Groundwater Remediation at Complex Sites:

Case Studies of Alternative Endpoints and Strategies

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Outline

- Overview of alternative endpoints/strategies
- ITRC's interest in this topic
- Case studies
  - Groundwater management: Illinois, Texas and Tennessee
  - Low-threat closure: California
  - Adaptive site management: New York

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Alternative Endpoints: Overview

- ARAR waivers
  - Technical impracticability
  - Greater risk
  - Equivalent performance
  - Inconsistent application of state standards
  - Fund balancing
  - Interim remedy

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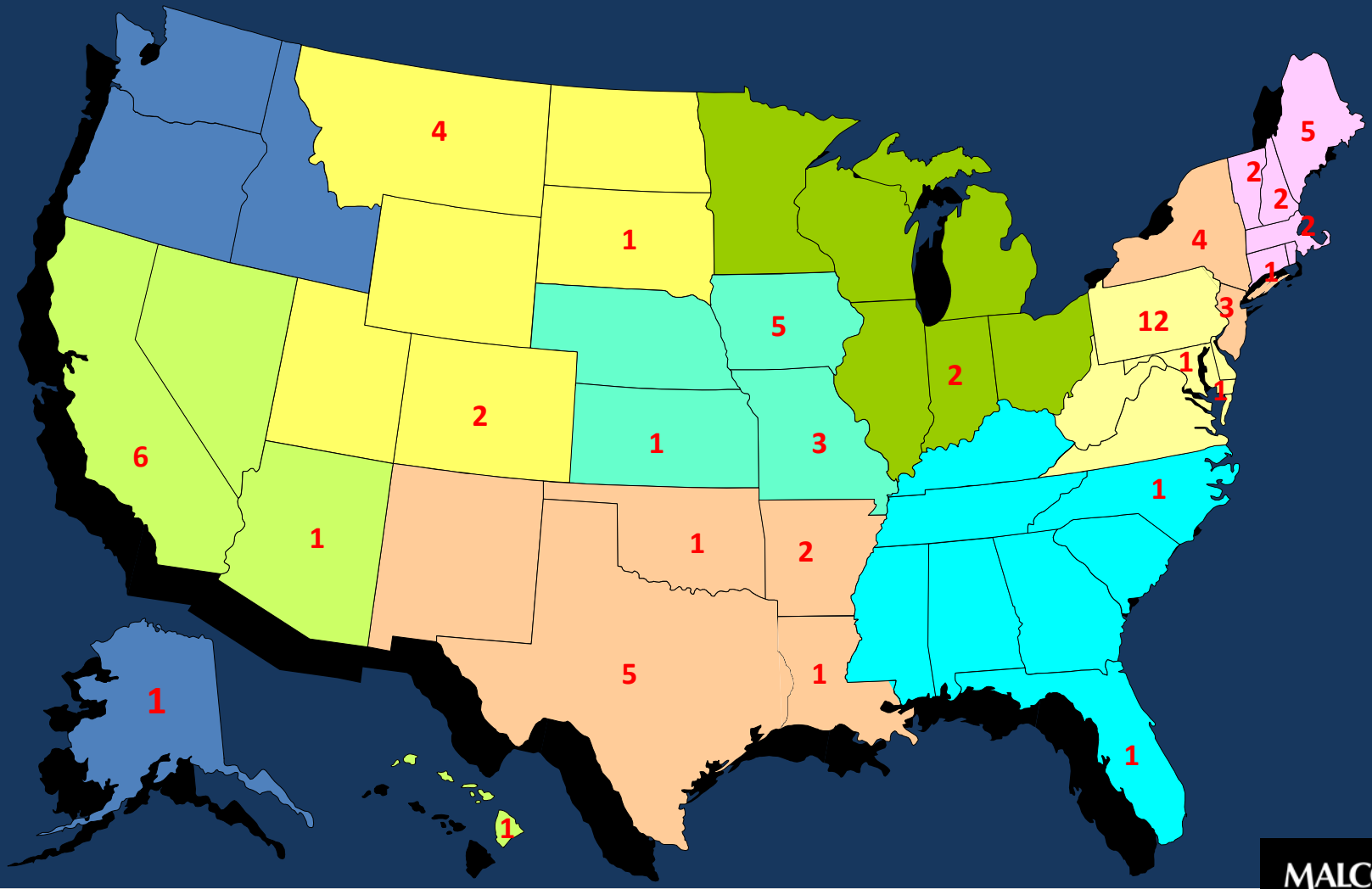
Sites with TI Waivers (Groundwater)



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Alternative Endpoints: Overview (Cont'd)

- Alternate Concentration Limits (ACLs)
  - ARARs replaced by other values
  - Exception set up to account for groundwater that is discharging to surface water to rectify discrepancy between groundwater and surface water standards
- State designations
  - e.g., CA containment zone (similar to a TI zone) which is considered at sites where cleanup to water quality objectives is technologically and/or economically infeasible. Monitoring is often required to ensure that the plume is contained. CZ sites are expected to remain open indefinitely

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Alternative Strategies: Overview

- Long-term goal may be the same (e.g., MCLs) but approach clearly communicates limitations of meeting goals throughout contaminated zone
- Examples
  - MNA over long timeframes
  - Remediation to the extent practicable
  - Adaptive site management
  - Designated points of compliance (groundwater management zones, containment zones)
  - Groundwater reclassification/classification exemptions
  - Low-risk closure

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ITRC Interest in this Topic

- One of the desired deliverables from ITRC's RRM team is an overview document on technical impracticability assessments
- RRM process
  - Identify strategies to mitigate potential risk events and position contingency response decision logic before a risk event occurs
- Application of RRM at complex sites
  - Risk: Traditional remediation objectives cannot be achieved in the near term
  - Strategy: Alternative endpoints/strategies may be appropriate and protective ways to manage contamination

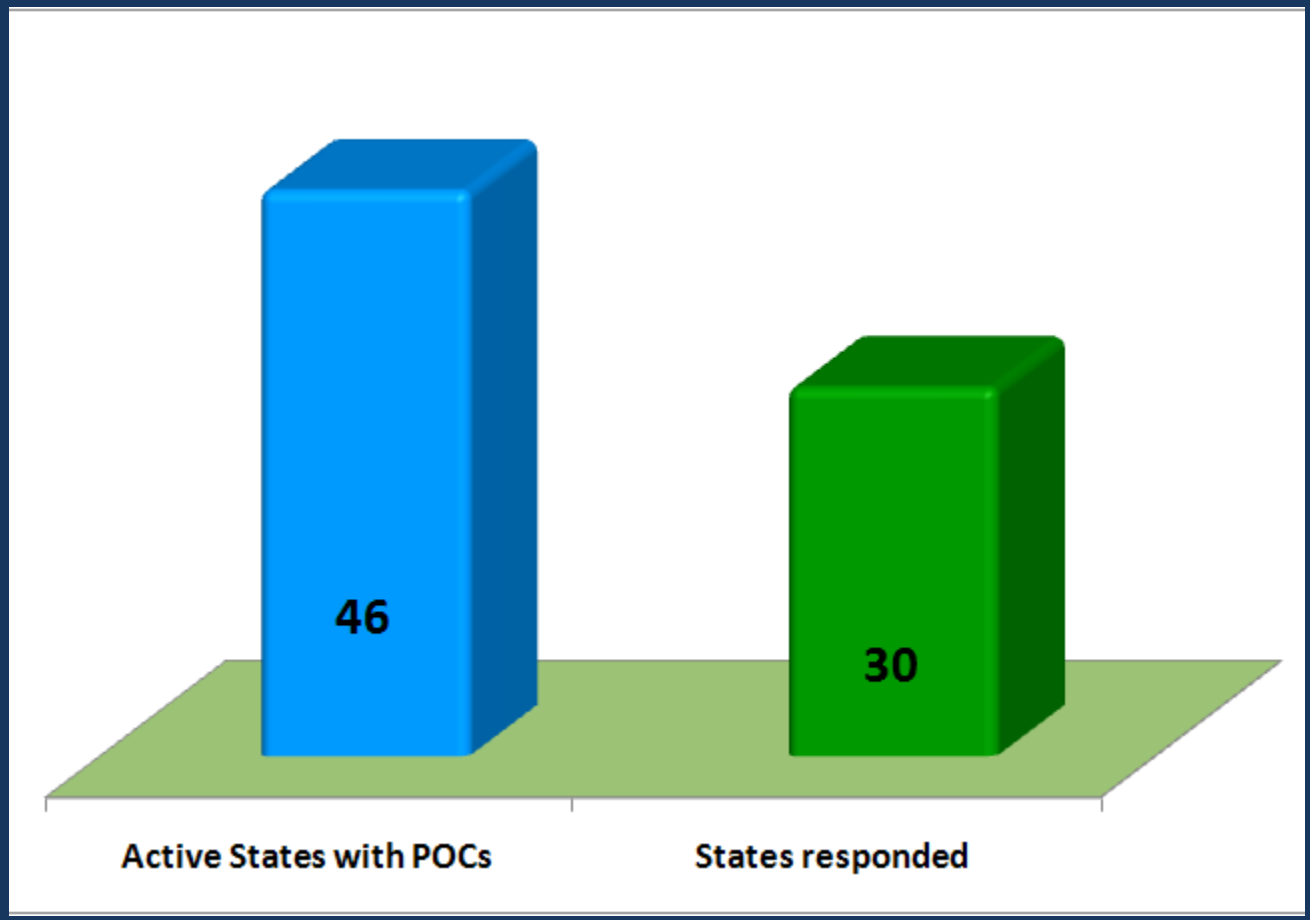
ITRC Interest in this Topic (Cont'd)

- There has been a resurgence of interest in this topic
  - EPA: Summary of sites with TI Waivers since the program's inception; possible updates to 1993 guidance
  - ESTCP: Information/case studies on all alternative endpoints
- Per the direction of ITRC's Board, a focused survey solicited input from state Points of Contact (POC) on the proposed topic
- Background information (detailed outline, table of contents) of the overview document was attached to the survey and provided to state POCs

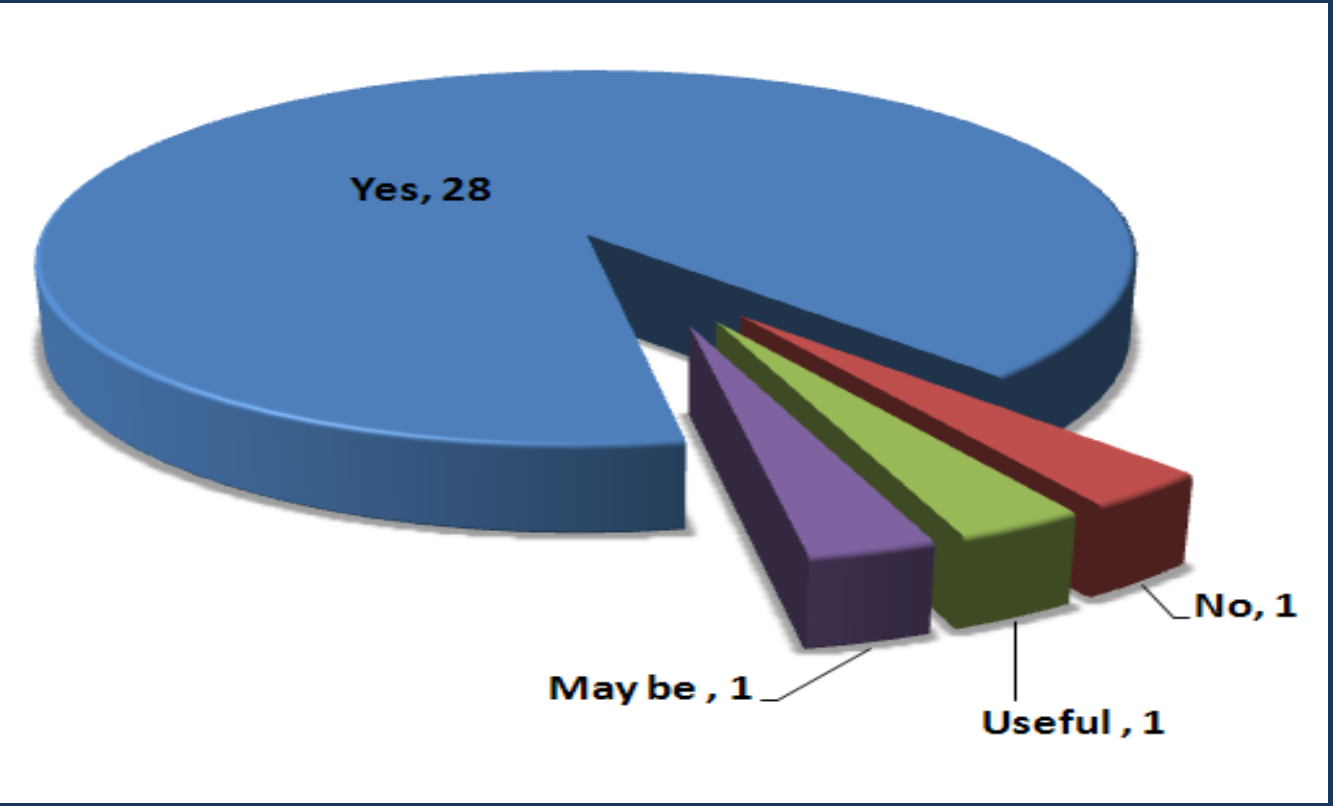
ITRC Survey: Sample Questions

- **Q#17**: Which of the following alternatives are considered in your state/program area (LUCs, LTM, MNA, ACL, MZA, TI, etc.)?
- **Q#18**: … list the options your state/program area considers when selected remedies make progress toward remedial objectives but are not on track to meet them during initial projected time to completion
- **Q#19**: Does your state/program area follow a protocol for considering alternative remedial objectives, if the selected remedies are not on track to meet established remedial objectives?
- **Q#26**: Would an overview document on how to do a technical assessment of whether any remedy, based on currently-available technology, would meet remedial objectives be useful for your state/program area?

ITRC Survey: Results



ITRC Survey: Results



ITRC Survey - Results

- Overview document will not delve into policy issues. It will present the subject of technical infeasibility of site cleanup within the context of RRM
  - Remedy failure due to technical infeasibility as a potential risk event
  - How to determine if such a potential risk event is likely
  - How to mitigate potential risk event
- Other survey results
  - Currently at least 19 states consider technical impracticability in their programs
  - Most common alternatives: MNAs, LUCs
  - Least common alternatives: MZA, Other

CASE STUDIES
Alternative Endpoints & Alternative Strategies

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Case Studies: Approach

- Case studies meant to show examples of the variety of approaches used at complex sites
  - How we can improve groundwater cleanup/management efforts
- What case studies are not meant to do
  - Not meant to clarify policies, viewpoints of regulators and other stakeholders, or reasons for decision-making
- Case study information obtained from public documents
  - State Register, State Executive Orders
  - Statements of Basis
  - RODs, ESDs, ROD Amendments, Five-Year Review Reports

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Groundwater Management

Covers variety of containment/groundwater management zone terminology

Illinois, Texas and Tennessee

Groundwater Management

- At least 13 states consider some designation for groundwater containment in their corrective action policies, such as groundwater management zones, containment zones, and groundwater classification exemption areas
- Designation varies by state
- Common elements for various designations
  - Used to define areas that currently exceed water quality standards
  - Can simplify tracking for deed restrictions, water use restrictions, and other institutional controls
  - Have been used to close sites (NFA letters where MCLs have not been achieved throughout contaminated zones)

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Different State Designations

- Plume management zone (Texas)
- Site-specific impaired groundwater (Tennessee)
- Groundwater management zone (Delaware, Illinois, New Hampshire)
- Containment zone (California SWRCB)
- Classification exemption area (New Jersey)
- Urban setting designation (Ohio)
- Technical impracticability zone (Wyoming, Georgia)

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Overview of Approaches in States

Description	Illinois	Texas	Tennessee
Designation	Groundwater management zone (GMZ)	Plume management zone (PMZ)	Site-specific impaired groundwater
Regulation	35 Ill. Adm. Code Part 620.250	30 Texas Admin. Code 350.33(f)	TDEC Chapter 1200-4-3
Jurisdiction	Illinois EPA and Site Remediation Program	Texas Risk Reduction Program	Tennessee Water Quality Control Board
Purpose	• For areas that do not yet meet cleanup standards • Used to delineate and track institutional controls	• Modifies groundwater cleanup objectives by controlling and preventing the use of and exposure to groundwater	• For contaminated groundwater where the Board finds it is not reasonable or is not technologically feasible to fully remediate (petition process)

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Case Study 1: Joliet AAP, Illinois

- Remedial challenges
  - Explosives-contaminated groundwater with cleanup timeframes ranging from 20 to 340 years
- Approach
  - Three GMZs established around areas that exceeded Class I and Class II state standards
  - Contamination within GMZs addressed via limited action
    - Deeding and zoning restrictions
    - Periodic site inspections
    - Groundwater and surface water monitoring
    - Natural attenuation

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Case Study 2: Hardy Street Rail Yard, TX

- TCEQ Voluntary Cleanup Program
- Remedial challenges
  - Diesel plume (NAPL over a 650-ft long area)
  - Stable/declining chlorinated solvent plumes in groundwater
- Approach
  - Established PMZ, recorded in real property records
  - NAPL recovery to the extent practicable (17 recovery wells; 80,000 gallons of diesel removed)
  - MNA for residual NAPL and chlorinated solvents
  - 2008: TCEQ issued a Phased Conditional Certificate of Completion, approving residential land use with restrictions

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Case Study 3: Porter Cable/Rockwell Site, TN

- TDEC Water Quality Control Board site
- Remedial challenges
  - Slowly-moving chlorinated solvent plume
  - Would attenuate naturally before ever leaving the property
- Approach
  - "Site-specific impaired groundwater" classification within boundary
  - Enhanced biodegradation by nutrient injection
  - Deed restrictions against use of groundwater, residential property uses
  - General use criteria apply beyond the boundary

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Case Study 4: Isabella/Eureka Mine Site, TN

- TDEC Water Quality Control Board site
- Remedial challenges
  - Former mining operations created acid mine drainage, metals, low pH
  - Property was abandoned in bankruptcy court
- Approach
  - “Site-specific impaired groundwater” classification
  - Monitoring program to assure protection of human health and environment

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Summary: Groundwater Management

Approach	Description
Goal	Manage (identify and track) long-lasting contamination that is not a threat to human health and environment; identify and implement appropriate remedial responses
Applicability	Has been used at a variety of state-lead sites, RCRA sites and CERCLA sites
Conceptual site model	Would indicate that plume is stable or shrinking, or that hydraulic containment system is effective
Remedy selection	Containment approach, can be thought of as groundwater reclassification
Implementation	Varies by state. Work with state lead agency to determine procedural requirements

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Low-Threat Closure

"Low-threat" closure applicable at sites that are expected to reach cleanup standards under natural conditions within a reasonable timeframe. This is <u>unlike</u> CA containment zones (CZs) which are intended for sites where residual contamination is not expected to degrade significantly over time, and where cleanup to water quality objectives is technologically and/or economically infeasible

California

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Low-Threat Closure

- Recent draft final report on low-threat chlorinated solvent sites (SF RWQCB, 2009)
- Presents 9 criteria for site closure, consistent with existing RWQCB policy

Description	California
Designation	Low-threat closure
Regulation	35 Ill. Adm. Code Part 620.250
Jurisdiction	Regional Water Quality Control Board, SF Bay Region
Purpose	Close sites that pose little threat to human and ecological health, water quality and beneficial uses but do not yet meet cleanup standards at all locations

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Case Study 5: Intel Fab 1, California

- Lead agency SF Bay RWQCB
- Remediation challenges
  - Low-level asymptotic contaminants above cleanup goals
- Approach
  - Containment zone established under Resolution 92-49
  - Recently rescinded containment zone
  - Issued low-threat closure
- Similar story at Norge Cleaners, Napa, CA
  - Low-threat closure for residual VOCs (maximum concentration: 700 µg/L)

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Summary: Low-Threat Site Closure

Approach	Description
Goal	Close sites before final cleanup goals are reached in all locations, as long as low-threat conditions
Applicability	Sites where plume is expected to reach cleanup standards under natural conditions
Conceptual site model	Basis for expectation of reaching cleanup standards under natural conditions (attenuation rates, lack of exposure)
Remedy selection	Applicable to site closure stage of cleanup, rather than during remedy selection
Implementation	Process laid out in draft SF RWQCB document (2009) Work with state regulator for implementation

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Adaptive Site Management

Iterative, rather than linear, path to site closure (has been illustrated as a meandering river). The remedial approach may be revisited and altered over time

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Adaptive Site Management

- Applicable at sites where uncertainties are high and the path to site closure is unclear
  - Sites are likely highly complex, may be situated in fractured rock environment
  - Multiple pilot studies may be conducted
  - Tools and metrics used may be experimental, costly
  - To maximize cost-benefit, establish short-term goals, metrics and decision points throughout remedial process

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Case Study 6: Watervliet Arsenal, NY

- RCRA site, under lead agency NYSDEC
- Remediation challenges
  - Chlorinated solvents present in fractured rock
- Approach
  - Five years of $KMnO_4$ injections, post-injection rebound monitoring, long-term monitoring
  - Decision points based on results of post-injection rebound monitoring, long-term monitoring, mass flux analyses
  - Innovative tools and metrics including mass flux analyses, rock crushing and analysis, multi-level monitoring network

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Site Background

Building 40 Area

- Site located ~350 feet west of Hudson River
- Chlorinated VOCs from suspected degreaser source in fractured shale
- PCE concentrations as high as 170 mg/L
- Depth of contamination 20 to 150 ft bgs
- 1-5 ft surficial shale, 5-10 ft overburden followed by black medium-hard laminated shale

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Remedial Objectives

- MCLs are ultimate long-term objective
- Unlikely to be achieved in “reasonable timeframe”
- Source area is matrix-dominated fractured rock environment with DNAPL
- Source area mass reduction potentially achievable
- Mass-based metrics used to formulate exit strategy
  - Mass discharge across property boundary
  - Integrated mass flux testing using short-term constant rate pumping test over entire affected area

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Site Characterization and Remedial Activities at WVA

- Define fracture network and system hydraulics
  - Borehole geophysical and hydrophysical logging
  - Inter-borehole flow testing
- Estimate contaminant mass in fractures
  - Multi-level groundwater characterization (CMTs, Westbay, FLUTe, Zist)
- Estimate contaminant mass in matrix pore water
  - Bedrock coring with VOC sub-sampling and rock matrix characterization

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Site Characterization and Remedial Activities at WVA (Cont'd)

- In situ chemical oxidation pilot study
  - Measure distribution and effectiveness of permanganate
  - Evaluate persistence and invasion of permanganate
  - Estimate matrix diffusion rates
- Full scale application
  - $NaMnO_4$ (not potassium permanganate) was injected for 5 years as it persists longer than $KMnO_4$ and is available at higher oxidant strengths

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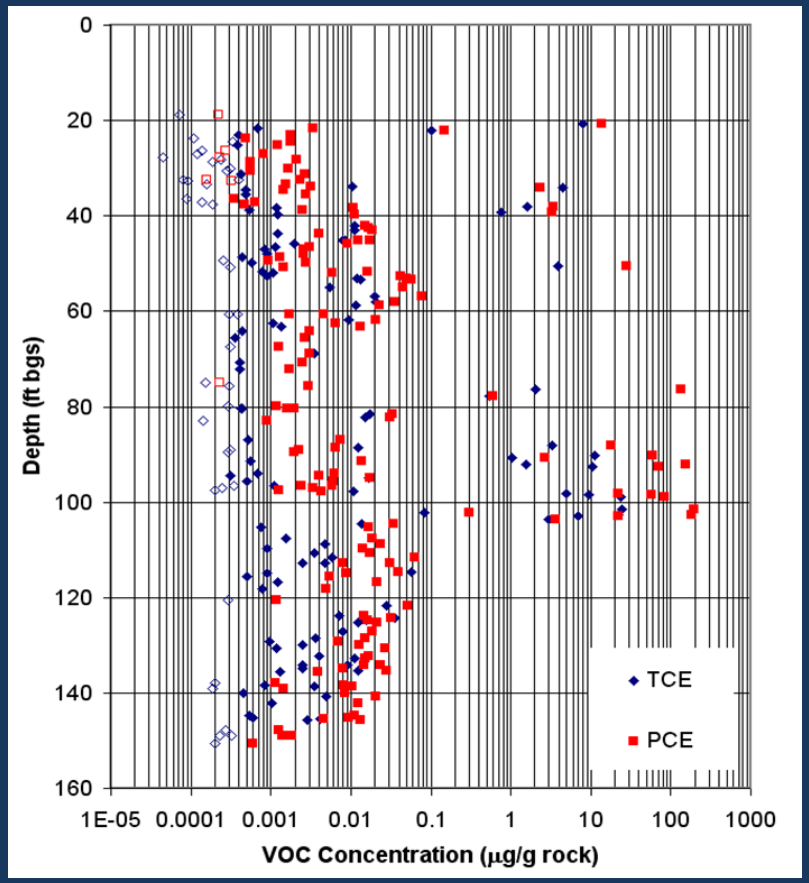
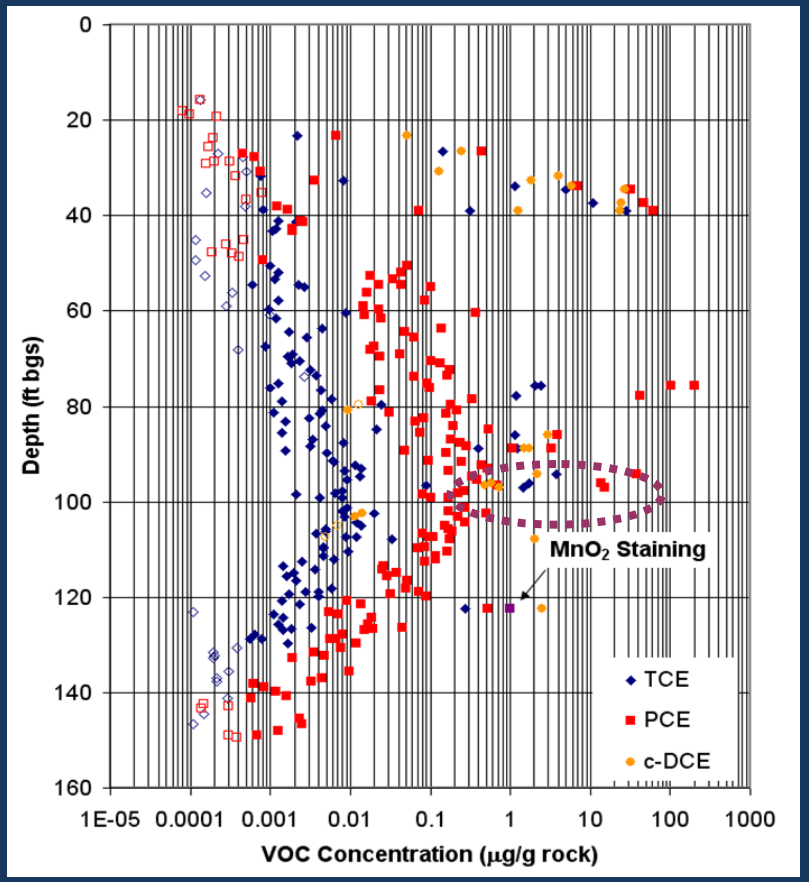
Rock Core VOC Profiles

Before – 10/2003



After 3 years – 12/2006



Similar peak concentrations indicate that no substantial remediation was accomplished

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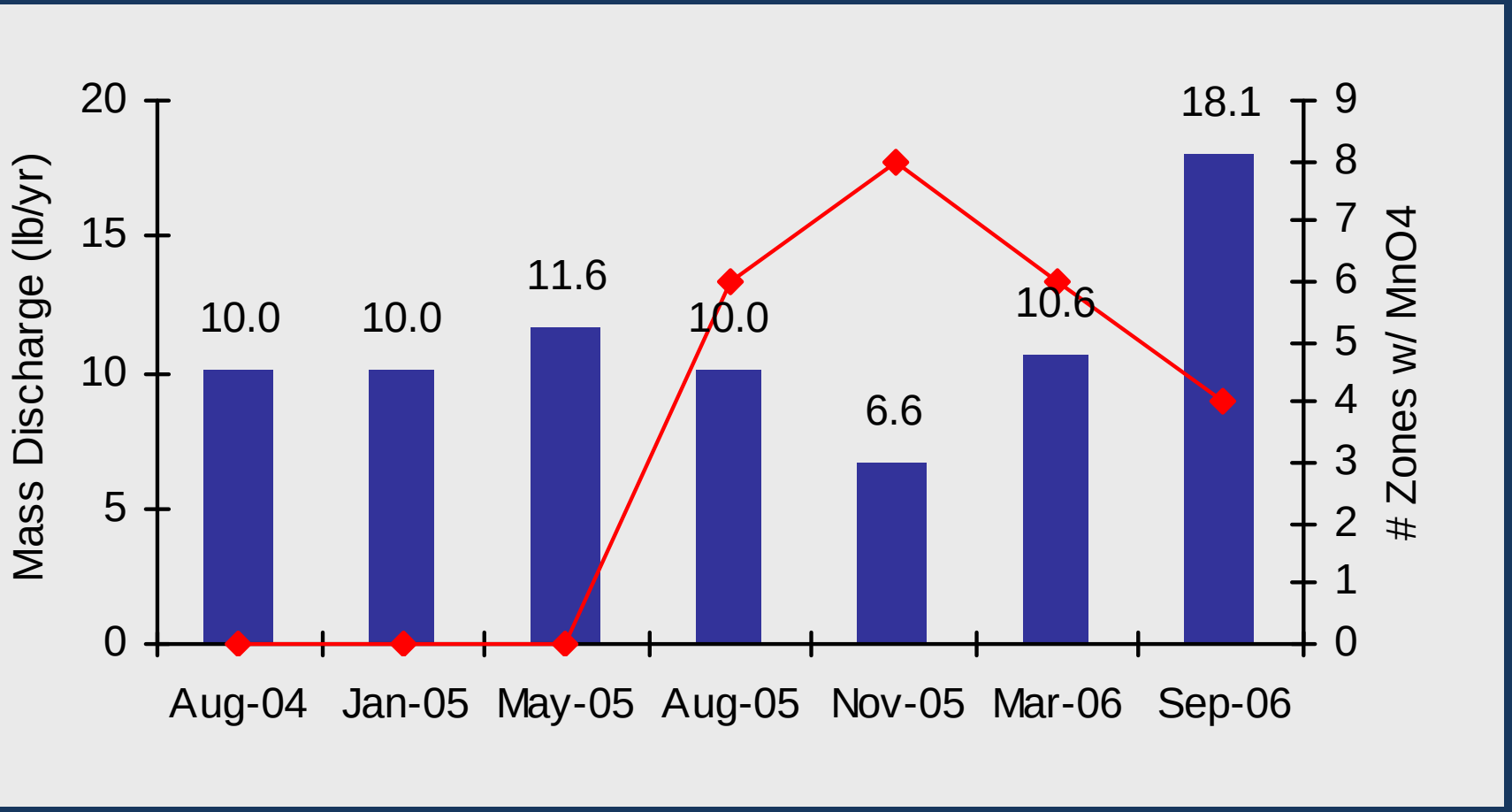
Boundary Mass Discharge*



** All calculations were made using baseline hydraulic conductivity values*

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Alternative Strategy

- MCLs/Aquifer restoration not achievable within "reasonable timeframe" in matrix-dominant fractured rock
- MnO_4 distribution declining over time
- Limited change in VOC mass discharge at site boundary
- Limited effectiveness of treatment based on comparative results of rock coring
- Attempted mass removal "to extent practicable"
- Applying for a determination of ACLs based on post-injection monitoring data and analyses

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Summary: Adaptive Site Management

Approach	Description
Goal	Focus on remedial progress as a priority, as defined by short-term objectives and metrics
Applicability	Complex sites (e.g., sites with fractured rock, heterogeneous setting, multiple contaminants)
Conceptual site model	Continually refined as more data is gathered to better select and support the final remedy
Remedy selection	May be an iterative process, rather than linear
Implementation	Establish short-term metrics and decision points Document progress towards metrics Adapt/innovate/refine remedial approach

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Concluding Thoughts

- A variety of alternative endpoints and strategies (formal and informal) can be used at complex sites
- These approaches are intended to be protective of human health and the environment
- Formal designations often supplement, rather than replace, other remedial components
  - Mass removal to the extent practicable
  - Containment
  - MNA, institutional controls

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Concluding Thoughts (Cont'd)

- Case studies provide examples of site-specific ways to meet cleanup expectations
- Variety of state approaches and case studies
  - Difficult to research policies and procedures in different states and cleanup programs
- Recent changes in state policies and guidance necessitate ongoing awareness by cleanup managers

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Questions?

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- Sale et al., 2008. Frequently asked questions regarding management of chlorinated solvents in soils and groundwater
- SERDP/ESTCP, various documents
- Updated EPA guidance on technical impracticability, including brief fact sheets describing CERCLA sites that have received TI waivers in the past (EPA, in press)

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