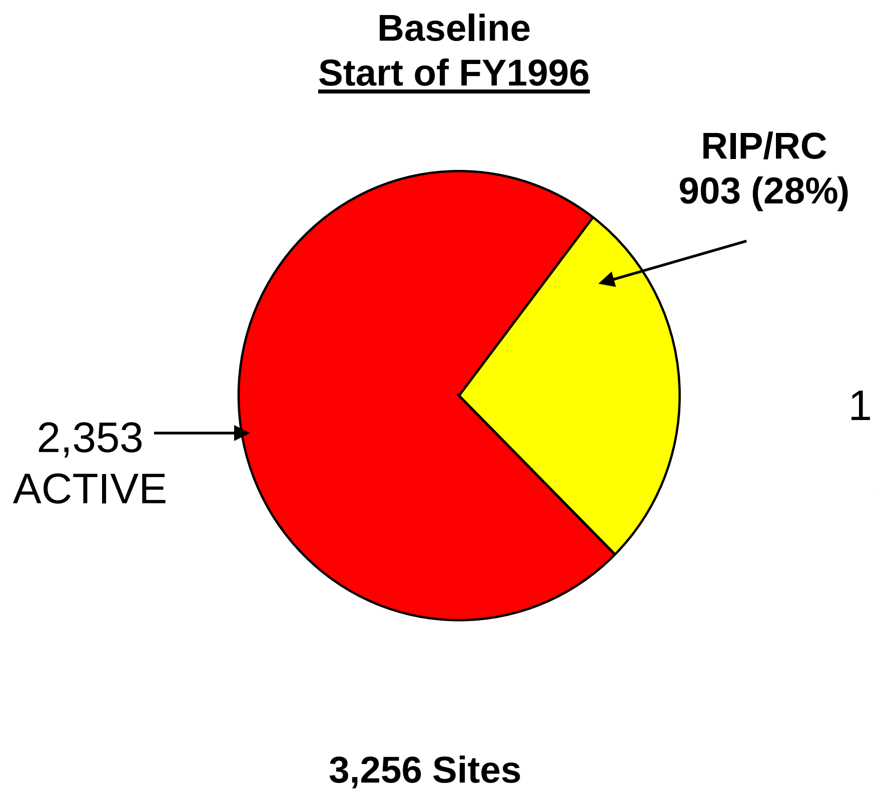
Introduction

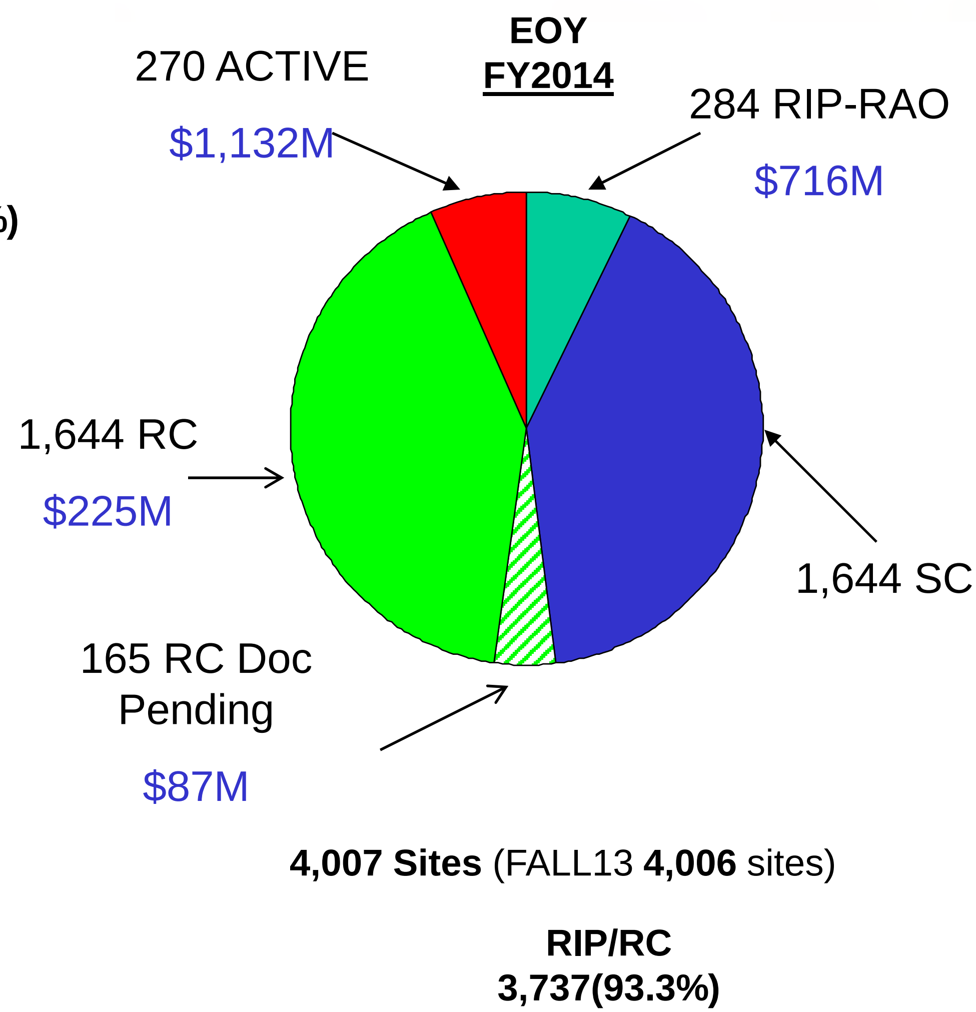
- Complex groundwater sites remain a major challenge for the Environmental Restoration, Navy (ER,N) program
  - Primarily chlorinated solvent sites
  - Long-term management costs
  - Extended remediation timeframes
  - Difficult to meet RC goal of 2021
- Technology limitations make achievement of MCLs throughout plumes at most complex sites unlikely in next 50-100 years
- Protection of human health and the environment remain primary goal
- Alternative approaches needed for long-term management of complex groundwater sites

Defense Environmental Restoration Program (DERP)

- **SARA established the Defense Environmental Restoration Program (DERP) in 1986**
- **ER,N responsible for remediation of past contamination from hazardous substances, pollutants, and contaminants on Navy and Marine Corps installations**
- **Achieve RIP or RC at:**
  - **100 percent of sites by end of FY2014**
- **Achieve RC Milestone at:**
  - **90 percent of sites by end of FY2018**
  - **95 percent of sites by end of FY2021**
- **Approximately 5,000 sites in ER,N Program**
  - **Installation Restoration (IR) Program**
  - **Munitions Response (MR) Program**

Snapshot of ER,N IR Program – FY14



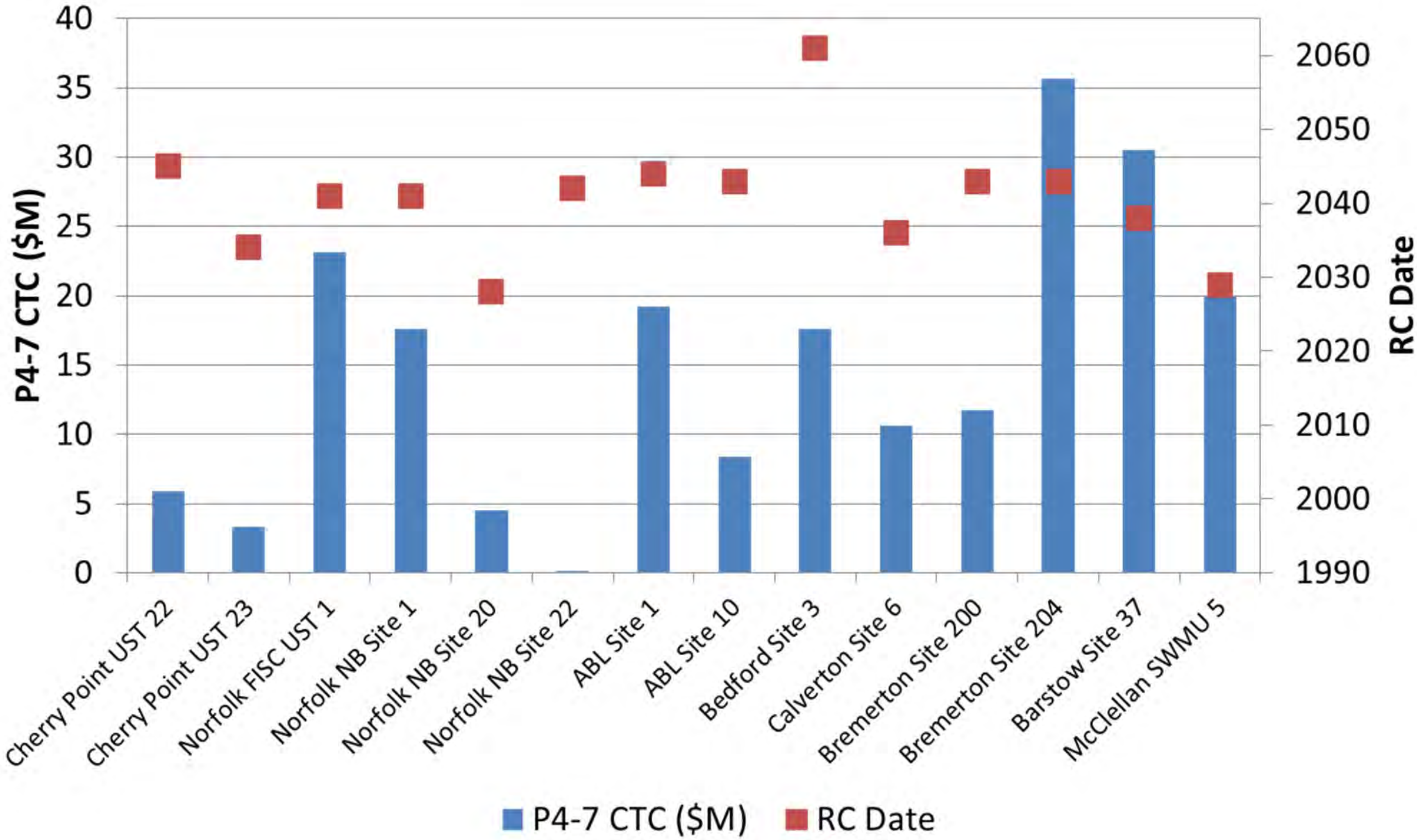


Projects Only

Status of 2018/21 RC Goals

- **183 sites currently not projected to meet RC goal by EOY 21**
  - **Estimated RC dates range between 2021 and 2061**
  - **Phase 4 to 7 CTC estimated at approximately $1B**
- **Majority of the remaining sites have characteristics that make reaching UU/UE difficult**
  - **Large plumes**
  - **Complex hydrogeological conditions**
  - **DNAPL source zones**
  - **Contaminants stored in low permeability zones**
  - **Multiple exposure pathways**
- **Two broad categories of sites emerge**
  - **Large-scale pump and treat systems**
  - **In situ remedies with treatment trains including extended MNA**

Category 1 – Complex Sites with Pump and Treat Containment



Category 1 Example – Area M, NWIRP McGregor

Remedy-in-Place

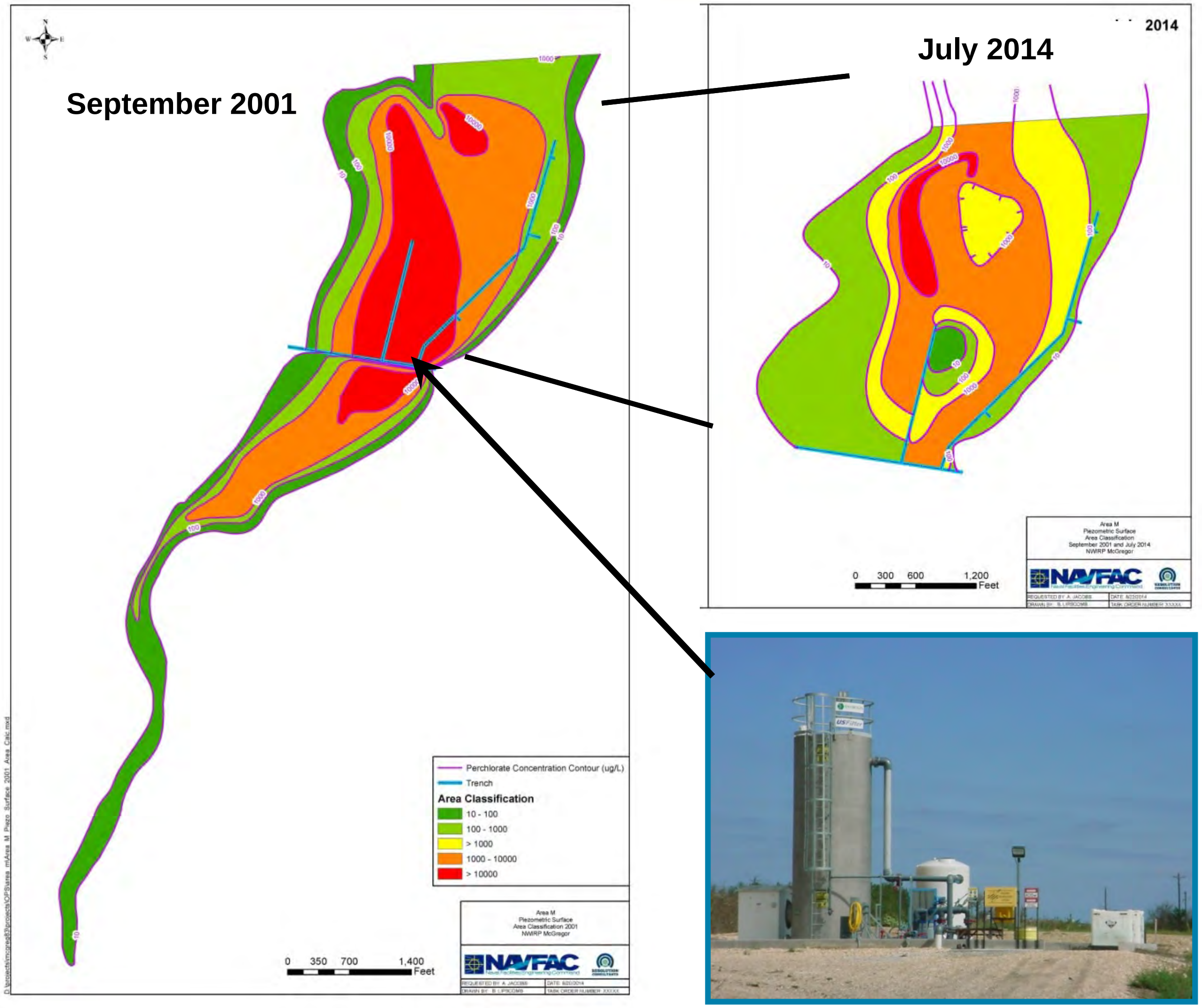
- Mixed CVOC and perchlorate plume
- Pump and treat system cuts off plume at property boundary
- Natural attenuation and biobarriers in downgradient plume

Challenges

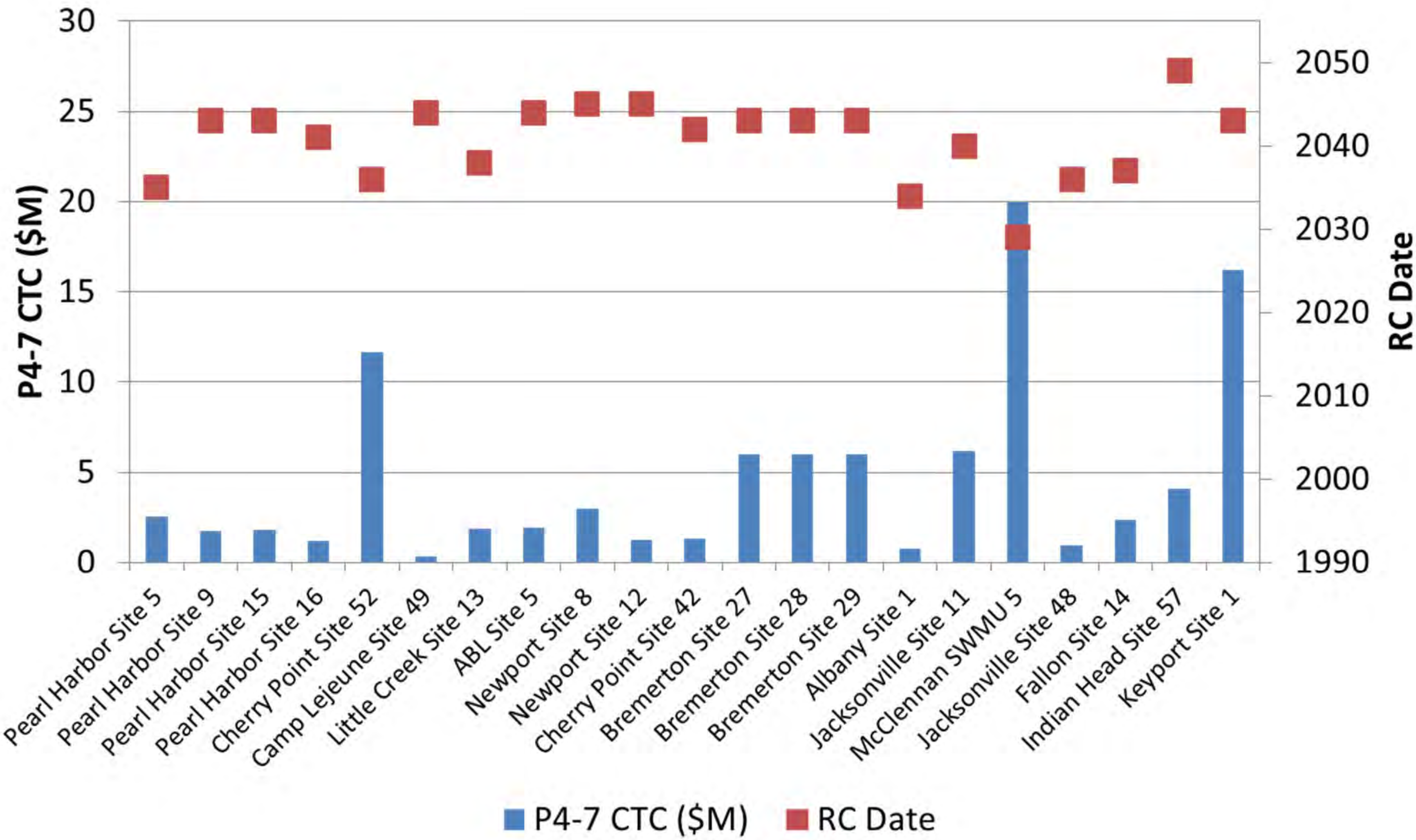
- Significant annual O&M costs
- Extended timeframe

Optimization Focus

- Transitioning from pump and treat to a passive bio-barrier to maintain control of plume



Category 2 – Complex Sites with In Situ Treatment Trains



Category 2 Example – Site 57 NSF-Indian Head, MD

Remedy In Place

–TCE and breakdown products

–Source area: reductive dechlorination

–Downgradient plume: enhanced aerobic bioremediation

–MNA

Challenges

–Expected timeframe > 50 years

–Incomplete understanding of plume architecture

–Preferential pathways due to dense utility in source area

Optimization Focus

–Passive treatment of source area and refinement of timeframe and cost estimates

Alternative Approaches to Managing Complex Groundwater Sites

- **Adaptive management**
  - **Initially controlling exposure pathways (e.g., vapor intrusion, surface water discharge, potable water intake)**
  - **Followed by long-term management of groundwater plumes through a combination of:**
    - Partial source zone treatment
    - Monitored natural attenuation
    - Institutional controls to minimize exposure
    - Containment systems to control migration as necessary
    - Long-term monitoring
- **Formal ARAR waivers**
- **Groundwater management/containment**
- **Alternate concentration limits (ACLs)**
- **Groundwater classification**
- **Continuous optimization throughout remedial process to ensure remedy protectiveness and cost-effectiveness**

Definitions

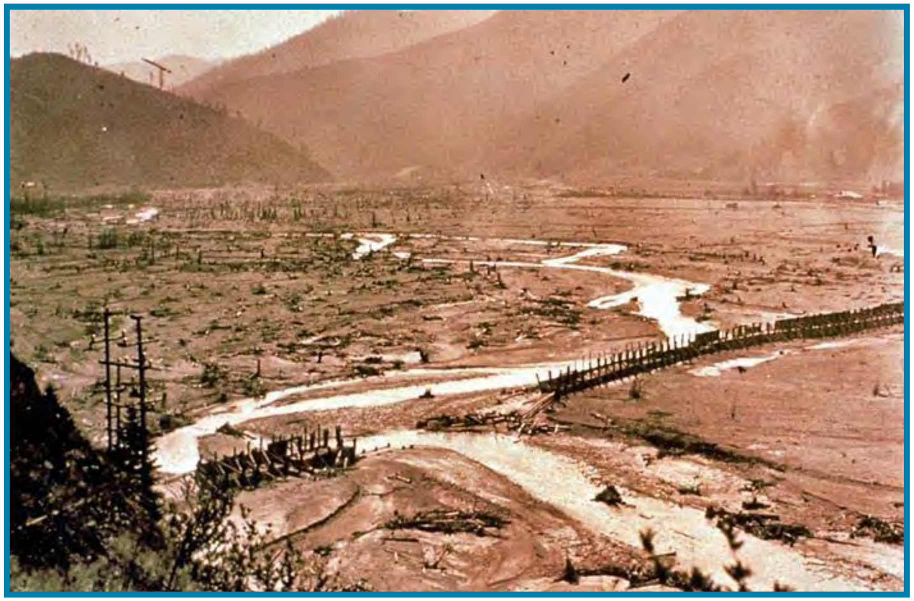
- **Traditional endpoints**
  - **Risk-based cleanup objectives**
  - **ARARs**
- **Alternative endpoints**
  - **Formally waive or substitute for final cleanup standards (e.g., ARAR waivers)**
  - **Alternative goals can be used to guide intermediate milestones, remedy transition points (adaptive site management)**

Context for Alternative Endpoints

- Applicable for use at highly complex sites
- Meet regulatory requirements despite technical limitations
  - Establish common expectations for remedial performance
  - Provide a pathway towards remedy-in-place, long-term management strategies, regulatory closure
  - Manage remedial project risks
  - Use resources more efficiently and sustainably
- Protection of human health and environment remains the primary goal
- Alternative endpoints are no quick or easy fix. Long-term management needed to address residual contamination

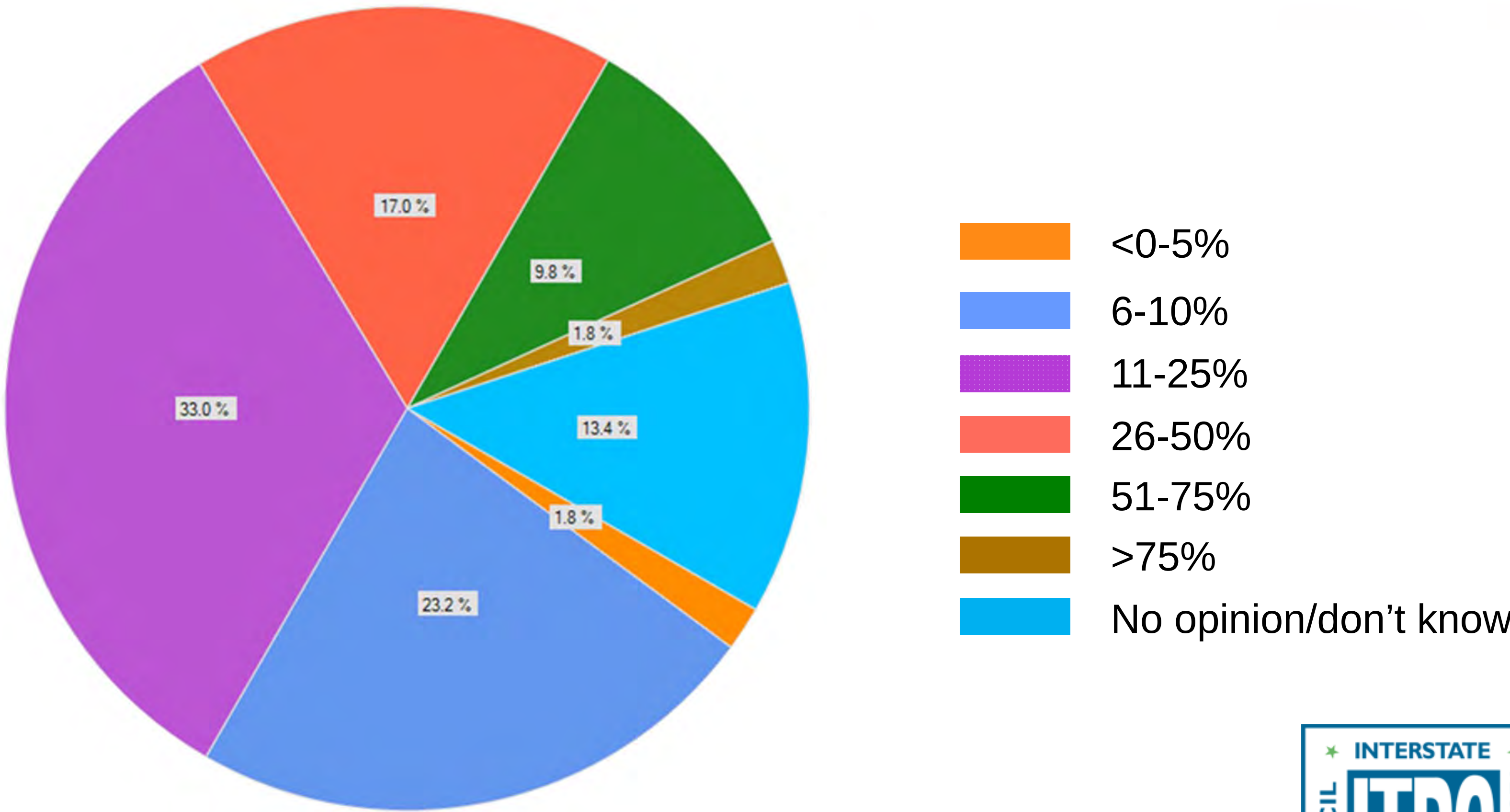
Definition of "Complex Sites"

- **Significant uncertainty around the term "complex site"**
  - **Not a term with a formal or generally-accepted definition**
- **Little agreement in the industry**
  - **Attributes of a complex site**
  - **Percentage of complex sites**



Coeur d'Alene Superfund Site

Percentage of Sites that are Complex
ITRC Survey (2014)



Attributes of Complex Sites

- Highly heterogeneous subsurface geologic environments
- Large releases of contaminants over long timeframes
- Nature and extent of contamination
  - Presence of NAPL, mixtures of contaminants or recalcitrant compounds
  - Levels of contaminants several orders of magnitude above MCLs
- Several years of remedial efforts likely with an indication of "asymptotic" performance (multiple 5-year reviews)
- Restoration lifecycle costs > $20 - $50 million
- Other imitations to groundwater restoration (e.g., political and legal issues)

WHY ALTERNATIVE ENDPOINTS?

Project Risk Identification at Complex Sites

- **Complex site setting**
  - **Highly heterogeneous geology**
  - **Contaminants in fractured rock, sequestered in low permeability units**
  - **Widespread regional contamination**
  - **Long-lived inorganic contaminants**
- **Potential project risks**
  - **Lack of exit strategy/ pathway to site closure**
  - **High cost of iteratively implementing, optimizing technologies**
  - **Long cleanup timeframe**

Types of Alternative Endpoints

Alternative Endpoints	CERCLA	RCRA	State(s)*
ARAR waivers	X		
Technical impracticability (TI) waivers	X	X	
Greater risk waivers	X		
Other waivers (Interim remedy, inconsistent application of state standards, fund balancing, equivalent performance)	X		
Alternate Concentration Limits (ACLs)	X	X	
Groundwater management/containment	X	X	X
Groundwater reclassification	X	X	X

Various terminology is used under different state cleanup programs

Types of Other Approaches

Other Approaches	CERCLA	RCRA	State(s)
MNA over long timeframes	X	X	X
Adaptive site management	X	X	X

Types of ARAR Waivers

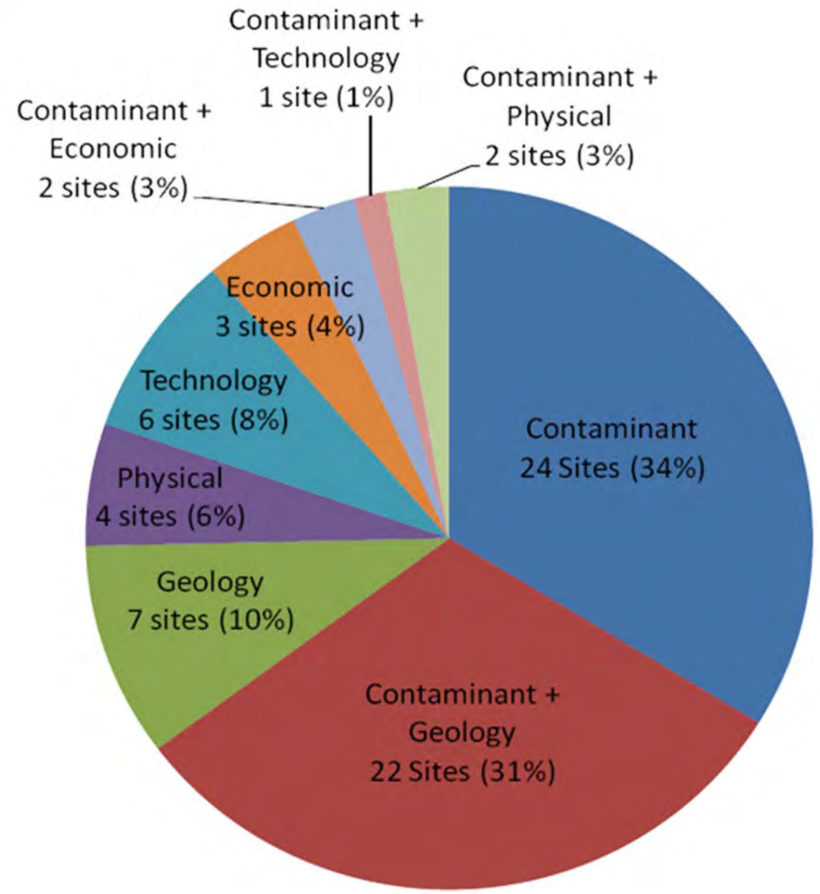
Technical Impracticability Waiver	Where compliance with ARARs is technically impracticable from an engineering perspective within a reasonable timeframe
Greater Risk to Health and the Environment	Where remedy results in greater risk
Equivalent Standard of Performance Waiver	Where remedy results in equal benefit
Interim Measure Waiver	Where final remedies will be implemented later
Inconsistent Application of State Standard Waiver	Where a state standard has not been consistently implemented
Fund Balancing Waiver	Where money would be better spent elsewhere

TI Waivers: Process

- Applies at sites where it is "technically impracticable to meet cleanup requirements within a reasonable timeframe"
  - Applies to specific contaminants, ARARs
  - Applies within a defined area and vertical extent (TI zone)
- Site-specific TI evaluation is required (EPA, 1993)
  - Description of the location (area and depth) and ARARs for which TI waiver applies; conceptual site model (CSM); evaluation of restoration potential; proposed remedial strategy
- Stakeholder consensus is critical
- Documented in ROD, ROD amendment or Explanation of Significant Difference (ESD)

TI Waivers: Primary Reasons

- **75% of all TI waivers are based on contaminant and/or geologic setting**
  - **DNAPL**
  - **Extensive regional contamination (e.g., mining sites)**
  - **Immobile, low risk**
  - **Fractured rock, karst environments**



TI Waivers: Hydrogeology

Hydrogeologic Setting	# Sites	# Sites where hydrogeology led to TI	Percent of Total
Fractured rock/karst/mining voids	36	21	47%
High heterogeneity	10	2	13%
High heterogeneity overlying bedrock	4	-	5%
Layered high- and low-permeability	9	2	12%
High-permeability sands and gravels	7	-	9%
High-permeability sands and gravels overlying bedrock	2	-	3%
Low-permeability silts and clays	6	6	8%
Low-permeability silts and clays overlying bedrock	3	-	4%
TOTAL	77	31	100%

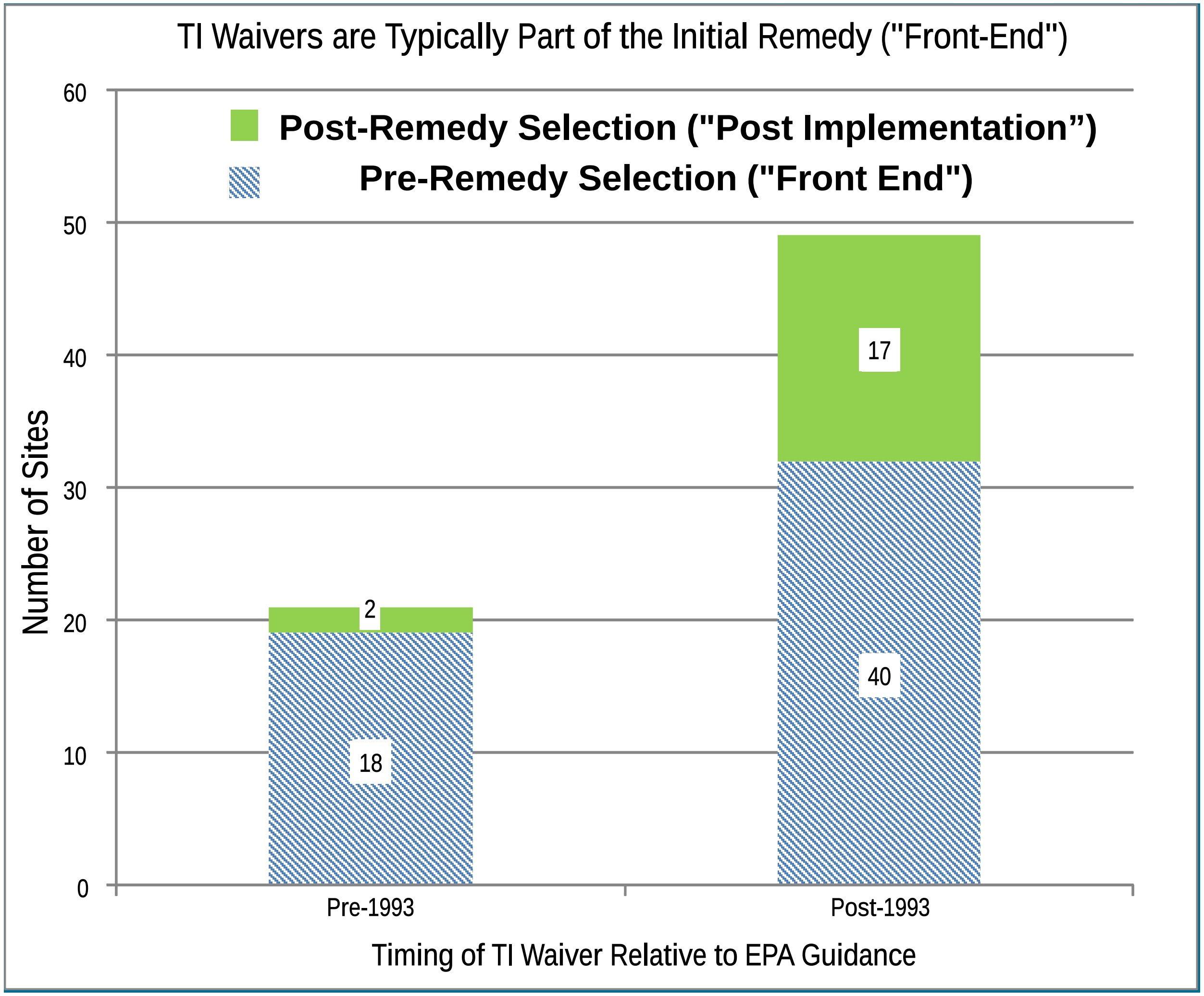
TI Waivers: Contaminant Characteristics

- **NAPL is present at 56% of all sites**
- **Mix of various contaminants**
  - **Chlorinated solvents**
  - **Creosote/PAHs**
  - **Metals/mine drainage**

Compounds	# Sites
Chlorinated solvents, VOCs	16
Coal tar, PAHs, creosote	11
Metals	14
BTEX	1
PCBs	2
Pesticides	2
Mixture (2 or more types)	20
Mixture (3 or more types)	11
Total	**77**

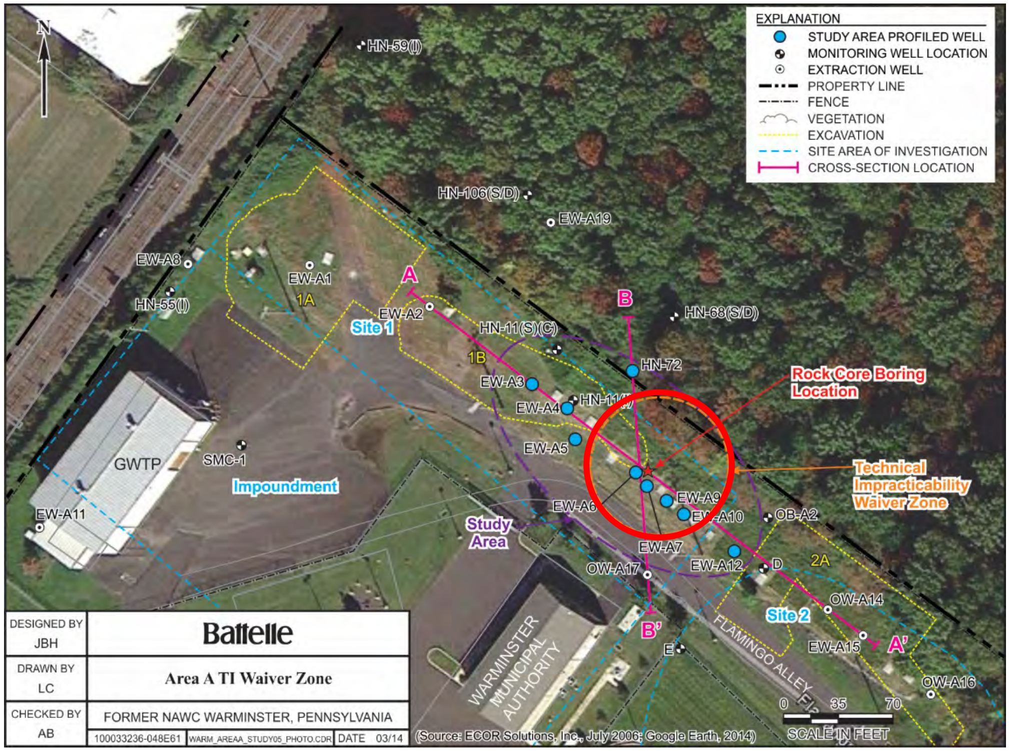
TI Waivers: Timing Considerations

- **Most TI waivers (75%) are "front-end" (pre-ROD), based on RI/FS evaluations**



TI Waivers: Case Study
Former NAWC Warminster, PA

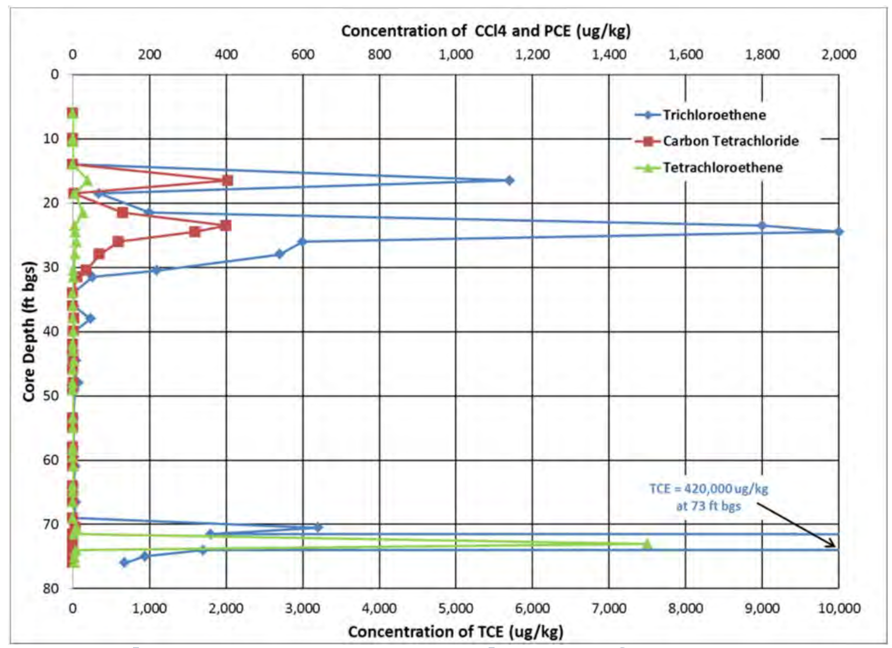
- **OU1A – Area A groundwater**
- **Sludge disposal area**
- **Added to NPL in 1989**
- **TCE, PCE and carbon tetrachloride**



- **DNAPL likely present in fractured bedrock**

TI Waivers: Case Study
Former NAWC Warminster, PA (Cont'd)

- **Pump and treat system operating since 1999**
- **Monitoring and institutional controls**
- **TI waiver in 2000 ROD**
- **TI zone 80 feet in diameter and 75 feet deep**
- **Remediation timeframe estimated at 200 years**
- **Vertical rock core profiling in source area to enhance conceptual site model**



Rock core concentrations of PCE, TCE, and carbon tetrachloride

Greater Risk Waiver
Onondaga Lake LCP Bridge Street Site, New York

- **DNAPL mercury contamination**
- **Managed in place because of the greater risk of exposure during excavation and off-site transport**
- **Remedy included greater risk waiver, slurry wall, pump-and-treat system, excavation of shallow soils, temporary cap, and long-term monitoring**

Alternate Concentration Limits (ACLs)

- **Replaces or modifies groundwater cleanup requirements**
- **Only applies at sites where contaminated groundwater discharges to surface water**
  - **Accounts for dilution that occurs prior to point of exposure**
- **Basis for ACL value in groundwater**
  - **Can be calculated from surface water quality criteria (assuming dilution, perhaps using mixing zone model)**
  - **Can be risk-based value**
- **Formal process under CERCLA (EPA, 2005) and RCRA**

ACLs: Case Study
Former Naval Station, Long Beach, CA

- **Sites 1 and 2**
- **Former solid waste landfill (1940s-1960) and drum storage area (1960s-1980s)**
- **Primary contaminants in groundwater**
  - **TCE (1,000 µg/L)**
  - **DCE (86,700 µg/L)**
  - **VC (14,000 µg/L)**
- **Remedial action objective for groundwater**
  - **Minimize migration potential**

ACLs: Case Study
Former Naval Station, Long Beach, CA (Cont'd)

NAVFAC

- **Established ACLs based on CA Ocean Plan Criteria**
  - **ACL point of compliance at land's edge**
  - **Followed air sparge/vapor extraction system to prevent migration to surface water**
  - **MNA as polishing step**
  - **VC cleanup goal of 13 µg/L**
- **Currently in long-term management (RC in 2007)**
  - **Maintaining LUCs, five-year reviews**

Groundwater Management

- **Used to define areas that exceed water quality standards and manage contaminants in place**
- **Terminology and meaning varies from state to state**
  - **Sometimes indicates cleanup is technically infeasible**
  - **Can be used for tracking land use controls**
- **Formal designations in federal and state cleanup programs**
  - **Plume management zone (Texas)**
  - **Technical impracticability (Wyoming, Georgia)**
  - **Waste Management Areas (RCRA, CERCLA)**

Groundwater Management
Three Examples

Description	Georgia	Texas	Illinois
Designation	Technical impracticability (TI) zone	Plume management zone (PMZ)	Groundwater management zone (GMZ)
Regulation	Part 3 of the Georgia Voluntary Remediation Program Act (2009)	30 Texas Admin. Code 350.33(f)	35 Ill. Adm. Code Part 620.250
Jurisdiction	Georgia Voluntary Remediation Program	Texas Risk Reduction Program	Illinois EPA and Site Remediation Program
Purpose	• Site delineation or remediation not required beyond the point of TI, if the site does not pose imminent or substantial danger	• Modifies groundwater cleanup objectives by controlling and preventing the use of and exposure to groundwater	• For areas that do not yet meet cleanup standards • Used to delineate and track institutional controls
Example site	May include DNAPLs in fractured bedrock settings	Naval Weapons Industrial Reserve Plant (NWIRP) Dallas, Texas	Joliet Army Ammunition Plant, Illinois

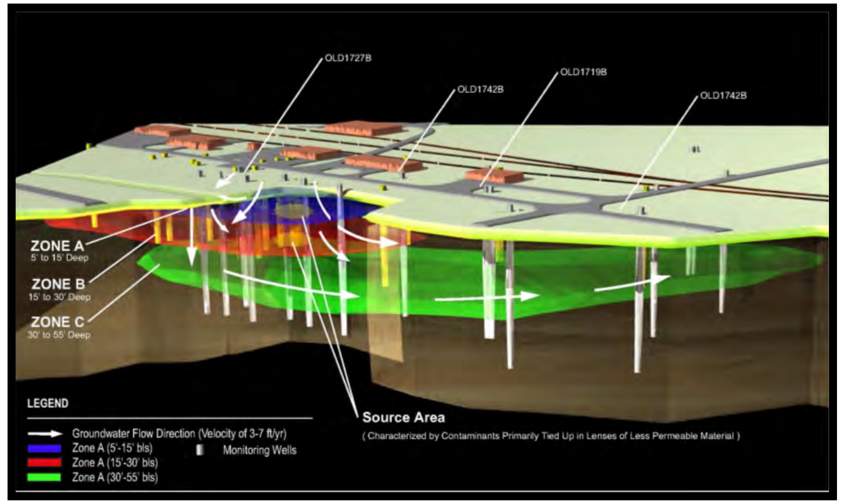
Other Approaches

- **MNA over long timeframes**
- **Adaptive site management**

MNA over Long Timeframes

- Monitoring and/or limited action, approved over long timeframe (e.g., ~100 years)
- Applied at sites where circumstances warrant and stakeholders accept long timeframe
  - Timeframe for all other remedial options may be similar
- No separate formal process
- Avoids controversy of ARAR waivers
- MNA is fairly well-accepted, low cost, may be greener

MNA Over Long Timeframes
Case Study: Former NTC Orlando, FL



- **Site setting (vehicle maintenance, waste oil/fuel drums, wash racks, TCE likely present as DNAPL)**
- **Past remedial activities**
  - **ISCO (Fenton's) as an interim remedy to reduce total chlorinated VOCs below 500 µg/L (lack of hydraulic connection, preferential flow path, rebound due to back-diffusion)**
  - **Enhanced bioremediation**

MNA Over Long Timeframes
Case Study: Former NTC Orlando, FL (Cont'd)

- **MNA multiple lines of evidence (stable plume, favorable geochemical conditions, functional genes present for dehalogenation, reductive dechlorination products)**
- **Approach supported by Partnering Team despite remedial timeframe of 60-70 years with source removal and VOC concentrations 10-100 times greater than MCLs**

Summary – Alternative Endpoints and Approaches

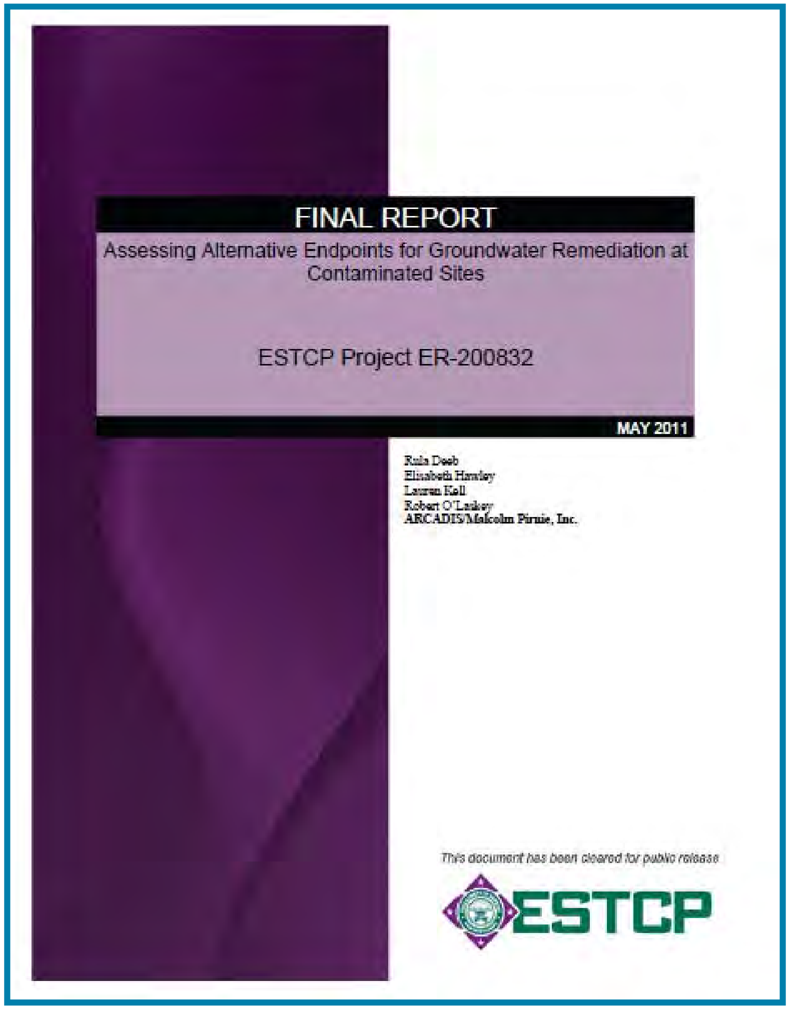
- **Several options for alternative endpoints and other approaches for groundwater at complex sites**
- **Applicable under CERCLA, RCRA, and/or several state cleanup programs**
- **Long-term management of residual contamination likely needed**
- **Remediation risk management principles can be used to identify, evaluate, mitigate, monitor and document project risks**

Summary – Alternative Endpoints and Approaches (Cont'd)

- **Factors that increase likelihood of implementing an alternative endpoint**
  - **Broad stakeholder agreement on conceptual site model**
  - **Controlled risks/threats (incomplete pathways)**
  - **Contingency measures to protect human health and environment**
  - **Durable and reliable ways to manage long-term residual contamination**
  - **Receptiveness of regulatory agency and stakeholder**
  - **Collaboration between stakeholders**
  - **Communication strategies to reduce barriers**

Overview of Past and Ongoing Related National Efforts

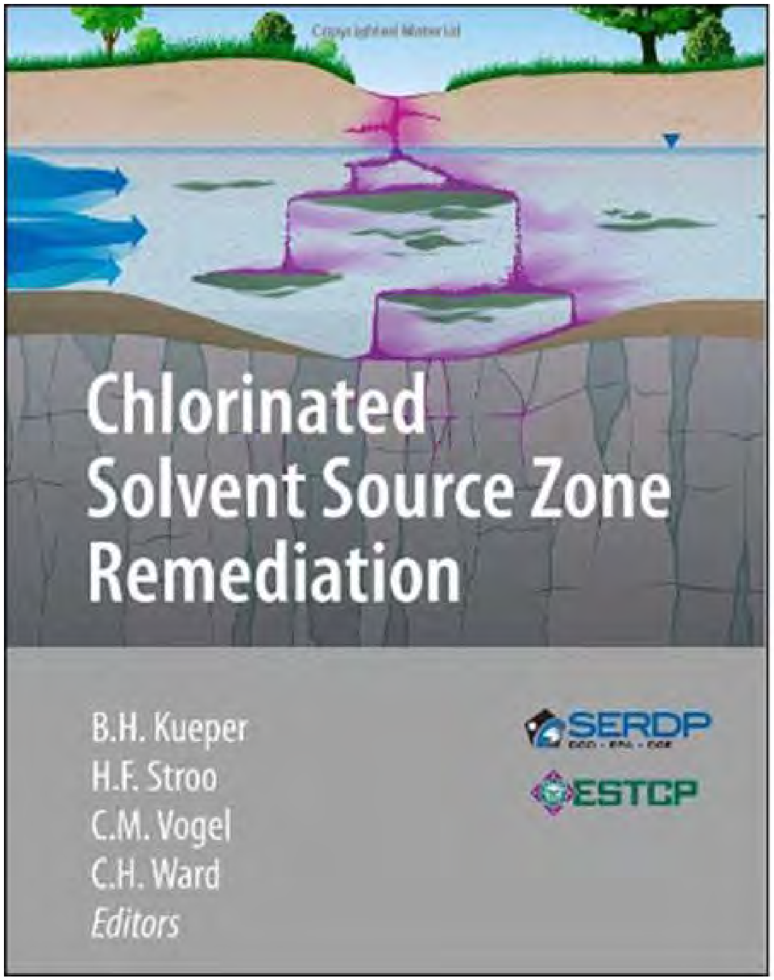
National Efforts SERDP & ESTCP



- **Several program focus areas are relevant to complex sites**
  - **Fractured bedrock**
  - **DNAPL source zone remediation**

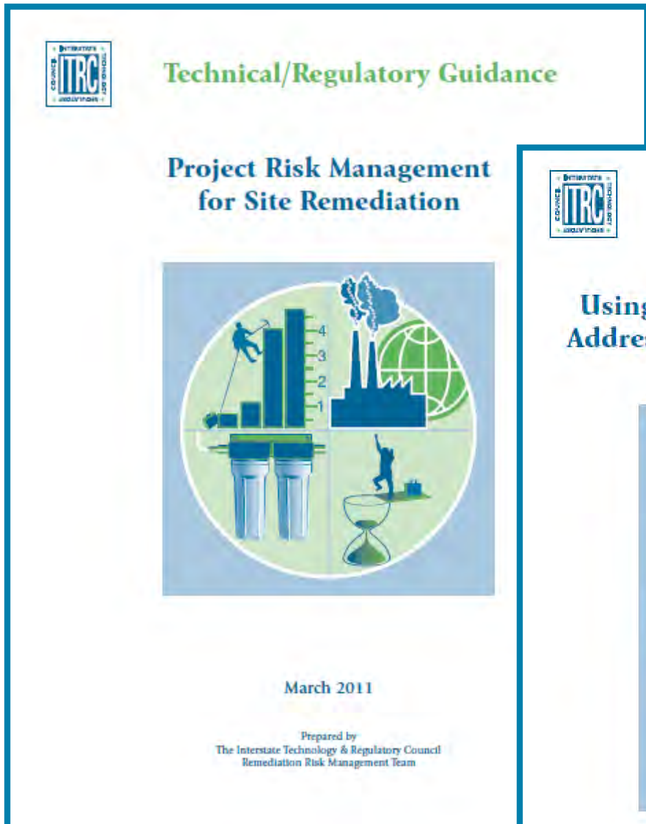
serdp-estcp.org

National Efforts
SERDP & ESTCP



CHAPTER 17 GROUNDWATER REMEDIATION AND THE USE OF ALTERNATIVE ENDPOINTS AT HIGHLY COMPLEX SITES 627

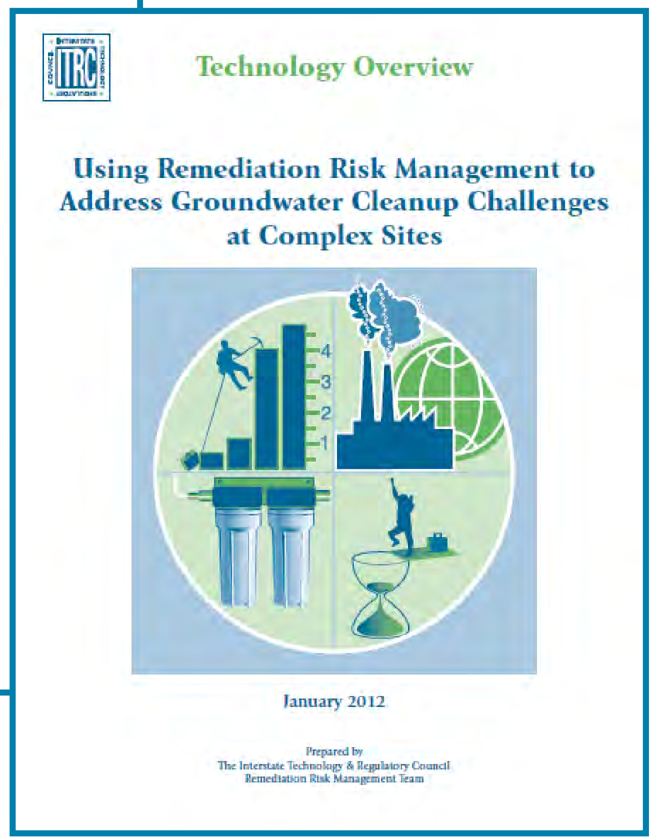
National Efforts
ITRC


Technical/Regulatory Guidance

Project Risk Management for Site Remediation

March 2011

Prepared by
The Interstate Technology & Regulatory Council
Remediation Risk Management Team


Technology Overview

Using Remediation Risk Management to Address Groundwater Cleanup Challenges at Complex Sites

January 2012

Prepared by
The Interstate Technology & Regulatory Council
Remediation Risk Management Team

2014 – 2017

Remediation Management of Complex Sites

www.itrcweb.org

National Efforts
NRC

National Research Council

National Efforts
The National Academies

BEST PRACTICES FOR RISK-INFORMED DECISION MAKING REGARDING CONTAMINATED SITES

SUMMARY OF A WORKSHOP SERIES

Committee on Best Practices for Risk-Informed Remedy Selection,
Closure and Post-Closure of Contaminated Sites

Nuclear and Radiation Studies Board
Division on Earth and Life Studies

Science and Technology for Sustainability Program
Policy and Global Affairs Division

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www.nap.edu

National Efforts
EPA

EPA United States Environmental Protection Agency

Summary of Technical Impracticability Waivers at National Priorities List Sites

REPORT WITH GENERAL TECHNICAL IMPRACTICABILITY SITE INFORMATION SHEETS

EPA United States Environmental Protection Agency

OSWER 9283.1-34

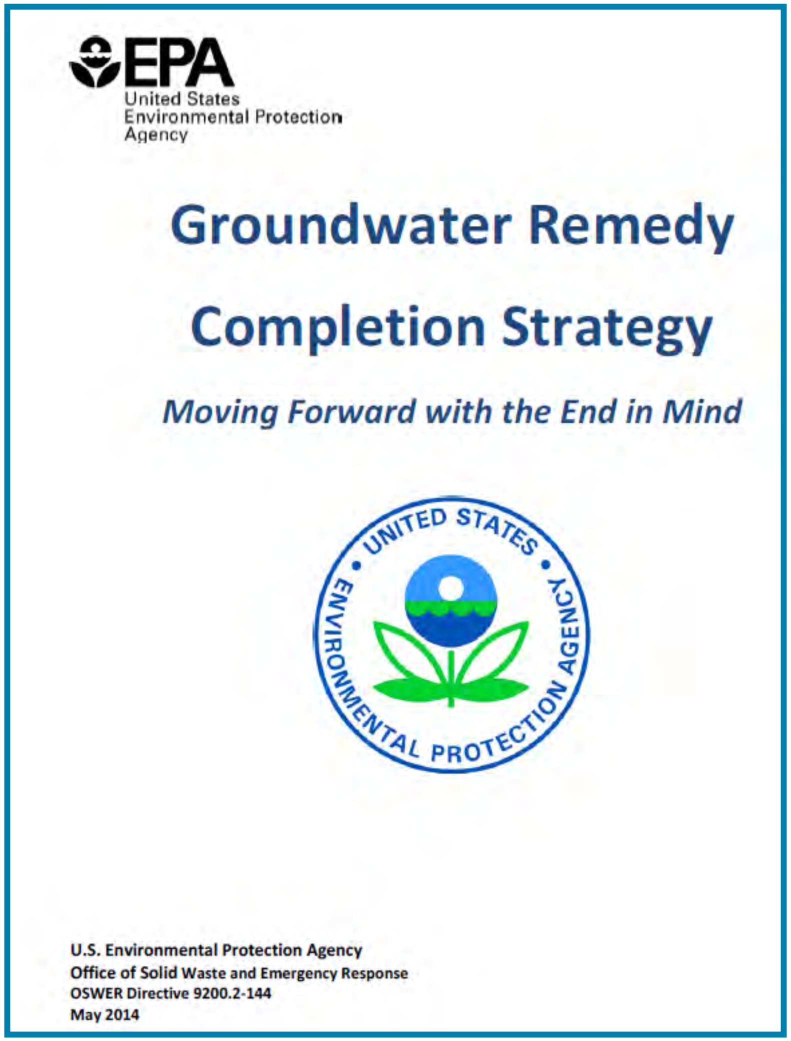
July 2011

Groundwater Road Map

Recommended Process for Restoring Contaminated Groundwater at Superfund Sites

www.epa.gov

National Efforts
EPA (Cont'd)


EPA United States Environmental Protection Agency

Groundwater Remedy Completion Strategy

Moving Forward with the End in Mind

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
OSWER Directive 9200.2-144
May 2014

http://www.epa.gov/superfund/health/conmedia/gwdocs/pdfs/EPA_Groundwater_Remedy_Completion.pdf

Summary

- **Several options for alternative endpoints and other approaches for groundwater at complex sites**
- **Applicable under CERCLA, RCRA, and/or several state cleanup programs**
- **Long-term management of residual contamination likely needed**
- **Renewed interest in alternative endpoints and approaches over the past several years due to many drivers**

Questions

Wrap Up

- **Please complete the feedback questionnaire at the end of this webinar. We are counting on your feedback to make this webinar series relevant!**

- **Next OER2 Webinar Info….**

LTM Requirements – A Smarter, Easier, and Better Approach to Reporting and SAPs

Presenter: Ken Bowers (NAVFAC LANT)

Date: July 22nd, 2015

Time: 11:00PST / 14:00 EST

- **Thank you for participating!**