
NAVFAC
Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER
Accelerating Progress along the Road to Response Complete/Site Closeout (RC/SC)
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NAVFAC EXWC
Mike Singletary
NAVFAC Southeast

Presenters

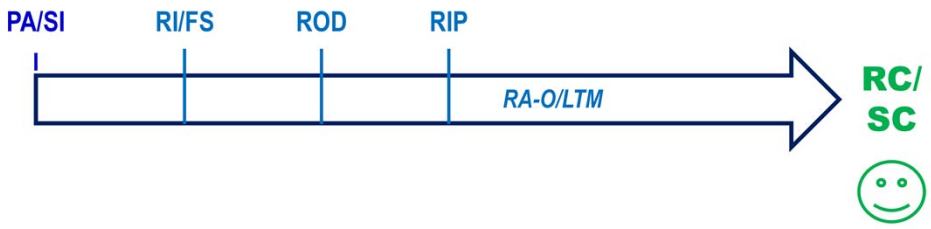
- **Arun Gavaskar**
  - 25 years experience in site remediation, several petroleum and chlorinated solvent sites
  - Cleanup projects for Navy, Air Force, Army, DOE, EPA, States, private, and international clients
  - Led multiple innovative technology development projects for DoD and EPA
- **Mike Singletary**
  - 20 years experience in environmental restoration working for the US Navy and private consulting
  - Performed optimization studies on over 100 sites in the Navy's ER Program
  - Focus areas include groundwater fate and transport process, bioremediation and other in situ remediation technologies, molecular biological tools

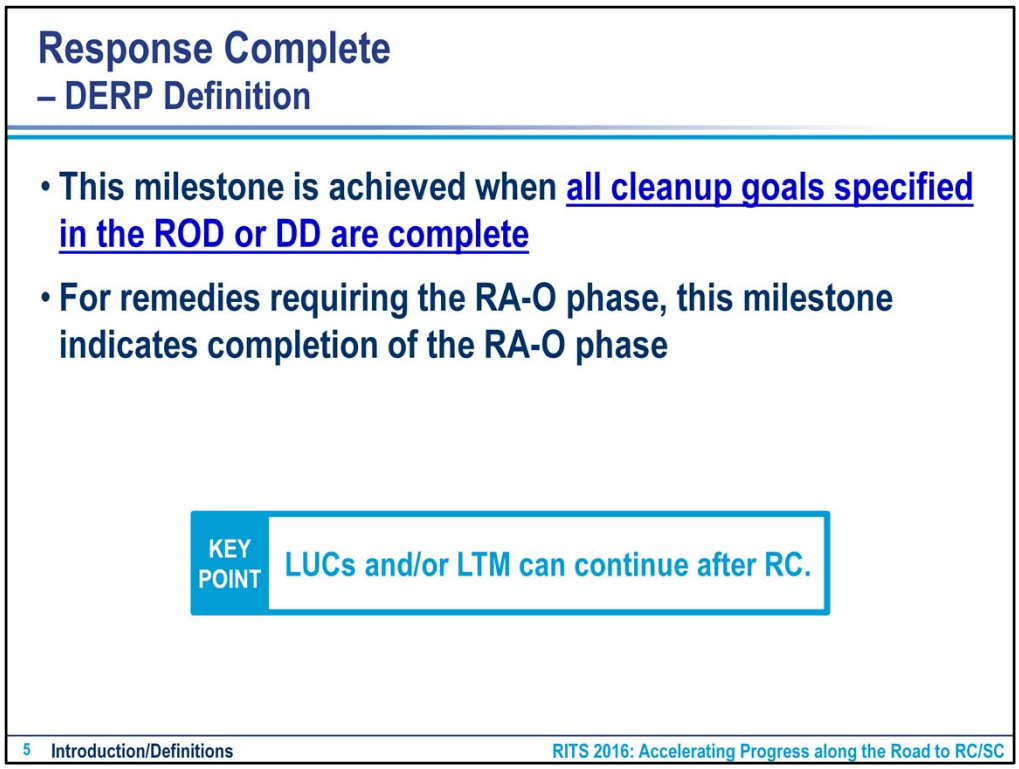
Presentation Overview

Introduction/Definitions of RC/SC

- Ask "How do we get there?"
  - Achieving 'No Unacceptable Risk' in a Cost-Effective Fashion
  - Reaching ARARs in a Cost-Effective Fashion
- Special Mention – Petroleum Sites
- New! Interim Transition Goal
- Wrap-Up

The ER Process
– Leading to Response Complete (RC)/Site Closeout (SC)




Response Complete
– DERP Definition
• This milestone is achieved when all cleanup goals specified in the ROD or DD are complete
• For remedies requiring the RA-O phase, this milestone indicates completion of the RA-O phase
KEY POINT
LUCs and/or LTM can continue after RC.
5 Introduction/Definitions
RITS 2016: Accelerating Progress along the Road to RC/SC

LUCs okay

RC Example
– Army Achieves RC at Sediment Site

- Pegan Cove, Natick, MA
- PCBs in sediment
- Three hot spots dredged, until surface-weighted average for sediment throughout the cove meets the 1 ppm cleanup target
- No MNR, no LTM
- EPA letter of concurrence

KEY POINT Fish advisory continues.

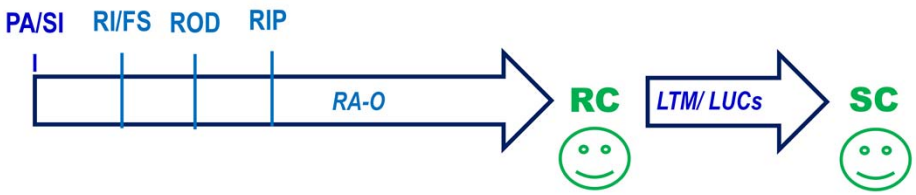
Site Closeout (SC)
– DERP Definition

This milestone signifies that DON has completed active management and monitoring at a site, the remedy is protective of human health and the environment, contaminant levels at the site allow for unlimited use and unrestricted exposure, and there is no expectation of expending additional ER,N or BRAC funds at the site

KEY POINT **No LUCs or LTM after SC.**

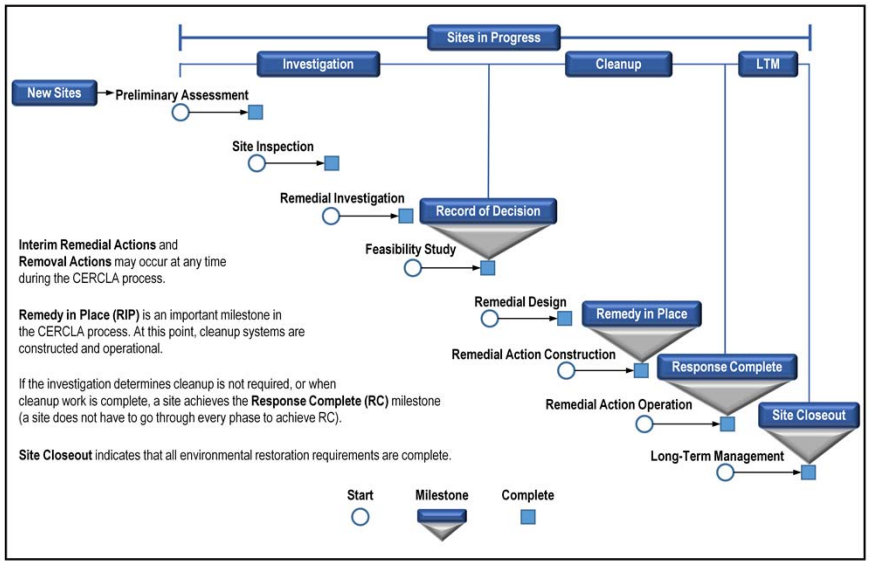
Further information on SC can be found in *DON Guidance to Documenting Milestones throughout the Site Closeout Process* (Users Guide [UG]-2072-ENV).

The ER Process
– Leading to Response Complete (RC)/Site Closeout (SC)



The Environmental Restoration (ER) Process

– *Navy Environmental Restoration Program*



Interim Remedial Actions and **Removal Actions** may occur at any time during the CERCLA process.

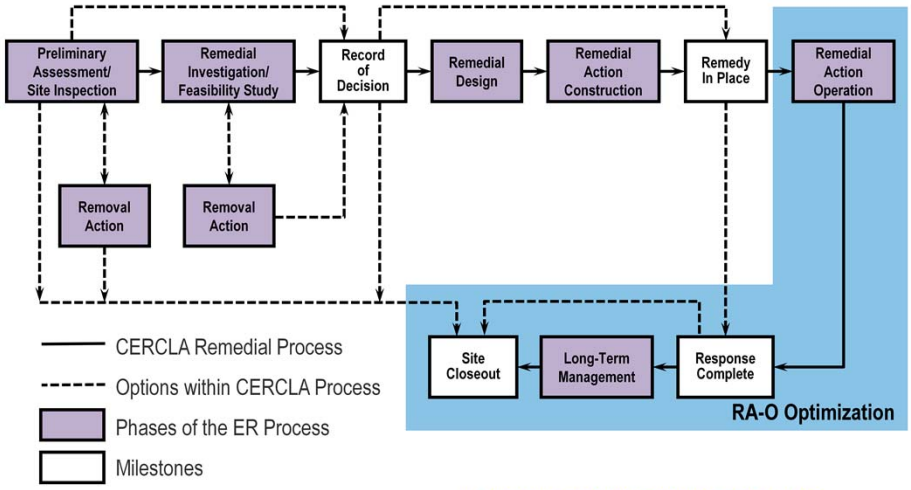
Remedy in Place (RIP) is an important milestone in the CERCLA process. At this point, cleanup systems are constructed and operational.

If the investigation determines cleanup is not required, or when cleanup work is complete, a site achieves the **Response Complete (RC)** milestone (a site does not have to go through every phase to achieve RC).

Site Closeout indicates that all environmental restoration requirements are complete.

The Environmental Restoration (ER) Process

– *Guidance for Optimizing Remedial Action Operation (RA-O)*

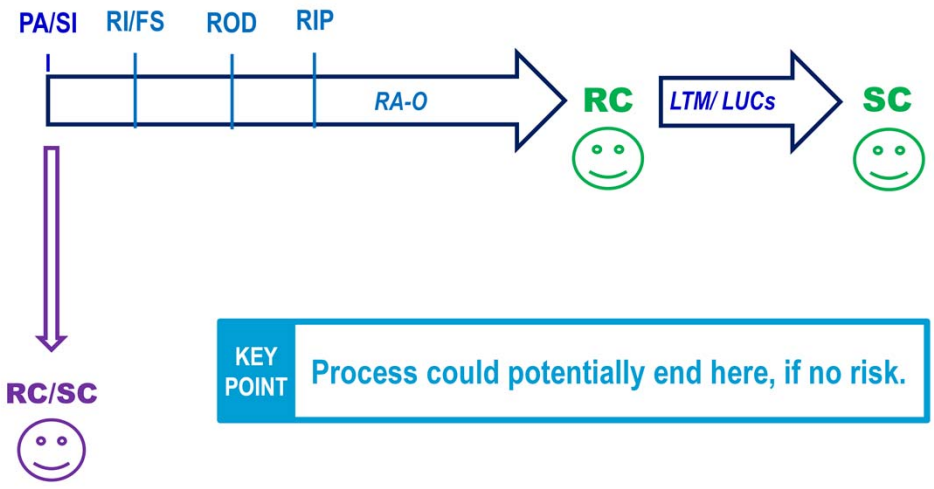


Users' Guide, UG-NAVFAC EXWC-EV-1301

Do we have to go through all the ER stages to reach RC/SC?

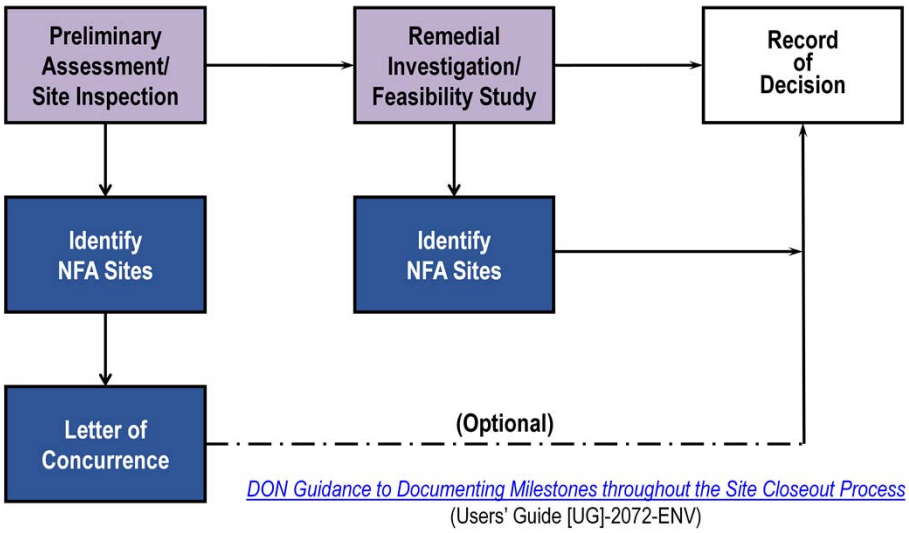
- The RC/SC milestone can occur at any stage during the response action, depending on the remediation requirements, including at the completion of the PA/SI, removal action, RI/FS, RA-O, or LTMgt phases

Example: Emerging Contaminants Suspected at a Site
– Process is Equivalent to Starting with PA/SI



KEY POINT: Process could potentially end here, if no risk.

SC in Early Stages of ER Process



DON Guidance to Documenting Milestones throughout the Site Closeout Process
(Users' Guide [UG]-2072-ENV)

Preliminary Assessment (PA)
– DERP Definition

"A PA is intended to be a relatively quick, low-cost compilation of existing information about a site. It should assess the following:

- Source and nature of a release;
- Potential contaminant migration via four pathways (surface water, groundwater, air, and soil); and
- Potential receptors (humans and ecological resources) that could be affected by the release or contaminant migration."

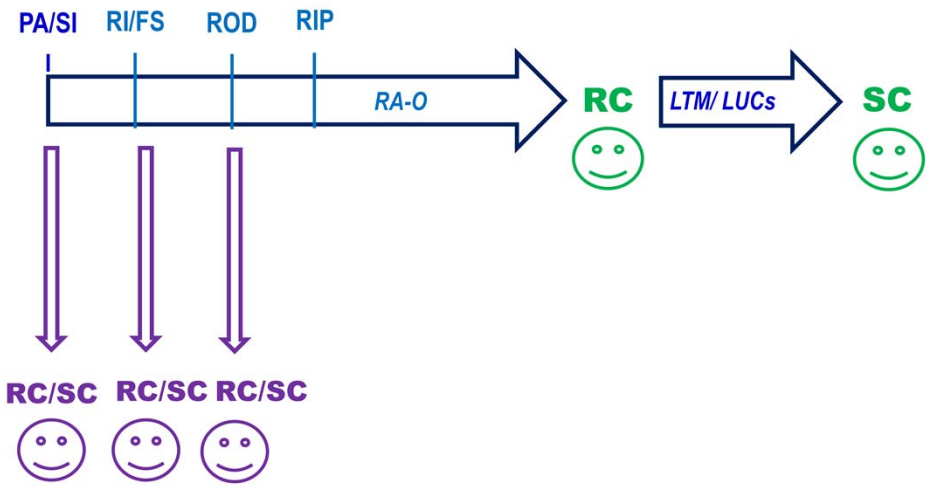
PA/SI Step

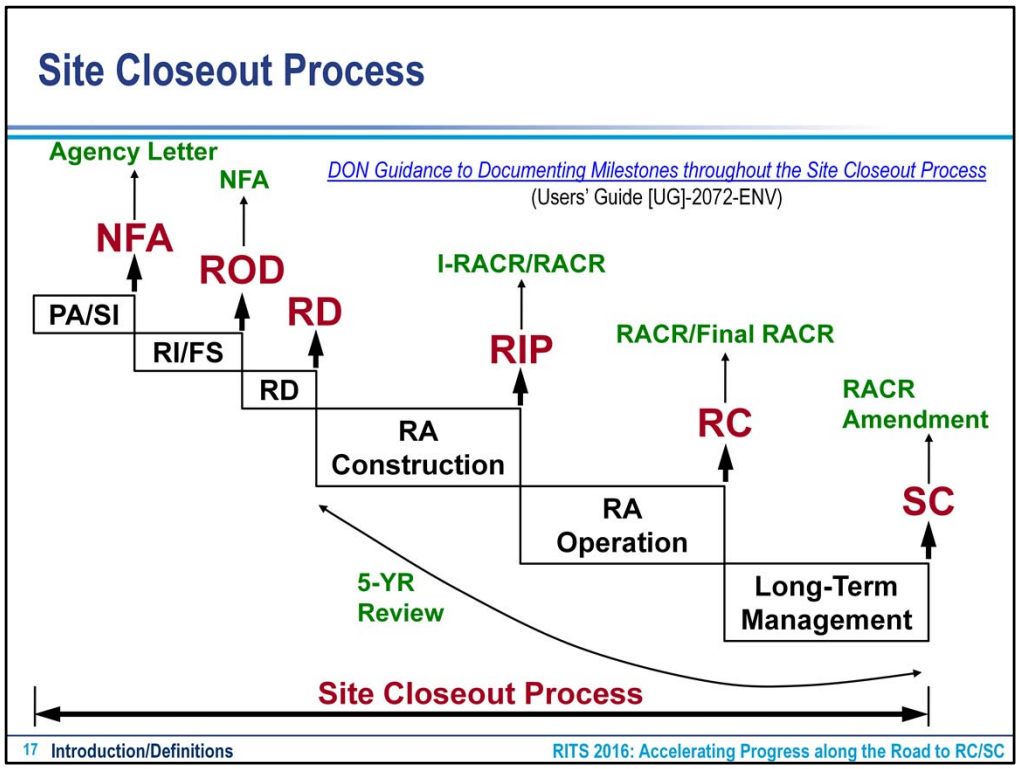
"A PA is required…if a release site is discovered, a hazardous waste site is discovered. The purpose of the PA is to:

1. eliminate sites that do not pose a threat to human health or the environment from further consideration
2. determine if there is a potential need for removal action
3. set priorities for SIs; and
4. gather information for the HRS evaluation."

KEY POINT SI may be needed if the PA finds that the release poses a potential threat to human health or the environment.

The ER Process
– Many paths leading to RC or SC




Site Closeout Process
Agency Letter
NFA
NFA
ROD
RD
I-RACR/RACR
RIP
RACR/Final RACR
RC
RACR
Amendment
SC
PA/SI
RI/FS
RD
RA
Construction
RA
Operation
Long-Term
Management
5-YR
Review
Site Closeout Process
DON Guidance to Documenting Milestones throughout the Site Closeout Process
(Users' Guide [UG]-2072-ENV)
17 Introduction/Definitions
RITS 2016: Accelerating Progress along the Road to RC/SC

Presentation Overview

- Introduction/Definitions of RC/SC
- Ask "How do we get there?"
  - Achieving 'No Unacceptable Risk' in a Cost-Effective Fashion
  - Reaching ARARs in a Cost-Effective Fashion
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How do we get to RC/SC?

- Relatively <u>easier</u> when contamination is limited primarily to soil or vadose zone
- <u>More difficult</u> when groundwater has been impacted by petroleum
- <u>Much more difficult</u> when groundwater has been impacted by chlorinated solvents or emerging contaminants, such as 1,4-dioxane or PFASs

KEY POINT For this presentation, our focus is on groundwater sites.

19 Ask "How do we get there?"

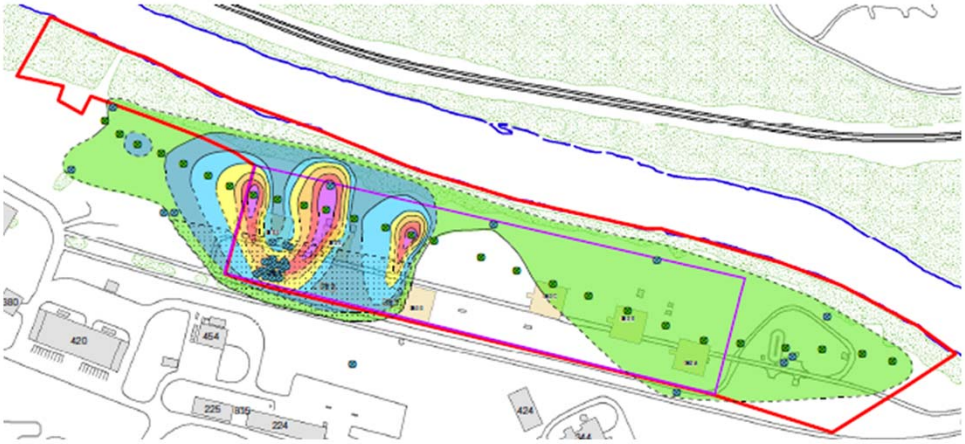
RITS 2016: Accelerating Progress along the Road to RC/SC

Why is it so difficult to reach RC/SC at groundwater sites?

- Persistence of upgradient sources (and therefore plumes)
- Matrix diffusion (slow back-diffusion of dissolved contaminants form lower-permeability lenses)

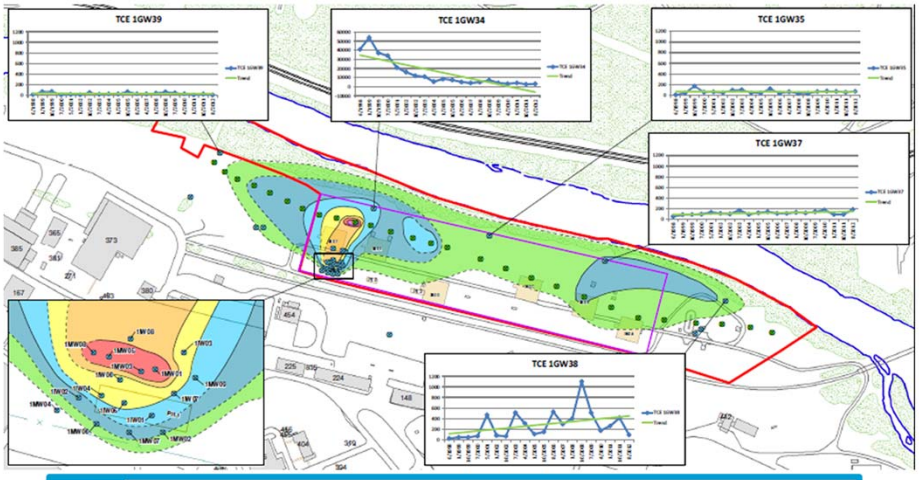
Persistence of Strong and Dispersed Sources

Example Site 1: TCE concentrations in aquifer in 1998 before P&T system



Persistence of Strong and Dispersed Sources (cont.)

Example Site 1: TCE concentrations in alluvium aquifer remain high in 2012



KEY POINT *Source strength continues to be strong – RC difficult.*

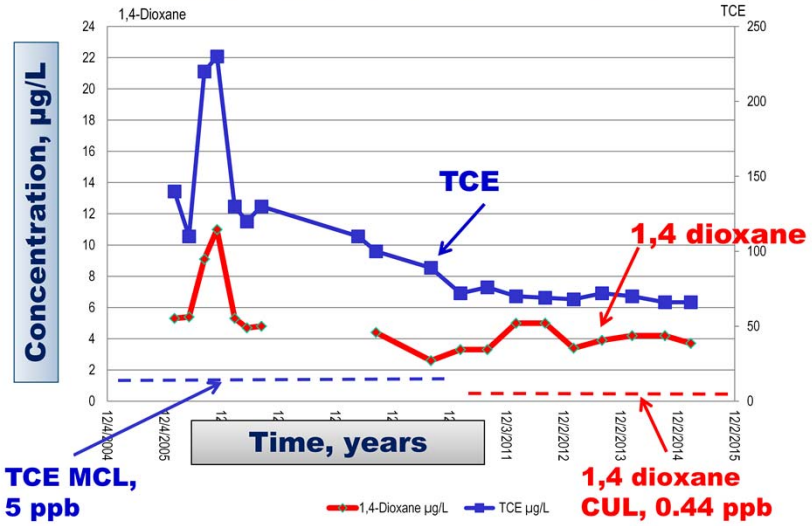
Source is weak, but dilute plume persists due to…

Example Site 2: P&T for TCE – 1997 and 2014

….Matrix Diffusion – P&T System, weak or depleted source

– Concentrations often drop to an asymptote above MCL

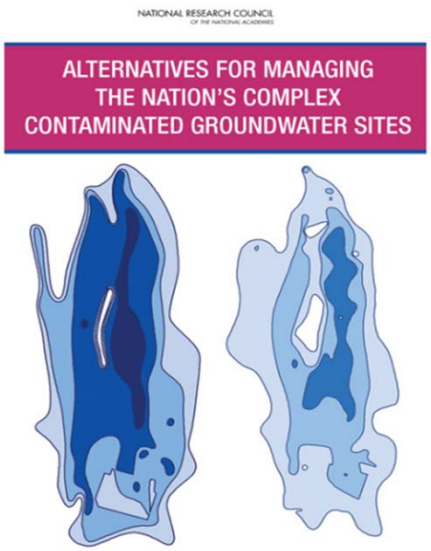
Example Site 2: P&T for TCE – 1997 and 2014



National Research Council, 2013

Acknowledges Difficulty of Reaching RC/SC at Groundwater Sites

"…*at complex sites characterized by multiple contaminant sources, large past releases of chemicals, or highly complex geologic environments, meeting the DoD's ambitious programmatic goals for remedy in place/response complete seems unlikely and site closure almost an impossibility*."



National Research Council, 2013

Acknowledges Difficulty of Reaching RC/SC at Groundwater Sites (cont.)

- *"…the Committee has concluded that regardless of the remedial technologies applied at complex sites, removal of sufficient mass to reduce contaminant concentrations in groundwater to levels that allow for unlimited use and unrestricted exposure is unlikely for many decades."*

National Research Council, 2013

What about future breakthrough technologies?

- "*Furthermore, no transformational remedial technology or combination of technologies appears capable of overcoming the inherent technical challenges to restoration at these complex sites.*"

- *"Rather, the nation's cleanup programs are transitioning from remedy selection into remedy operation and long-term management (LTM), potentially over long timeframes*."

How do we get to RC/SC or RC-T in a cost-effective fashion?

- No global answers for all sites
- Global questions, if asked in the right way, could lead to site-specific answers
- Many tools are available

RC-T = Response Complete-Transition

How do we get to RC or RC-T in a cost-effective fashion? *–Questions for Navy and Stakeholders (based on NRC, 2013)*

"Better decision making is needed at key points in the life cycle of a complex groundwater contamination site to address issues that frequently arise, including:

1. ***What is a 'reasonable time frame';***
2. ***What is the definition of contaminant removal 'to the maximum extent practicable';***
3. ***When should active remediation at a complex groundwater site be transitioned to a passive remedy, such as monitored natural attenuation (MNA) or natural attenuation (NA); and***
4. ***Can consensus be reached on a 'diminishing returns' concept applied to the performance of active remedies for groundwater cleanup at complex sites?"***

Reasonable Timeframe

- Reasonable timeframe is shorter if there is
  - "Unacceptable risk" to actual human health or environmental receptors under reasonably anticipated groundwater use scenarios
- Once "no unacceptable risk" has been achieved
  - ARARs can be met in a longer timeframe
  - When is it cost-effective to accelerate a site to RC/SC?

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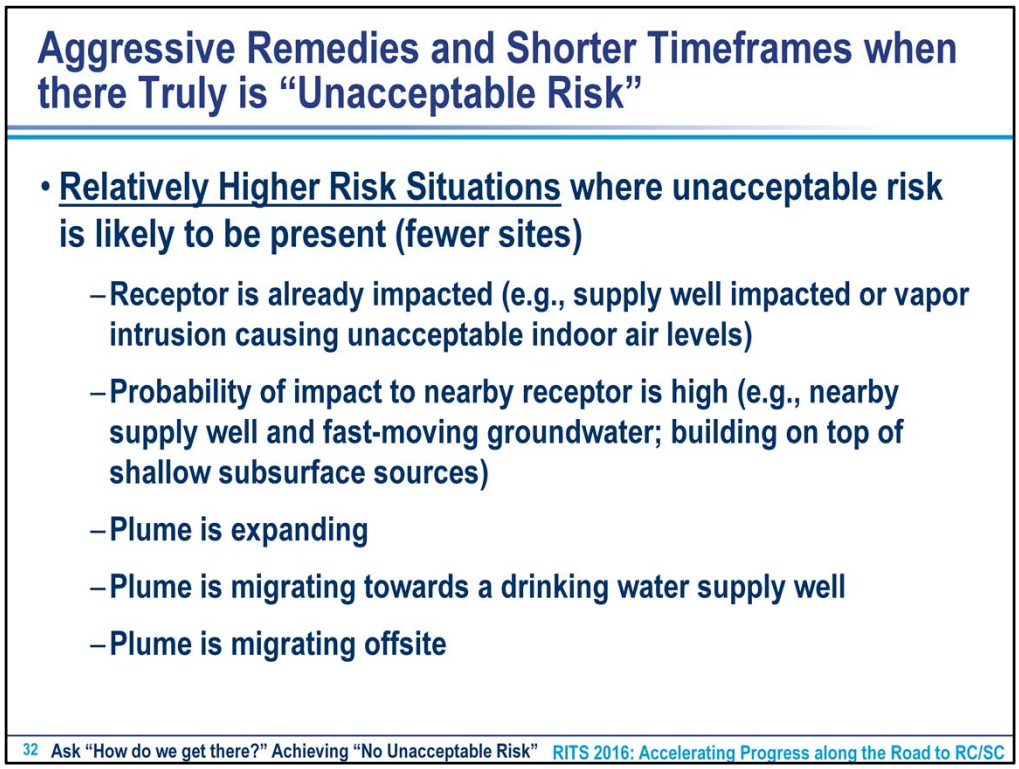
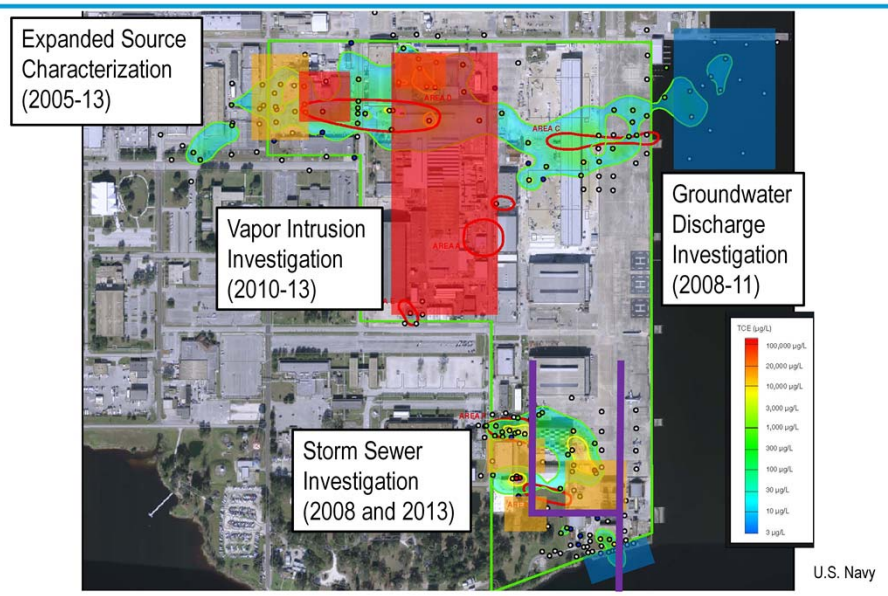


These are the exceptions. Most remaining sites are not high risk

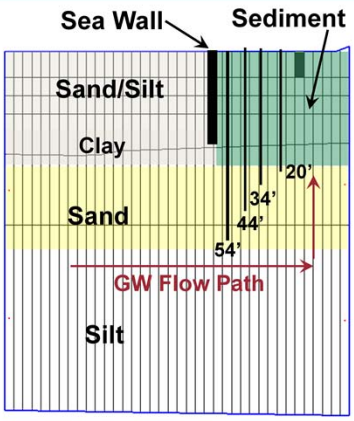
Case Study: OU3, NAS Jacksonville
Identifying "No Unacceptable Risk" Situations



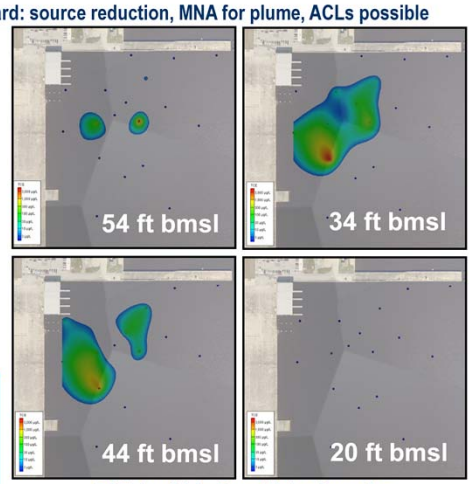
U.S. Navy

Case Study: OU3, NAS Jacksonville

St. Johns River Pore Water Sampling Results



- Showed no unacceptable risk to the river
- Allowed the site to focus on what else needs to be done to reach RC
- Path Forward: source reduction, MNA for plume, ACLs possible



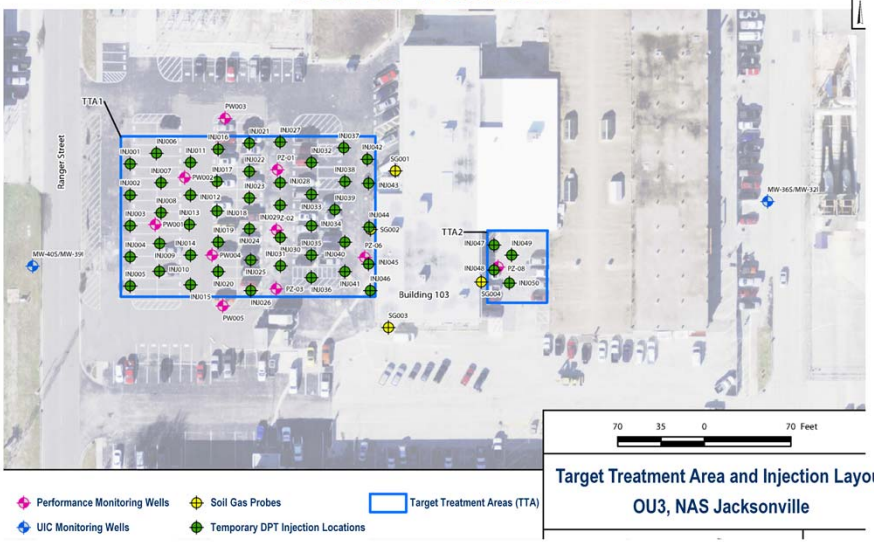
TCE (µg/L) in Pore Water Samples Collected Below St. Johns River

KEY POINT Investigation showed plume attenuates prior to discharge and does not impact shallow sediments or surface water.

Case Study: OU3, NAS Jacksonville

Former Bldg. 106 Pilot Layout (Permeable Sand)

Source Treatment



Target Treatment Area and Injection Layout
OU3, NAS Jacksonville

Achieving 'No Unacceptable Risk' in a Cost-Effective Fashion, in a Relatively Shorter Timeframe

- Identify true "unacceptable risk situations"
  - Plume is expanding
  - Receptor is already impacted or close to being impacted
  - Nearby drinking water supply wells or private wells
  - Vapor intrusion potential
  - Plume has migrated or is migrating off Navy property
- Aggressive treatment is often required for plume control
- Source treatment is worthwhile when remaining plume can be managed with MNA or LUCs alone

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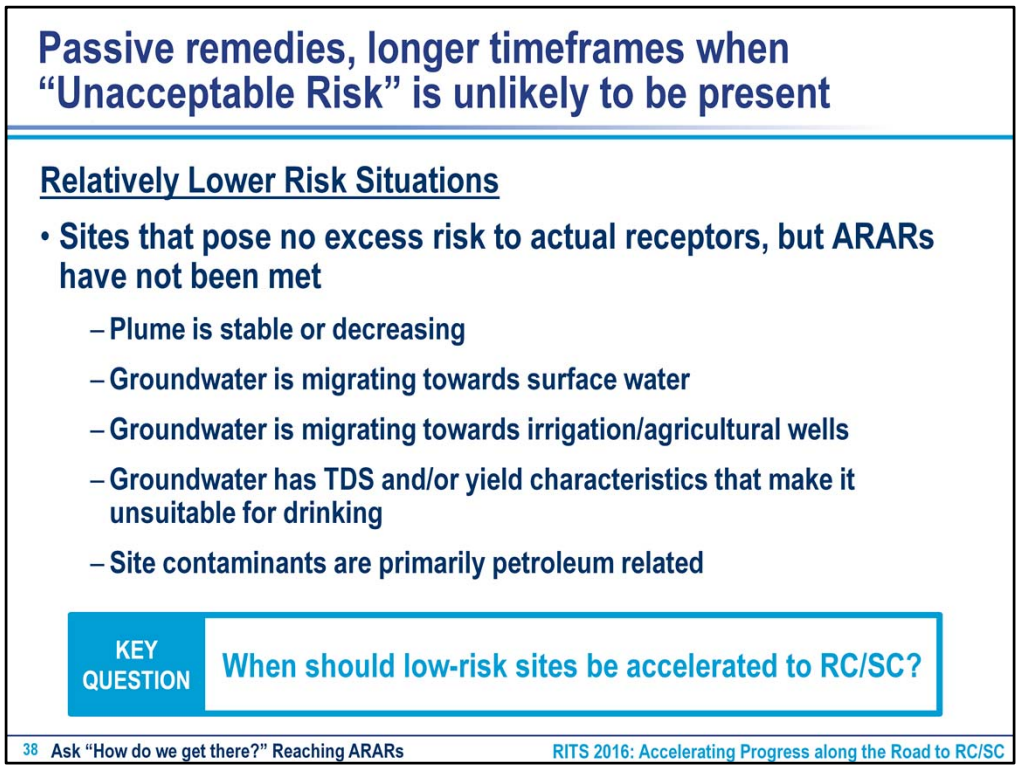


Beneficial. Surface water is a natural barrier with a highly active sediment interface

When would it be worthwhile to accelerate a site to RC/SC by using aggressive (costly) remedies?

How certain is the outcome of a costly aggressive remedy?

- Need to avoid a situation where we spend more in the short-term to avoid a long tail – and then end up with both the short-term expenditure and the long tail
  - Happens often
- If RC/SC will be achieved by the aggressive remedy in the next one or two years, the outcome probably has a high level of certainty
  - Predictive solute transport models showing cleanup will be complete in 10, 15, or more years is a highly uncertain outcome

Reaching ARARs at Former Reese AFB, Tower Area Plume

Former Reese AFB, Tower Area Plume
High-Permeability Channel vs. Hydraulic Gradient as Driver of Flow Direction

Former Reese AFB, Tower Area Plume

Forced-Gradient ERD in Source Area

Former Reese AFB, Tower Area Plume

Mid-Plume Area

Key components

- Groundwater extraction
  - Along plume core (most efficient mass recovery)
- Re-injection of clean/treated water
  - Targeting plume perimeter – plume collapse
- Contaminant flushing
  - Achieve sufficient pore volume exchange to target orders of magnitude reduction
  - Operation balanced by end point required

Operational strategy

- Multi-line
  - Smaller segments faster flushing
- Adaptive
  - Real time system modifications are critical

Former Reese AFB, Tower Area Plume
Achieved ARARs in 8 Years

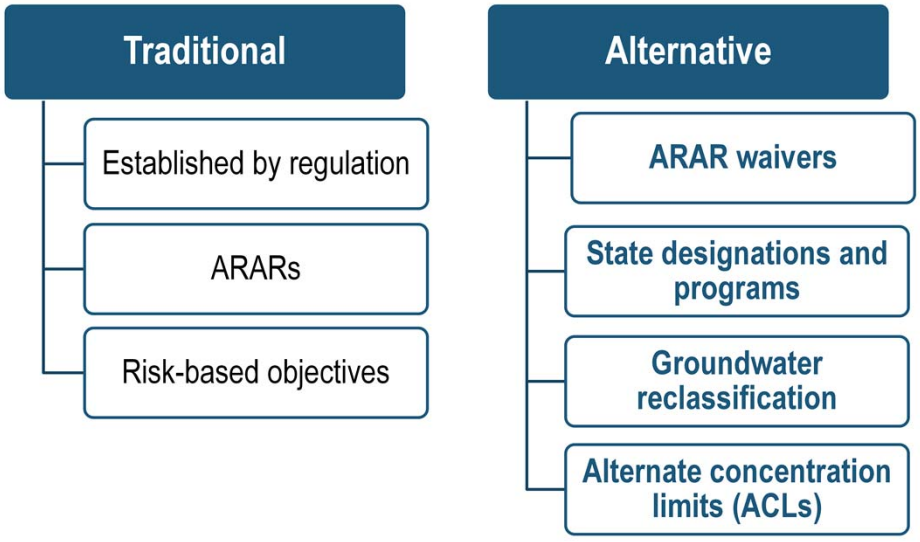
Reese AFB Experience – Can we replicate it to move other sites to RC?

- Special circumstances at Reese AFB
  - TCE source primarily in vadose zone, was successfully addressed by SVE
  - CTC was high, BRAC site
  - Site already had hundreds of monitoring wells, several more were added – characterization and growing understanding of plume continued until the plume was gone
- Huge investments involved

Prospects of Reaching ARARs at Groundwater Sites

- Most groundwater sites are unlikely to reach ARARs in the foreseeable future, without (or in spite of) huge new investments
- What alternative end points are available for groundwater sites?

Types of Endpoints

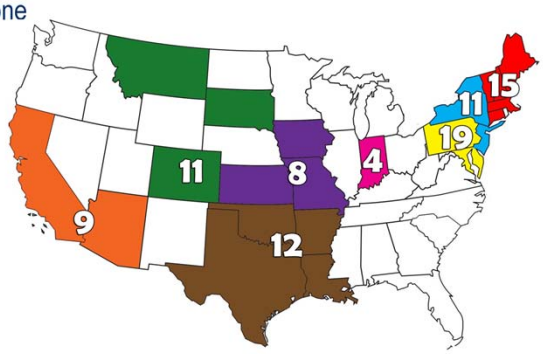


ARAR Waivers – 6 Types

- Interim Measure Waiver
- Greater Risk Waiver
- Technical Impracticability (TI) Waiver
- Standard of Performance Waiver
- Inconsistent Application of State Standard Waiver
- Fund Balancing Waiver

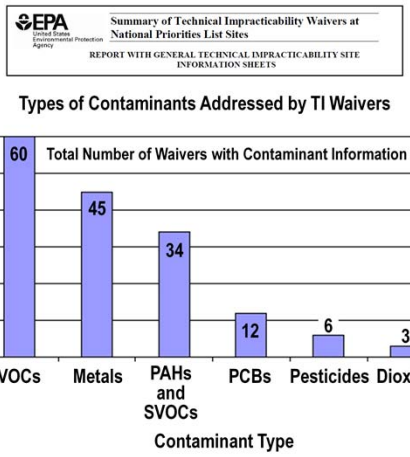
TI Waiver

- **Guidance for Evaluating the Technical Impracticability of Groundwater Restoration (EPA, 1993)**
- **TI Waiver Policy, 1995**
  - Only specific contaminants, ARARs
  - Applies only to established TI Zone
- **Decision is regional**
- **Timeframe is critical**
- **Difficult to obtain**
  - As of 2011 91 TI Waivers
  - Only 8 Federal Facilities



TI Waiver (cont.)

- **Primary Reasons**
  - **Complex geology and hydrogeology**
    - Fractured bedrock
    - Karst formations
    - Heterogeneous soils
    - Strong vertical gradient
  - **Contaminants present**
    - NAPL
    - Metals contamination
- **Policy Clarification 2011**
  - **Sites with DNAPL**



Naval Air Development Center, Warminster, PA
OU1A – Area A Groundwater (Former Sludge Disposal Area)

- **ROD signed 2000**
- **Soil removal action completed**
- **Groundwater RGs: MCLs**
- **Geology: Fractured Bedrock**
- **RC Timeframe: 200 years**
- **Institutional controls in place**
  - Prohibit use of groundwater
- **P&T – Interim Remedy, *ongoing***
- **TI Waiver established in ROD**
  - Only applies to TI Zone (not dissolved-phase plume)

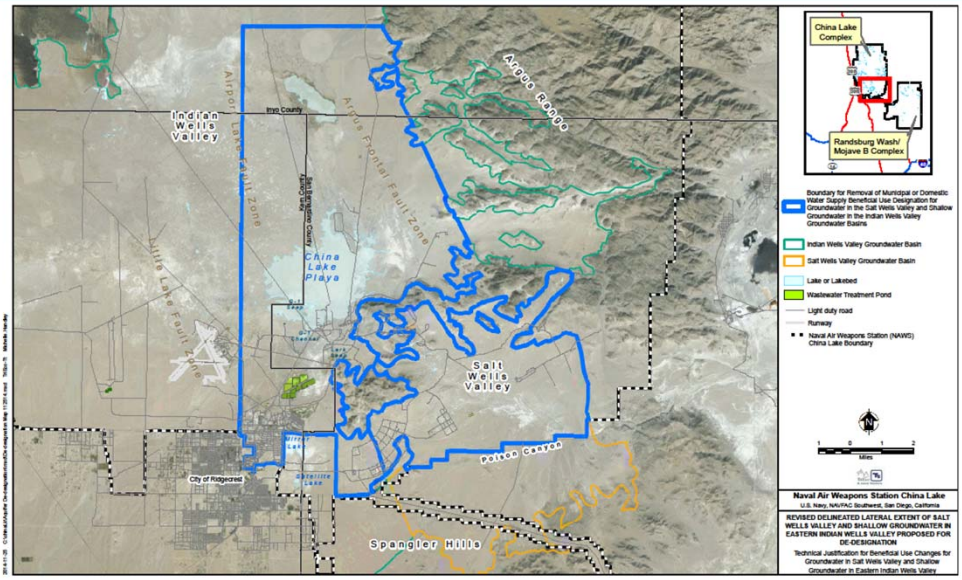
State Designations and Programs

- **State Designations**
  - **Containment Zone**
  - **Plume Management Zone (PMZ)**
    - Texas (NWIRP Dallas, NWIRP McGregor)
  - **Conditional points of compliance**
    - Washington
- **State Programs/Policy**
  - **Low-Threat Closure (California)**
    - UST Sites
    - Chlorinated Solvent Sites

Groundwater Reclassification

- Regulatory process
- Multiple states have groundwater classifications
- California
  - Basin Plan
  - SWRCB Resolution No. 88-63 (Source of DW Policy)
    - TDS >3,000 mg/L
    - Yield <200 gpd
    - Contamination
- Navy Examples
  - China Lake
  - Hunters Point

Groundwater Reclassification – China Lake Experience



54 Ask "How do we get there?" Reaching ARARs RITS 2016: Accelerating Progress along the Road to RC/SC

Be aware of State's program

Groundwater Reclassification – China Lake Arguments

- Technical Justification Memo for Beneficial Use Guidance
  - Drafted by Navy
  - Used by local Water Board to convince Regional and State Boards
- High TDS
- High background arsenic
- Low recharge rate

Alternate Concentration Limits (ACLs)

- ACLs replace or modify groundwater cleanup levels (MCLs)
- Must be protective of human health and the environment (based on reasonably anticipated groundwater use)
- ACLs are often based on surface water protection standards
  - Credit for mixing zones
  - Credit for attenuation from compliance wells along shoreline to surface water
- Formal process for both CERCLA and RCRA

Alternate Concentration Limits (ACLs) (cont.)

- May be more useful than TI waivers at Navy sites
- Surface water is nearest groundwater receptor for majority of Navy plumes
- ACLs have to be met at edge of the surface water body
- ACLs would make upgradient source treatment worthwhile

Former Naval Station Long Beach, CA, IR Sites 1 and 2

- ROD signed in 2000
- Land Use: Industrial
- GW Designation: Non-Beneficial Use
  - High TDS (>3,000 mg/L)
  - Designation of Terminal Island 1998
- ACLs based on California Ocean Plan
  - 4 VOCs above COP Criteria
- Point of Compliance: property edge
- Selected Remedy: IAS/SVE
- RC in 2007
- LTM: LUCs, five-year review, no groundwater monitoring

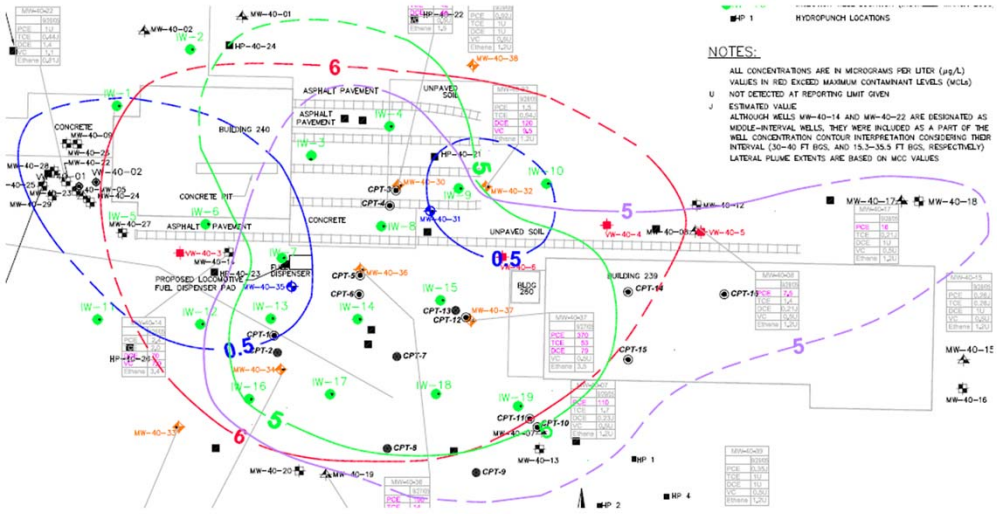
VOCs	COP (µg/L)	MCLs (µg/L)
1,1-DCE	0.9	7
Benzene	5.9	5
TCE	27	5
VC	36	2

Non-Federal Superfund Sites with ACLs

- Western Processing Company, Inc. Kent, WA (1996)
  - 1996 EPA (Region 10) and WDOE approved ACLs
- Savannah River Site Sanitary Landfill, Aiken, SC
  - Originally MCLs but for Site Closure negotiated ACLs at POC
- Butterworth Landfill Site in Grand Rapids, MI (1998)
  - State developed GW/SW interface criteria as the ACLs (1998)
  - ROD included establishment of ACLs for contaminated GW
- Sylvester/Gilson Road Superfund Site Nashua, NH (1983)
  - Supplemental ROD established in 1983
  - GW discharges to surface water, ACLs established in containment area, MCLs outside
- Yaworski Waste Lagoon, CT (1988)
  - ACLs established including 30 years of LTM
  - Exposure to GW via surface water feature

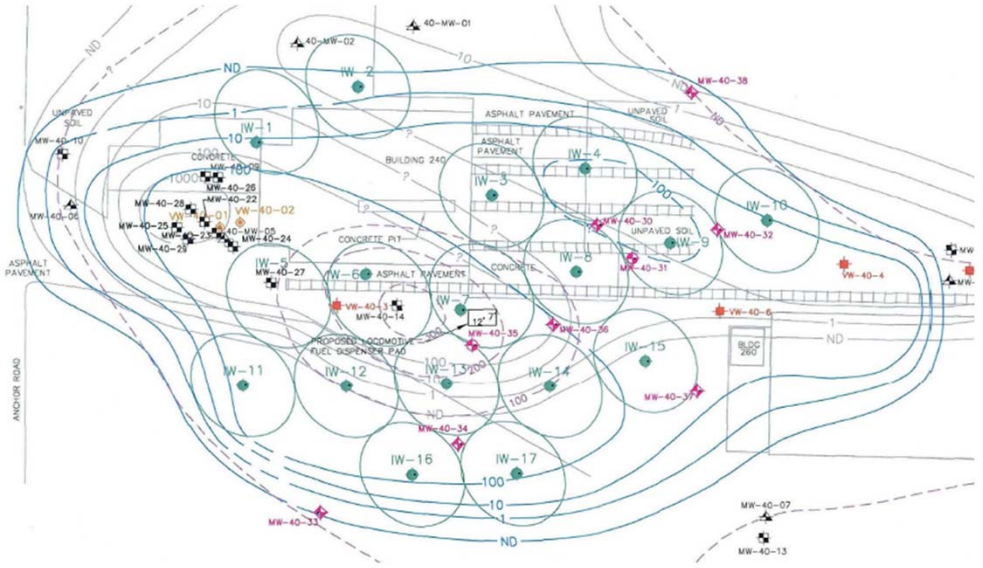
Case Study: NWS Seal Beach Site 40 Case Study

Primary PCE Plume, Pre-Remedy, 2003 (~2 acres, 40 ft. deep)



Injection Well, Lactate Electron Donor, Bioaugmentation (2005)

NWS Seal Beach Site 40



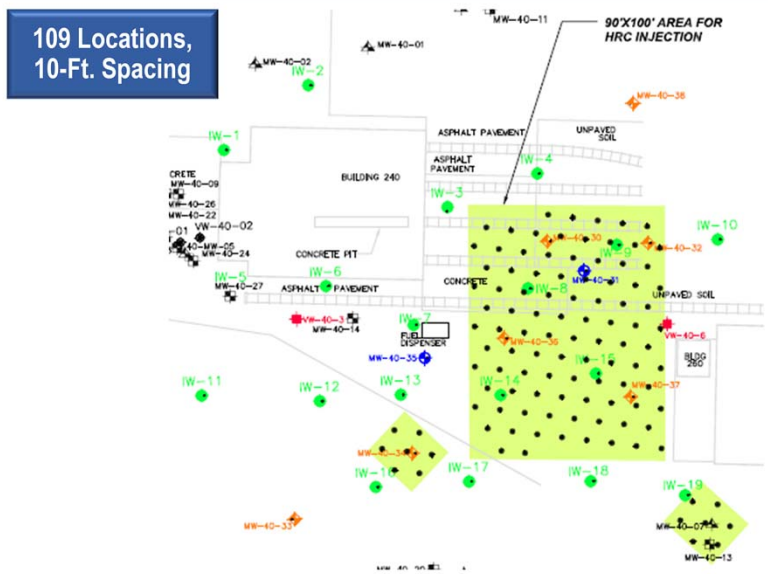
61 Ask "How do we get there?" Reaching ARARs

RITS 2016: Accelerating Progress along the Road to RC/SC

Detailed Optimization in 2006 followed by First HRC® Injection (April 2007)

NWS Seal Beach Site 40

109 Locations, 10-Ft. Spacing

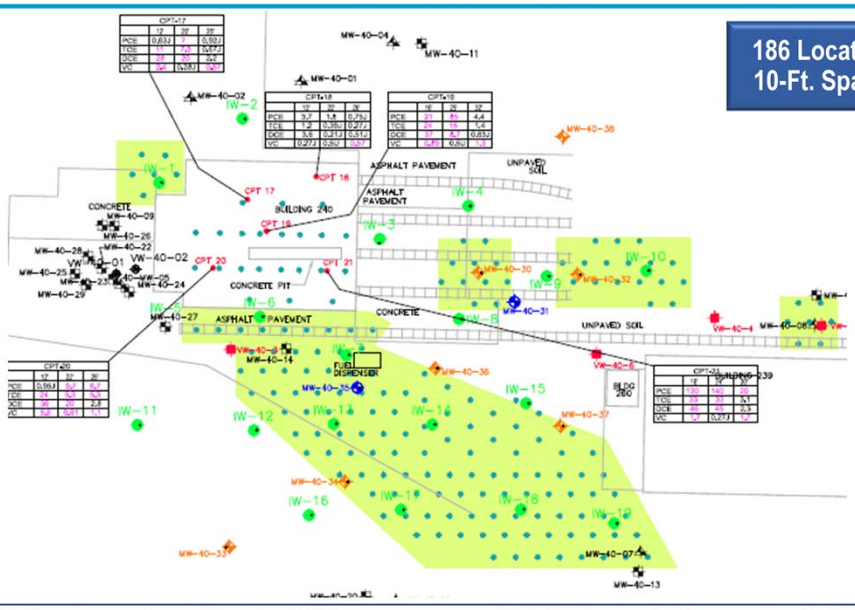


62 Ask "How do we get there?" Reaching ARARs

RITS 2016: Accelerating Progress along the Road to RC/SC

Second HRC® Injection (October 2008)

NWS Seal Beach Site 40



PCE, TCE Below Detection, Weak DCE Plume in Figure (December 2013)

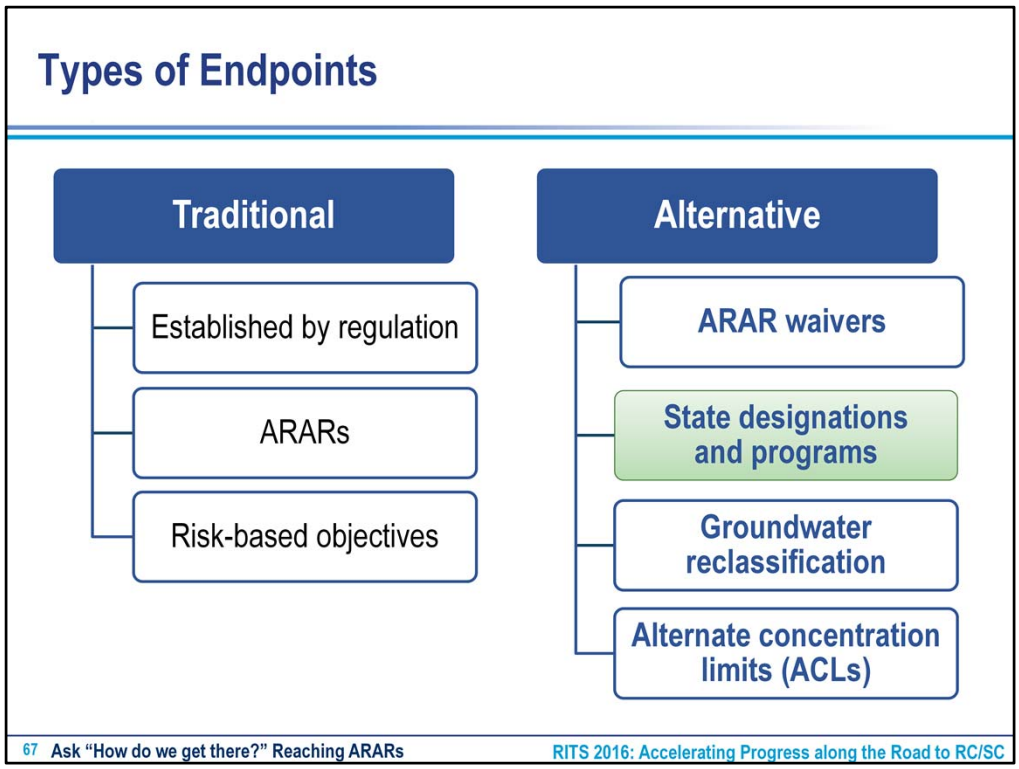
NWS Seal Beach Site 40

PCE, TCE Below Detection, Weak VC Plume in Figure (December 2013)

NWS Seal Beach Site 40

Can we replicate Seal Beach Site 40 experience?

- Seal Beach site representatives managed the remedy well (Initial remedy, quickly followed by detailed optimization, addressed gaps)
- More intensive application of the remedy in smaller plumes is relatively more viable from technical and economical standpoints (contrast with similar remedy at Site 70)
- Did native microbes kick in?
- Is low-threat closure possible under California's state program?


Types of Endpoints
Traditional
Established by regulation
ARARs
Risk-based objectives
Alternative
ARAR waivers
State designations and programs
Groundwater reclassification
Alternate concentration limits (ACLs)
67 Ask "How do we get there?" Reaching ARARs
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California State Program – Low Threat Closure – Underground Storage Tanks (USTs)

- Low-Threat UST Case Closure Policy
- SWRCB Resolution No. 2012-0016
  - Criteria for Low-Threat Closure
- Substitutive Environmental Document
  - Evaluates potential environmental effects of the statewide policy

Media Specific Criteria

1. Groundwater
2. Vapor intrusion
3. Direct contact/Outdoor air

General Criteria

1. Located within public water supply area
2. Only petroleum
3. Petroleum leak has stopped
4. Free product removed to maximum extent practicable
5. CSM developed
6. Secondary source removed to extent practicable
7. Soil or GW analyzed for MTBE
8. Water Code Section 12050 nuisance do not exist

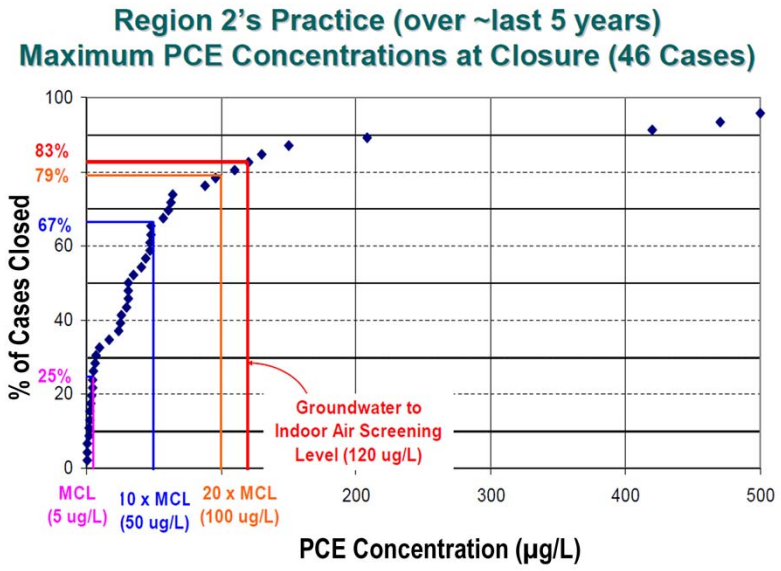
California Program – Low-Threat Closure – Chlorinated Solvent Sites

SFRWQCB – Assessment Tool 2009

Recommended Closure Criteria

Develop a Complete CSM	• Sources identified and evaluated • Site adequately characterized • Exposure pathways and receptors identified
Control Sources and Mitigate Risks	• Sources remediated to extent practicable • Unacceptable risks to HH or environment mitigated • Unacceptable threats to GW and SW mitigated
Residual Contamination Will Not Result in Adverse Affects	• Groundwater plumes decreasing and/or stable • Cleanup standards met in reasonable timeframe • Risk management measures are appropriate

California's Low-Threat Closure Guidance – PCE Sites Only in Figure Below



Presentation Overview

- Introduction/Definitions
- Ask "How do we get there?"
  - Achieving 'No Unacceptable Risk' in a Cost-Effective Fashion
  - Reaching ARARs in a Cost-Effective Fashion
- **Special Mention – Petroleum Sites**
- New! Interim Transition Goal
- Wrap-Up

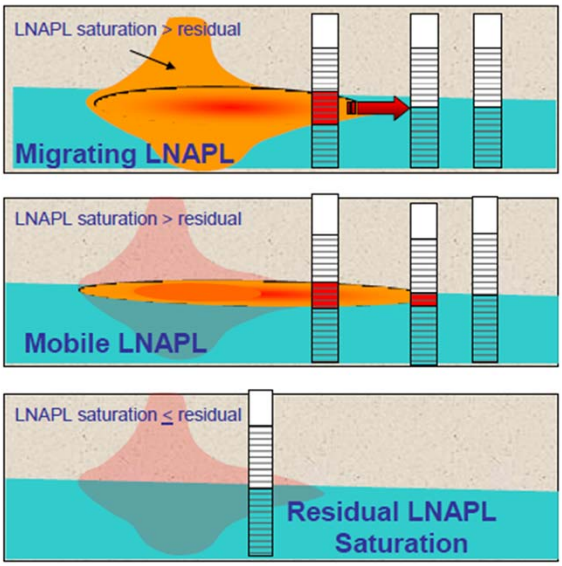
RITS 2016: Accelerating Progress along the Road to RC/SC

Petroleum Sites – Most Likely Candidates for Acceleration to RC/SC

- When do we stop NAPL recovery?
  - What does "recovering free product to the maximum extent possible" mean?
- When do we stop treating benzene plumes?

What does "recovering free product to the maximum extent possible" mean?

- Many states now recognize this as removing "migrating NAPL"



What does "recovering free product to the maximum extent possible" mean? (cont.)

- Ending LNAPL recovery when LNAPL stops migrating
  - Transmissivity tests (ITRC)
  - TPH Criteria Working Group (TPHCWG) Method
    - ESTCP Project
  - Source zone depletion assessment (CO_2 traps)
    - Results are often surprising

KEY POINT Coming Soon: 'New Developments in LNAPL Site Management" – 2016 Fact Sheet prepared by P-OPT.

BTEX Plume

- Several significant studies of groundwater plume lengths from hundreds of petroleum sites have been conducted across the U.S. since the mid-1990s (thru 2004)
- For all of these multi-site studies, the average benzene plume length was less than 200 feet
- Benzene plumes rarely migrate very far and attenuate easily under a variety of conditions (active treatment is rarely required)

KEY POINTS

1. Accelerating petroleum sites to RC/SC has good potential
2. Are petroleum sites better off in state's petroleum program (versus in CERCLA Program)?

Presentation Overview

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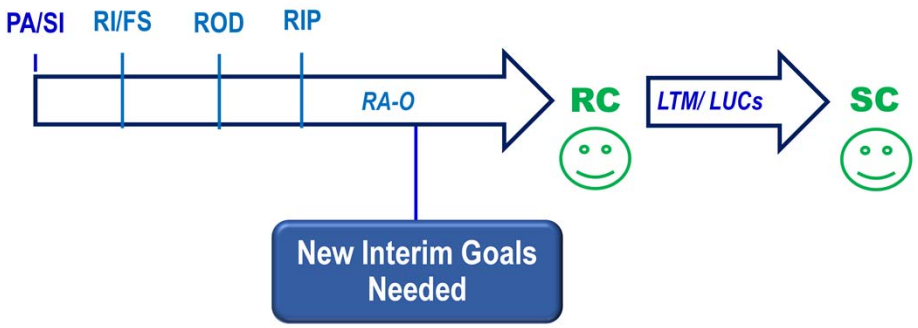
Need to track achievement of "no unacceptable risk" – Worthwhile goal!!!



RC-Transition (RC-T)

– Interim Goals recommended as part of Portfolio Optimization (P-OPT)

- **RC-T Type 1** sites are in monitoring status only; the remaining remedy components include periodic monitoring for trend analysis and land use controls.
  - No unacceptable risks with monitored natural attenuation (MNA), plume is stable or decreasing
- **RC-T Type 2** sites are those with the groundwater remedy constructed and is demonstrated to be operating successfully with continued operations and maintenance
  - No unacceptable risks with P&T system or bio-barrier that needs periodic replenishment, downgradient plume is stable or decreasing

Presentation Overview

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- Special Mention
- New! Interim Transition Goal

Wrap-Up

Key Points and Take-Away Messages

- Challenge reaching RC/SC at most groundwater sites in a cost-effective manner
- Persistent upgradient sources, matrix diffusion often prolong plume life despite aggressive remedies
- Achieve "no unacceptable risk" in short term at higher risk sites
- ARARs can generally be achieved in longer term, especially
  - At low-risk sites (stable plume, poor groundwater quality or yield, nearest receptor is surface water)
- Alternative end points need to be explored
  - To reduce the risk of investment in efforts to accelerate a site to RC/SC
- Petroleum sites often are good candidates for acceleration to RC/SC

Resources

- *Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites*, National Research Council, 2013
- *Alternate Concentration Limit Guidance*, OSWER Directive 9481.00-6C, EPA, July 1987
- *Use of Alternate Concentration Limits (ACLs) in Superfund Cleanups*, OSWER Directive 9200.4-39, EPA, July 2005
- *Guidance for Evaluating the Technical Impracticability of Groundwater Restoration*, OSWER Directive 9234.2-25, EPA, September 1993
- *Clarification of OSWER's 1995 Technical Impracticability Waiver Policy*, OSWER Directive 9355.5-32, EPA, September 2011
- *Summary of Technical Impracticability Waivers at National Priorities List Sites*, OSWER Directive 9230.2-24, EPA, August 2012

Resources (cont.)

- *Low-Threat Underground Storage Tank Case Closure Policy*, SWRCB, Adopted 2012
- *Assessment Tool for Closure of Low-Threat Chlorinate Solvent Sites*, SFRWQCB, 2009
- *Managing the Navy's Complex Groundwater Sites: Alternative Endpoints and Approaches*, OER2 Webinar, NAVFAC EXWC, April 29, 2015