

Starting Soon: Remediation Management of Complex Sites



- ▶ Remediation Management of Complex Sites, RMCS-1
<http://rmcs-1.itrcweb.org>
- ▶ Download PowerPoint file
 - CLU-IN training page at <http://www.clu-in.org/conf/itrc/rmcs/>
- ▶ Download flowchart and checklist for reference during the training class
 - http://www.clu-in.org/conf/itrc/RMCS/Excerpts_from_ITRC_RMCS-1_2017.docx

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Welcome – Thanks for Joining
this ITRC Training Class

Remediation Management of Complex Sites



Remediation Management of Complex Sites (RMCS-1)
ITRC Technical and Regulatory Guidance document

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Housekeeping

- ▶ Course time is 2¼ hours
- ▶ This event is being recorded
- ▶ Questions and feedback
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▶ Network

- State regulators
 - All 50 states, PR, DC
- Federal partners



DOE



DOD



EPA

- ITRC Industry Affiliates Program



- Academia
- Community stakeholders

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- Online and classroom training schedule
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Meet the ITRC Trainers



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Read trainer bios at
<https://clu-in.org/conf/itrc/rmcs/>

6 The Challenge – Meeting Site Objectives at Complex Sites

- ▶ Complete remediation (no use restrictions) is a significant challenge at complex sites
- ▶ ITRC team definition of a complex site:
 - Remediation progress is uncertain and remediation may not achieve closure or even long-term management within a reasonable time frame
 - “Reasonable time frame” for restoring resources to beneficial use is subject to interpretation and depends on site circumstances

The Challenge – Meeting Site Objectives at Complex Sites



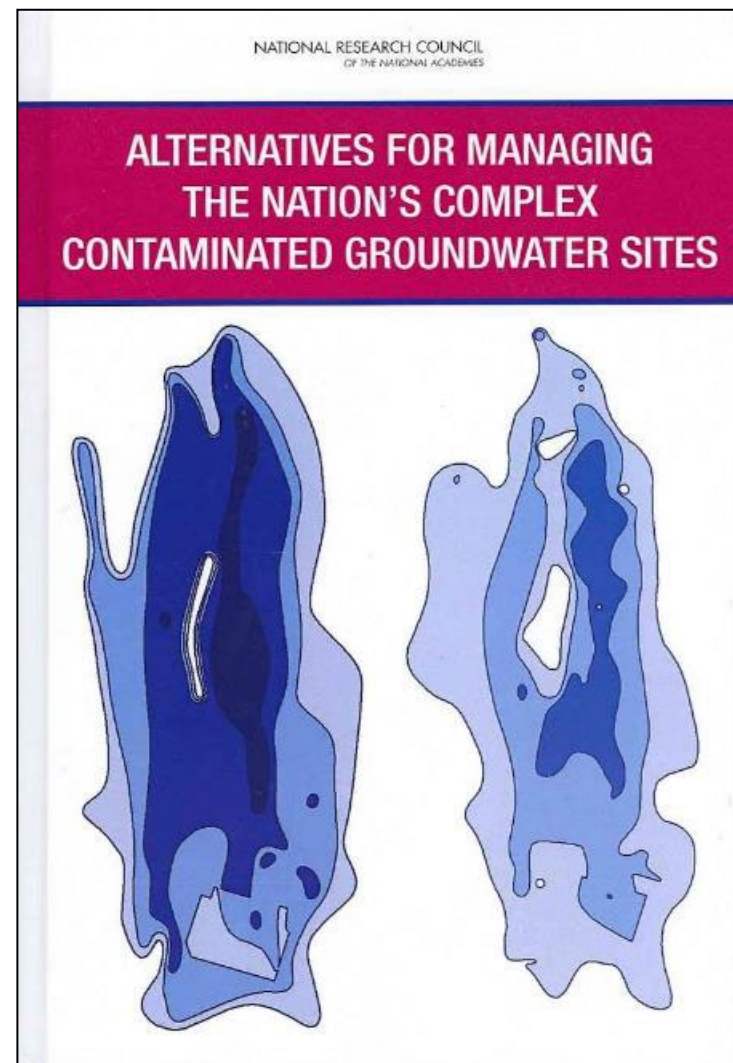
Aerial view of the Rocky Flats Site, Colorado
ITRC RMCS-1 Figure 15 (DOE 2017)



Delineating TCE plume in a residential area near Middlefield-Ellis-Whisman (MEW) Site, California
ITRC RMCS-1 Figure 12 (CPEO 2016b)

Complex Sites Nationwide

- ▶ National Research Council reported contaminant levels at 126,000 sites inhibit site closure
- ▶ Roughly 10% are “complex”
- ▶ Cost to complete = \$127 billion
- ▶ Clear need for additional guidance



National Research Council, 2013

ITRC Guidance for Complex Sites

- ▶ Recommended process for complex sites
 - Adaptive site management
- ▶ Consolidates existing guidance, best practices, tools, and technologies
- ▶ 16 case studies - real-world applications

Remediation Management of Complex Sites

Search this website

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6 Case Studies (Part Two)
7 Stakeholder Perspectives
Additional Information

HOME

Welcome
Remediation Management
of Complex Sites

At some complex sites, site-specific conditions make it difficult to fully remediate environmental contamination. Both technical and nontechnical challenges can impede remediation and may prevent a site from achieving federal- and state-mandated regulatory cleanup goals within a reasonable time frame. For example, technical challenges may include geologic, hydrogeologic, geochemical, and contaminant-related conditions as well as large-scale or surface conditions. In addition, nontechnical challenges may also play a role such as managing changes that occur over long time frames, overlapping regulatory and financial responsibilities between agencies, setting achievable site objectives, maintaining effective institutional controls, redevelopment and changes in land use, and funding considerations.

This ITRC guidance on the Remediation Management of Complex Sites provides a recommended holistic process for managing complex sites, termed "adaptive site management". This process is comprehensive, flexible, and iterative. It is well-suited for sites where there is significant uncertainty in remedy performance predictions. Adaptive site management includes

ITRC Technical and Regulatory Guidance
Remediation Management of Complex Sites
RMCS-1

<http://rmcs-1.itrcweb.org>

Adaptive Site Management

Comprehensive, Flexible, and Iterative

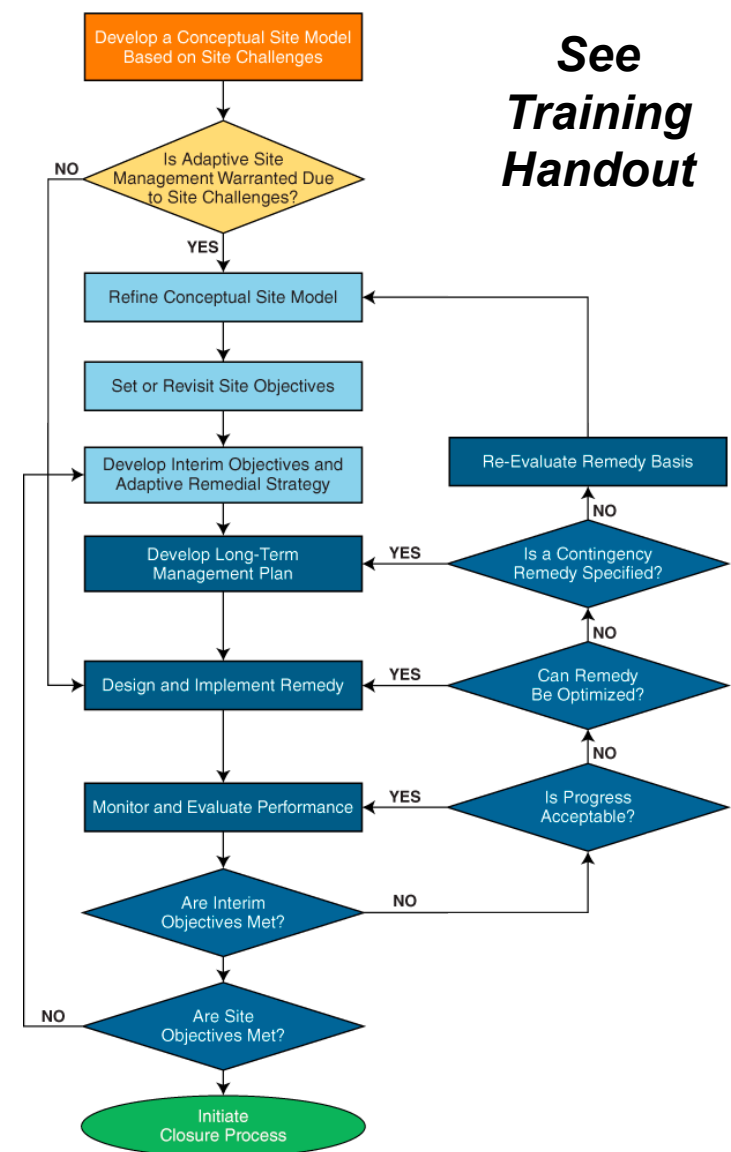
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

**See
Training
Handout**

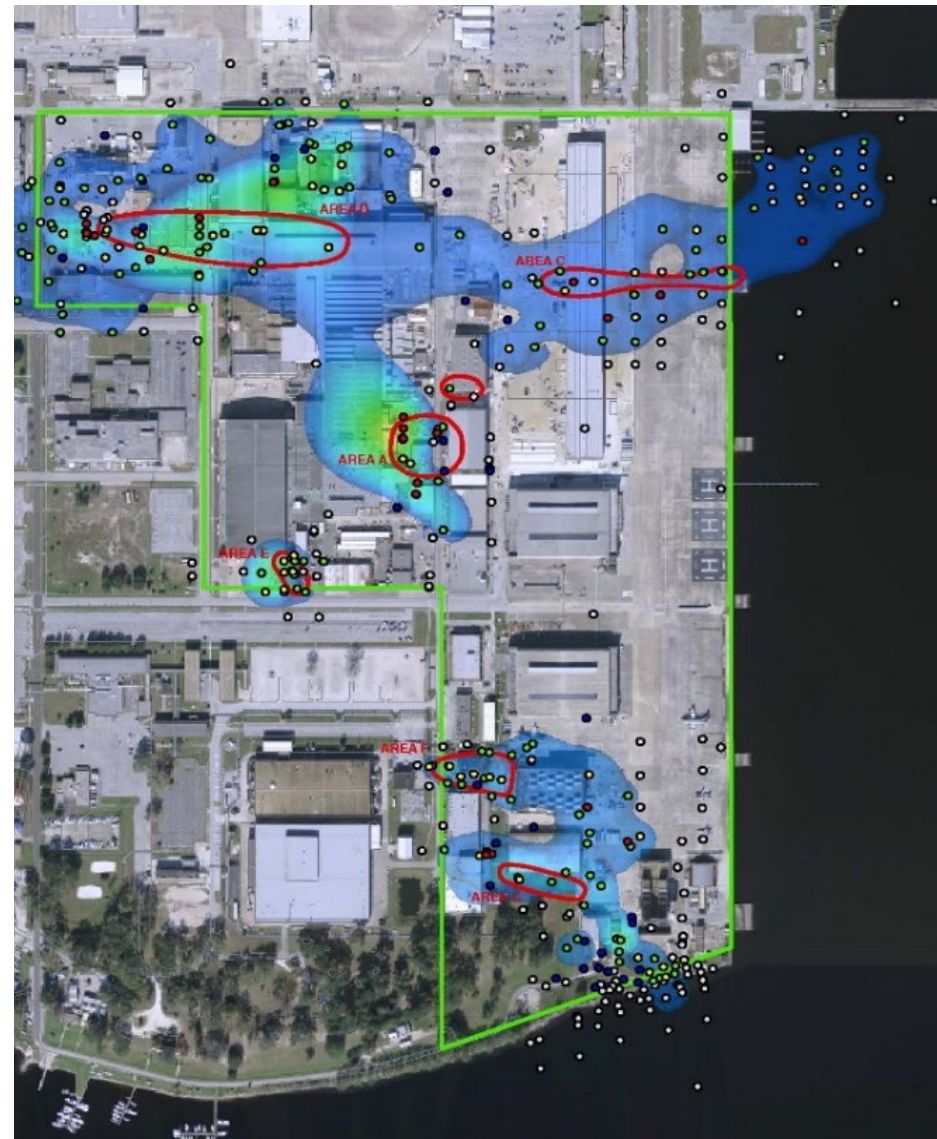


Benefits of Adaptive Site Management

- ▶ Maintain protection of human health and the environment and fulfill regulatory obligations
- ▶ Base decisions on robust conceptual site models
- ▶ Streamline decision making and save costs
- ▶ Demonstrate interim progress that leads to long-term results
- ▶ Reduce barriers to using available remedial approaches
- ▶ Return sites to beneficial reuse

Case Study: Naval Air Station Jacksonville, Florida, Operable Unit 3

- ▶ Used adaptive site management
 - Discontinued interim remedial actions
 - Refined conceptual site model
 - Determined key exposure pathways
 - Adopted a risk-based remedial approach
- ▶ Several pilot studies, innovative tools and technologies



Key to Your Success

Engage Stakeholders

- ▶ Stakeholders include citizen and Tribal communities, environmental advocacy members, and members of the affected public
- ▶ Methods for stakeholder involvement
 - Existing cleanup program processes
 - Restoration Advisory Board/stakeholder meetings
 - Public outreach and community meetings
 - Planning process
 - Adaptive site management



Case Study: Stakeholder Involvement at Middlefield-Ellis-Whisman Site

- ▶ Community members are constructive partners in decision-making
- ▶ Model permit process for cooperation between regulators and local land use planning jurisdictions



Vapor intrusion study area at Middlefield-Ellis-Whisman (MEW) site, California
ITRC RMCS-1, Figure 10, CPEO 2016a

After Today's Training We Expect You Will Be Able To:

- ▶ Identify and integrate technical and nontechnical site challenges presented by complex sites
- ▶ Use the Remediation Potential Assessment
- ▶ Apply adaptive site management principles
- ▶ Develop a long-term performance-based action plan
- ▶ Effectively engage stakeholders
- ▶ Access additional resources
- ▶ Communicate the value of this guidance

Today's Road Map

- ▶ Site challenges
- ▶ Remediation Potential Assessment
- ▶ Questions and answers
- ▶ Adaptive remedy selection
- ▶ Long-term management
- ▶ Preparing you to take action
- ▶ Questions and answers

17 Site Challenges Learning Objective

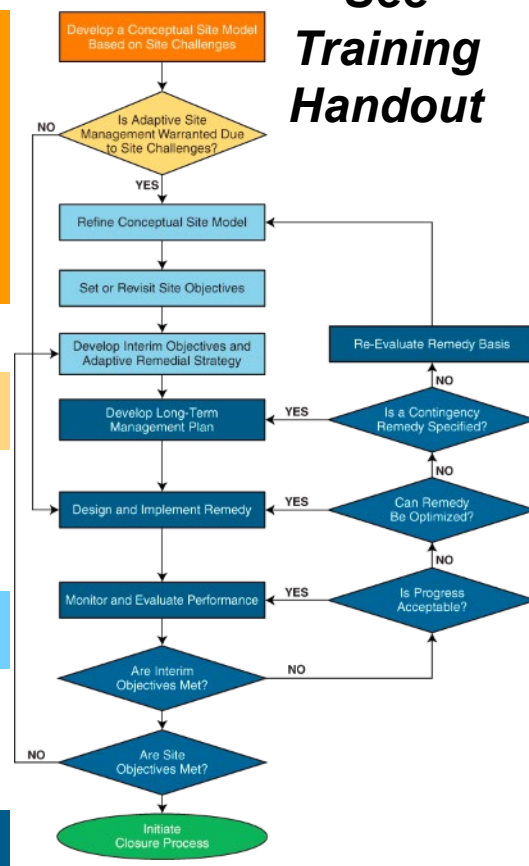
Chapter 2. Site Challenges
Identify and integrate technical and nontechnical site challenges into a holistic approach to remediation

Chapter 3. Remediation Potential Assessment

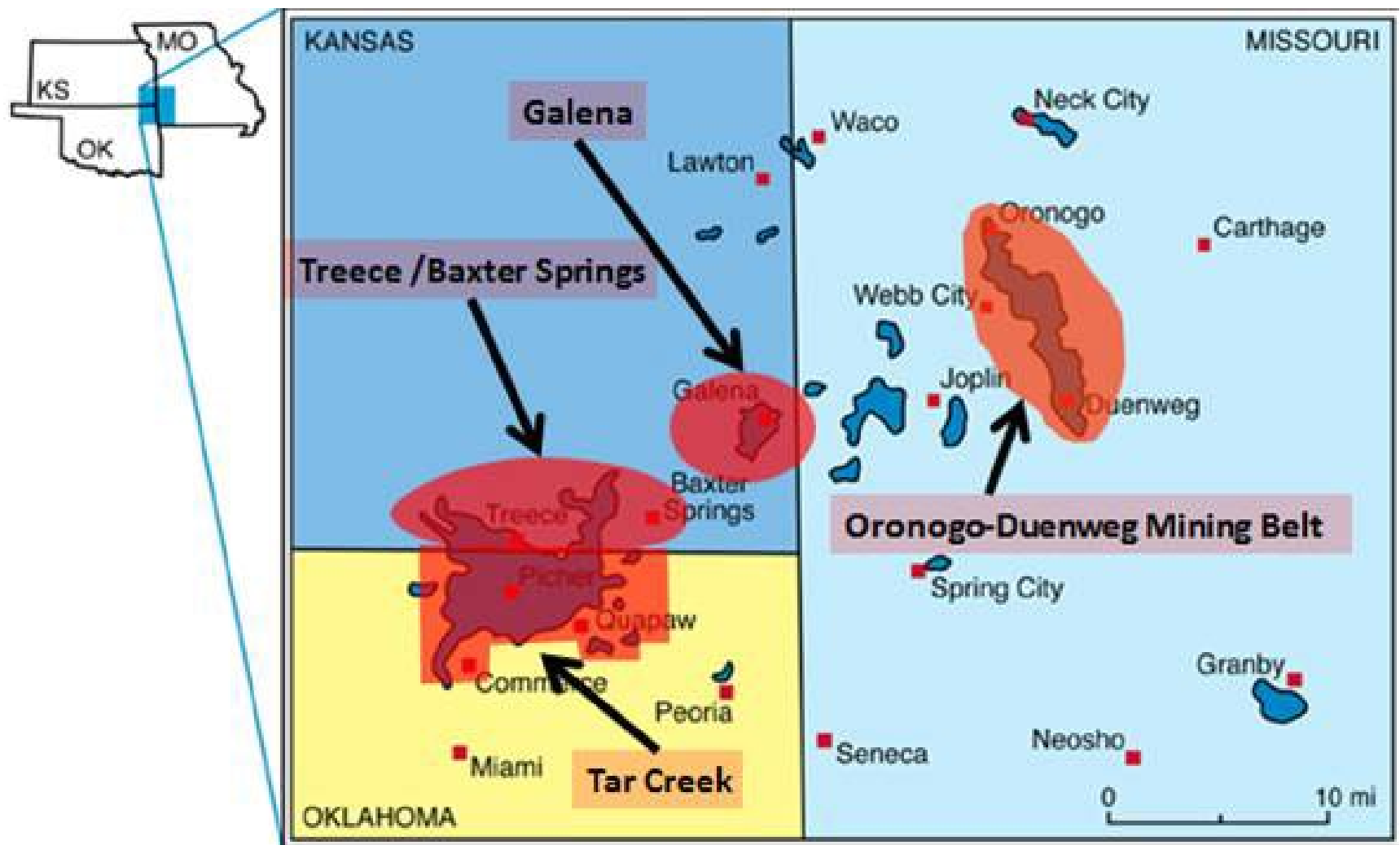
Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

See Training Handout



Complex Site?

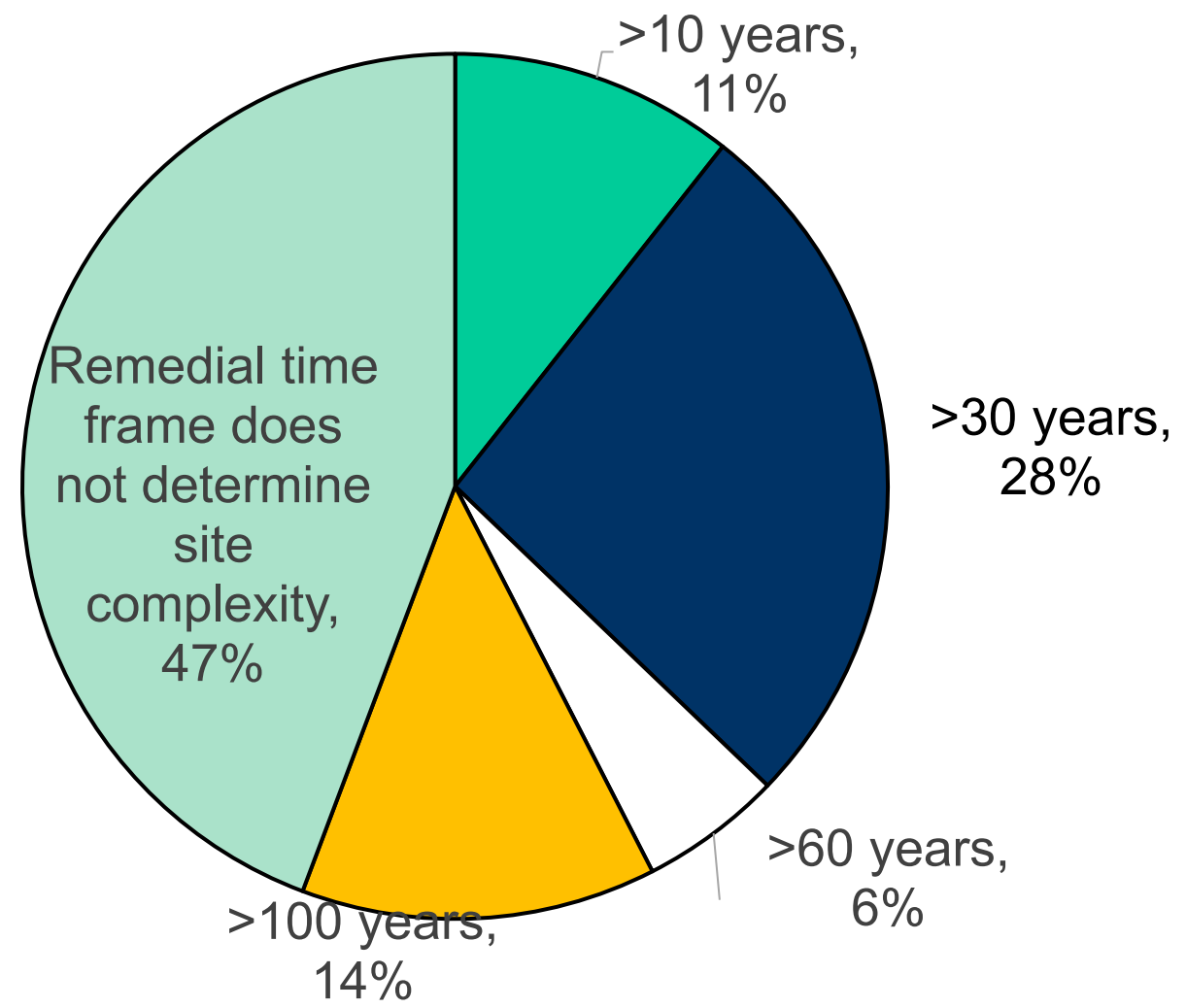


ITRC RMCS-1, Figure 37, modified from Kansas Geological Survey, 2001

Description of a Complex Site

- ▶ At “complex sites”, remediation progress is uncertain and remediation is not anticipated to achieve closure or even long-term management within a reasonable time frame
- ▶ Both technical and non-technical challenges can impede remediation
- ▶ Identifying challenges can improve the conceptual site model (CSM) and maximize remedial effectiveness

ITRC Survey Results: Diversity of Responses – Remedial Time Frame



Identify Site Challenges

Technical Examples

- ▶ Geologic
- ▶ Hydrogeologic
- ▶ Geochemical
- ▶ Contaminant-related
- ▶ Large-scale

Non-Technical Examples

- ▶ Site objectives
- ▶ Changes over long time frames
- ▶ Regulatory
- ▶ Institutional controls
- ▶ Land use
- ▶ Funding

Identify Technical Challenges Geologic Conditions

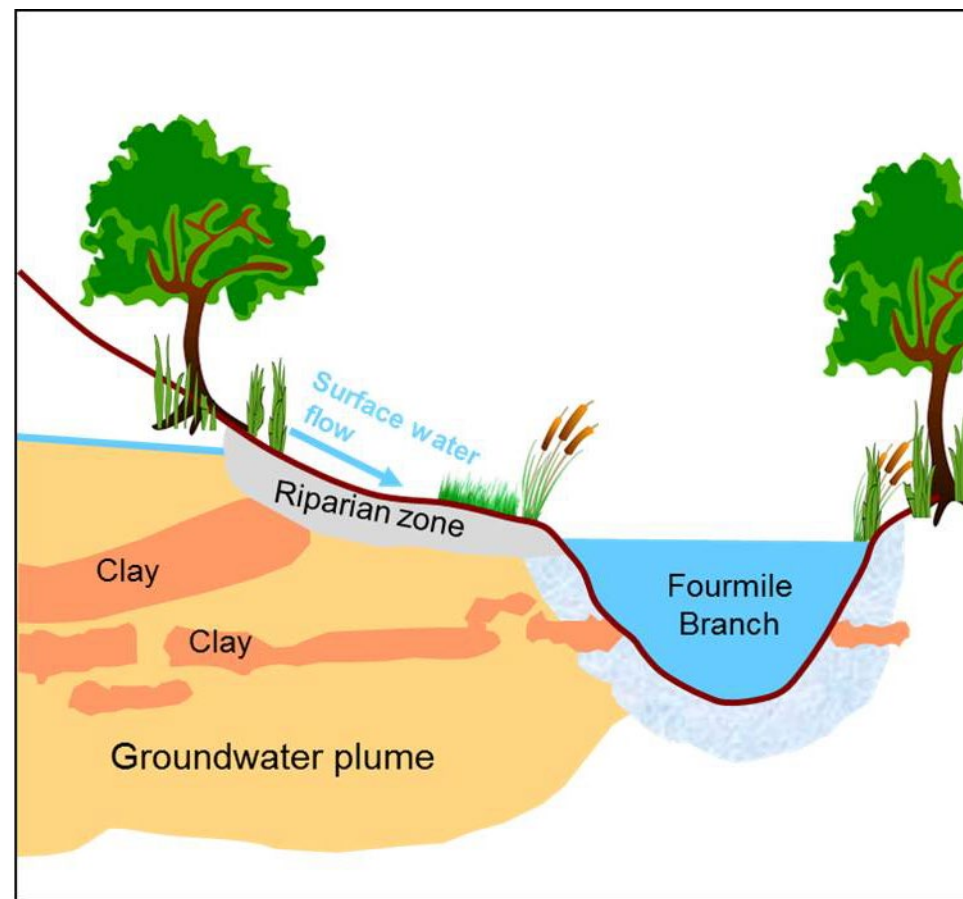
- ▶ Geologic heterogeneity/
preferential flow paths
- ▶ Fractured bedrock
- ▶ Karst bedrock
- ▶ Low-permeability media



Clay units (dark colored) dip from upper left to lower right, an example of stratigraphic heterogeneity Photo courtesy of Hubbard 2015

Identify Technical Challenges Hydrogeologic Conditions

- ▶ Extreme or variable groundwater velocities
- ▶ Fluctuating water table
- ▶ Deep contamination
- ▶ Surface water and groundwater interactions and impacted sediment



Surface water/groundwater interactions
downgradient of F-Area, Savannah River
Site, South Carolina

Identify Technical Challenges Geochemical Conditions

- ▶ Extreme geochemistry
 - Alkalinity, pH, redox conditions, salinity, ionic strength, hardness
- ▶ Extreme groundwater temperatures
 - Geothermal sources
 - Low temperatures, permafrost



Low temperatures decrease biological activity at North Slope Refinery, Alaska, Redbullet16 / Wikimedia Commons

Identify Technical Challenges

Contaminant-Related Conditions

- ▶ Light or dense nonaqueous phase liquids (LNAPL or DNAPL)
- ▶ Recalcitrant contaminants
- ▶ High concentrations or multiple contaminants
- ▶ Emerging contaminants



Technical/Regulatory Guidance

Integrated DNAPL Site Strategy



PFAS – Per- and Polyfluoroalkyl Substances

HOME

Welcome

Technical Resources for Addressing Environmental Releases of Per- and Polyfluoroalkyl Substances (PFAS)



This Interstate Technology and Regulatory Council (ITRC) online document includes fact sheets prepared by the ITRC PFAS team. The team is currently working on the associated Technical and Regulatory Guidance Document.

ITRC has developed six [fact sheets](#) to summarize the latest science and emerging technologies for per- and polyfluoroalkyl substances (PFAS). The fact sheets are tailored to the needs of state regulatory program personnel who are tasked with making informed and timely decisions regarding PFAS-impacted sites. The content is also useful to consultants and parties

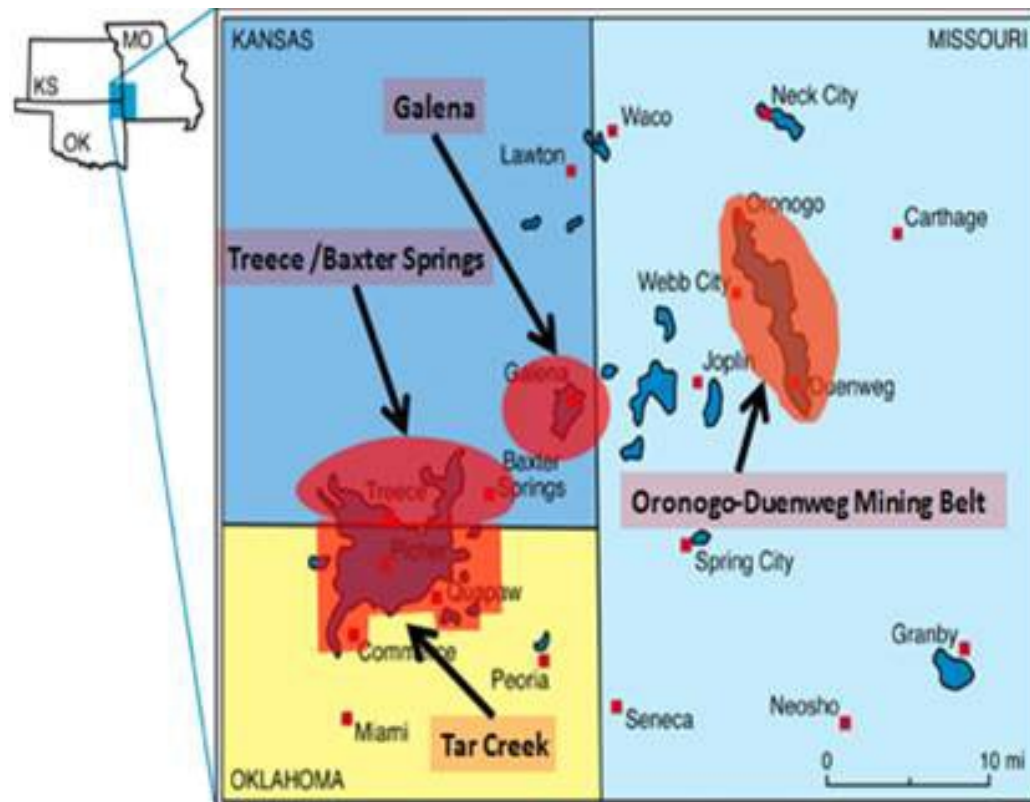
ITRC RMCS-1, Table 2; ITRC ISC-1 2015;

ITRC IDSS-1 2015; ITRC Fractured Rock and PFAS Team Fact Sheets, 2017

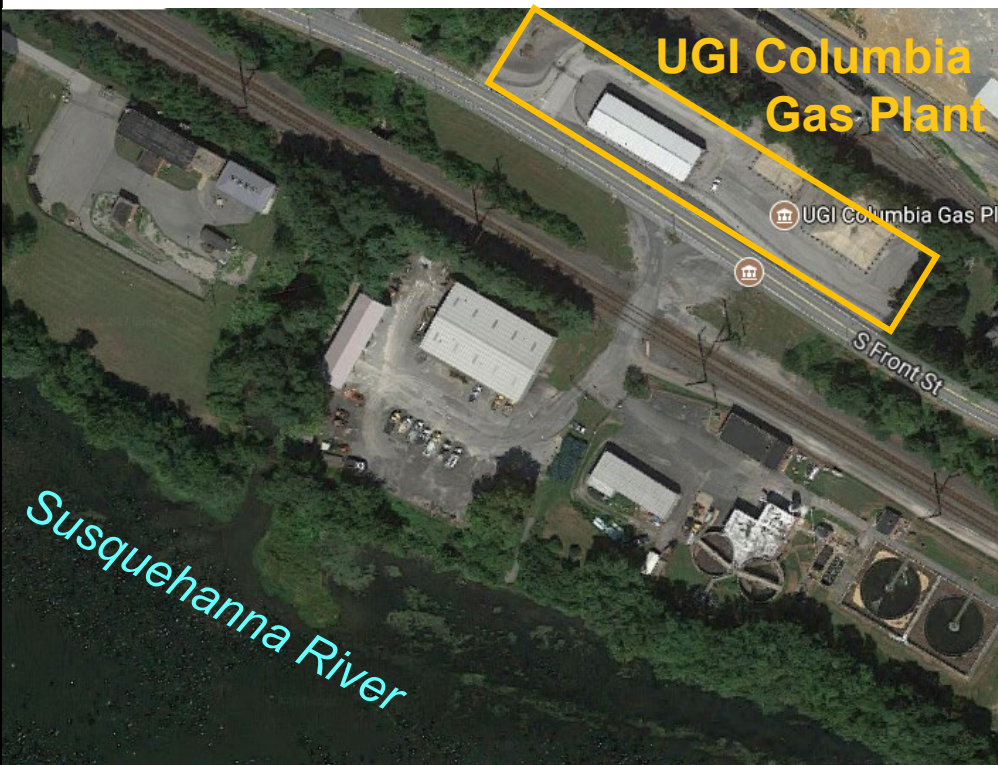
Identify Technical Challenges

Large-Scale Sites

- ▶ Location and extent of contamination
- ▶ Depth of contamination
- ▶ Number, type and proximity of receptors
- ▶ Extensive or comingled plumes



Technical Challenges Case Study: UGI Columbia Gas Site, Pennsylvania



Google Maps 2017

- ▶ Residual tar in river sediments, groundwater and deep in fractured bedrock
- ▶ Tar will slowly dissolve over centuries

Identify Non-Technical Challenges

▶ Site objectives

- Changing site objectives
- Societal expectations
- Green and sustainable remediation

▶ Managing changes over long time frames

- Phased remediation
- Future use
- Site management

▶ Regulatory

- Federal and state cooperation
- Changing laws and regulation
- Orphan sites
- Contaminants without regulatory guidance/criteria

Identify Non-Technical Challenges

- ▶ Institutional controls
 - Tracking and managing
 - Enforcing
 - Long-term management
- ▶ Land use
 - Changing land, water use
 - Multiple owners
 - Site access
- ▶ Funding
 - Lack of funds, political influence on program funding



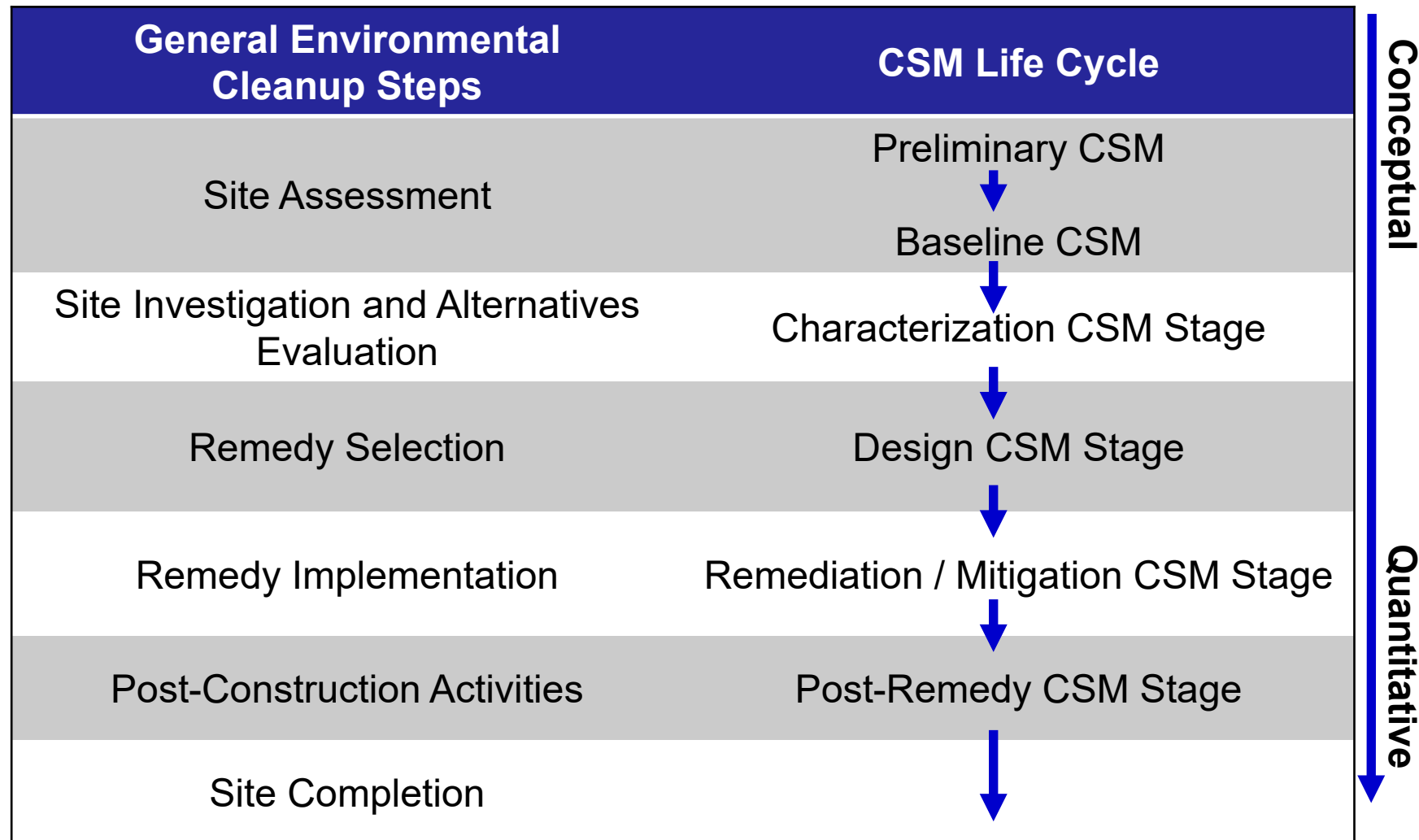
Deer graze on Rocky Flats National Wildlife Refuge in Colorado
Footwarrior, Wikimedia Commons

Non-Technical Challenges Case Study: Velsicol Site, Michigan



- ▶ Contaminated city wells and Pine River
 - DNAPL pools 100 feet deep
- ▶ Livestock impacts and community economic hardship
- ▶ Limited funding prompted stakeholder involvement

Conceptual Site Model Maturity



USEPA, 2011a. Environmental cleanup best practices: Effective use of the project life cycle conceptual site model. EPA 542-F-11-011.

Site Challenges Summary

- ▶ Complex sites typically have multiple challenges
- ▶ Both technical and non-technical challenges can impede remediation
- ▶ Identifying them can improve the conceptual site model and maximize remedial effectiveness

Today's Road Map

- ▶ Introduction
- ▶ Site challenges
- ▶ Remediation Potential Assessment
- ▶ Questions and answers
- ▶ Adaptive remedy selection
- ▶ Long-term management
- ▶ Preparing you to take action
- ▶ Questions and answers

Remediation Potential Assessment Learning Objective



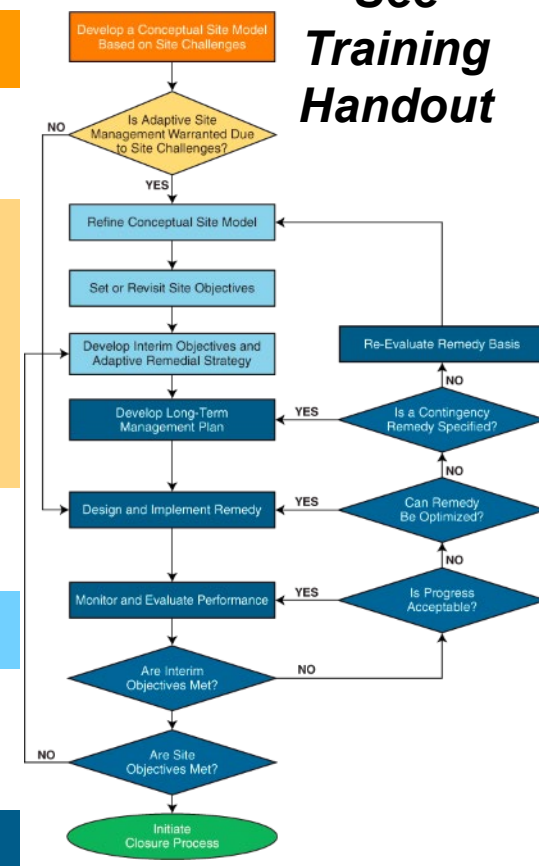
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment
Use the Remediation Potential Assessment to identify whether Adaptive Site Management is warranted due to site challenges

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

See Training Handout



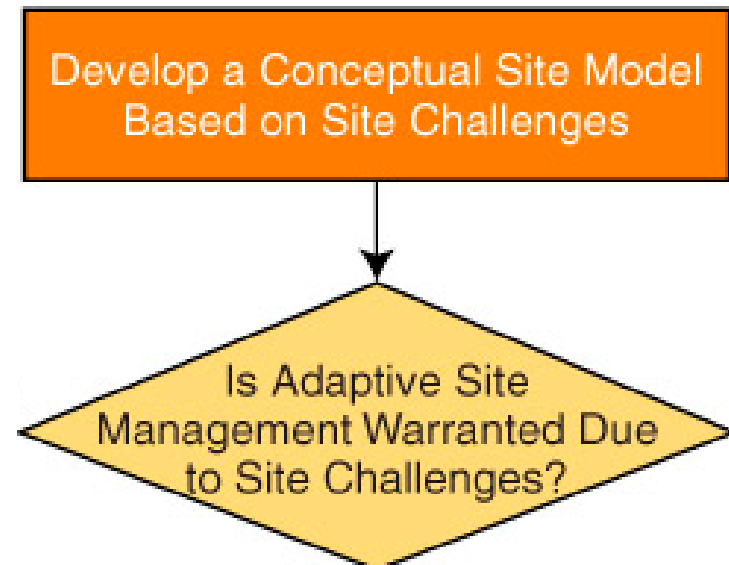
Remediation Potential Assessment Process and Outcome

Process

- ▶ Screening tool uses weight-of-evidence approach to assess if site is likely to achieve remedial objectives in a reasonable time frame
- ▶ Basis for aligning expectations with actual remediation potential
- ▶ Promotes effective and transparent interaction

Outcome

- ▶ Site objectives are attainable OR
- ▶ Remediation potential is low – consider adaptive site management



“Can You Get There?”



- ▶ Small, shallow site
- ▶ Sandy water bearing unit
- ▶ Low concentrations
- ▶ Benzene (attenuates fast)
- ▶ Very little non-aqueous phase liquid

“Can You Get There?”



- ▶ Small, shallow site
- ▶ Sandy water bearing unit
- ▶ Low concentrations
- ▶ BTEX (attenuates fast)
- ▶ Very little NAPL



- ▶ Large site, deep contamination
- ▶ Much of source under buildings
- ▶ Sand, silt, fractured clays
- ▶ Not much biodegradation
- ▶ Need > 99.9% reduction

Remediation Potential Assessment

Purpose

- ▶ Intended to inform the remedial decision process and determine if adaptive management process is beneficial
- ▶ Can allow for greater transparency and facilitate future reviews of the process
- ▶ Flexible process that can be modified as appropriate for the site

Remediation Potential Assessment (RPA)

DOES:

- ▶ Allow flexibility and site-specific input in an iterative process
- ▶ Require detailed supporting data on the nature and extent of contamination
- ▶ Consider remediation potential of individual factors in context of other pertinent factors

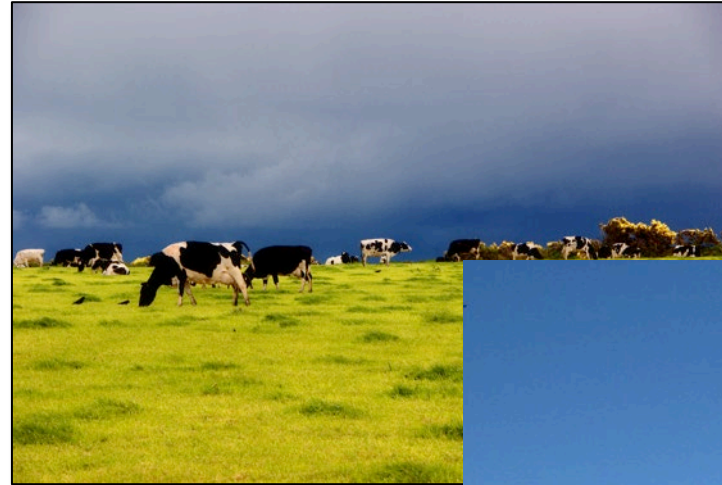
DOES NOT:

- ▶ Provide a means to avoid requirements
- ▶ Evaluate whether a site is complex
- ▶ Directly consider cost
- ▶ Produce a default decision

Remediation Potential Assessment Key Criteria (Pre-Remedy)

8 Questions...

1. How difficult is it to work at the surface of the site?



Martin Abegglen /
Wikimedia Commons



ITRC RMCS-1 Figure 12,
CPEO, 2016b

Remediation Potential Assessment

Key Criteria (Pre-Remedy)

8 Questions...

1. How difficult is it to work at the surface of the site?



Laurent Deschodt / Wikimedia Commons

2. How difficult is it to drill at the site?

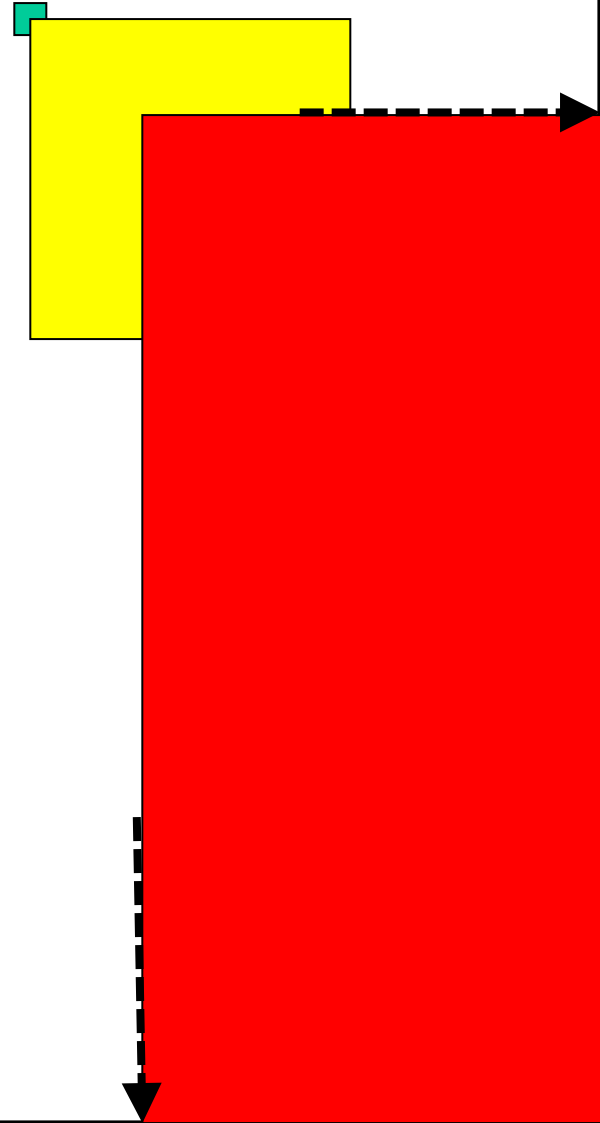


Wilson44691 / Wikimedia Commons

Remediation Potential Assessment

Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?



Remediation Potential Assessment

Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?

90% ?

4. What contaminant concentration reduction is needed?

99% ?

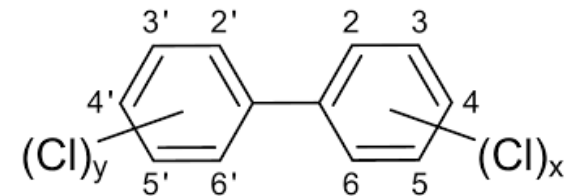
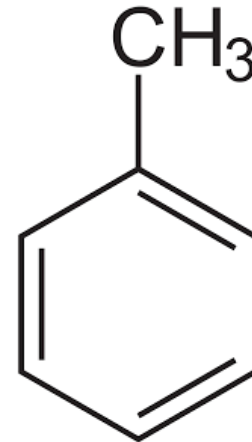
99.9% ?

99.99% ?

Remediation Potential Assessment

Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?
4. What contaminant concentration reduction is needed?
5. Do the key site constituents readily attenuate relative to the travel time to receptors?



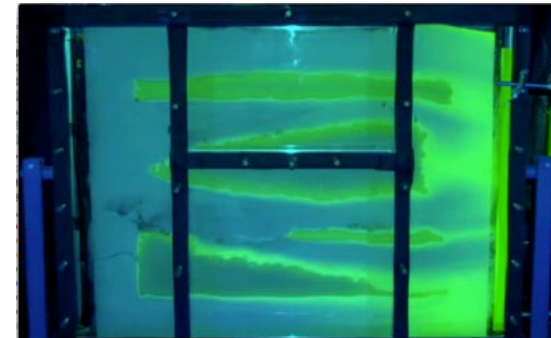
Remediation Potential Assessment

Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?
4. What contaminant concentration reduction is needed?
5. Do the key site constituents readily attenuate relative to the travel time to receptors?
6. Does difficult-to-remove mass exist at the site?

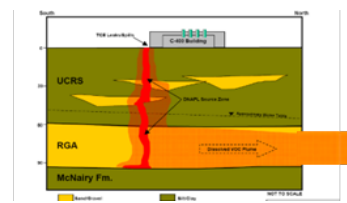
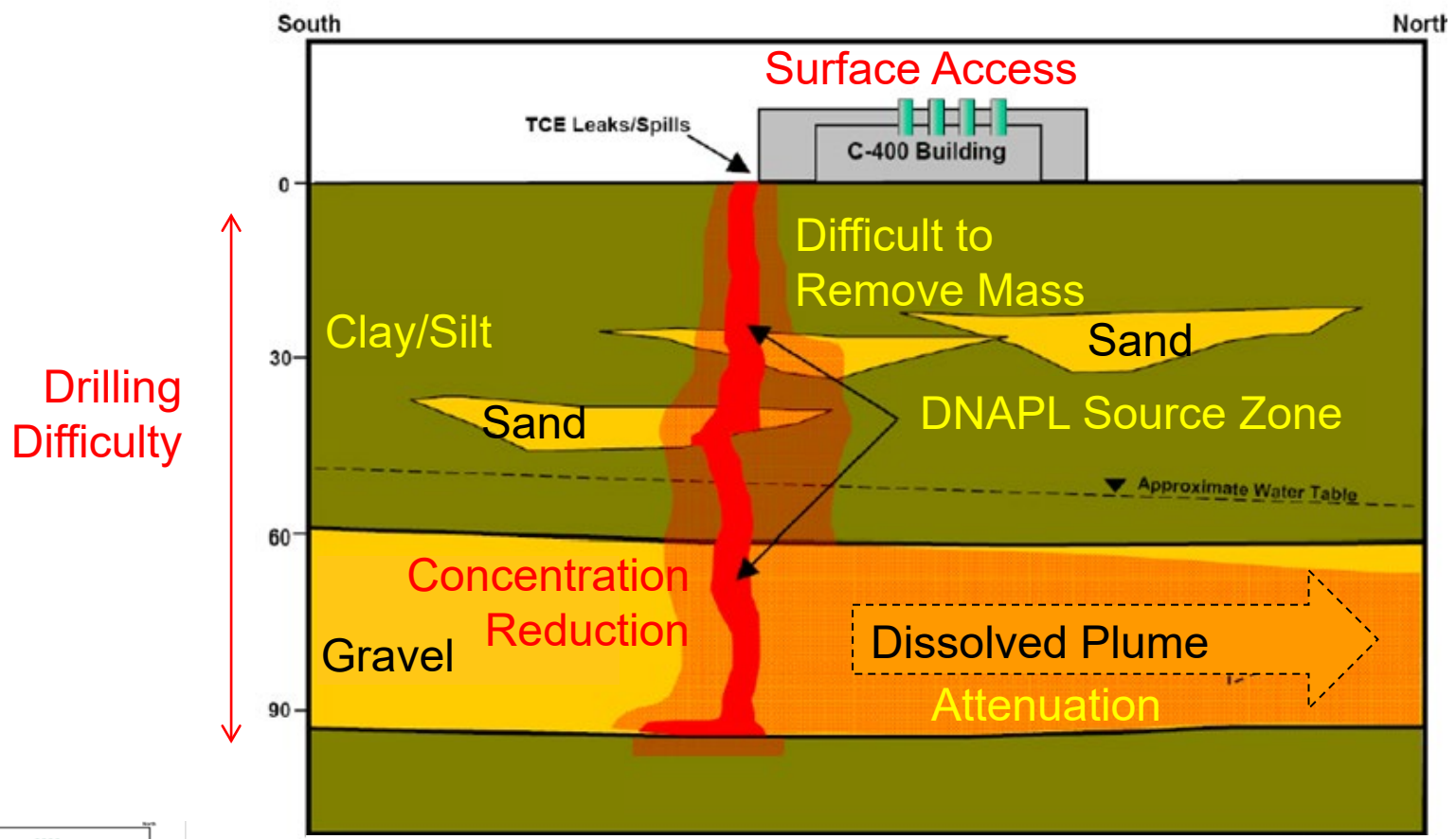


Al Silonov / Wikimedia Commons



L. Donor., T. Sale, CSU

Case Study: Paducah Gaseous Diffusion Plant, Kentucky



Scale of Source and/or Plume

Remediation Potential Assessment Key Criteria (Pre-Remedy)

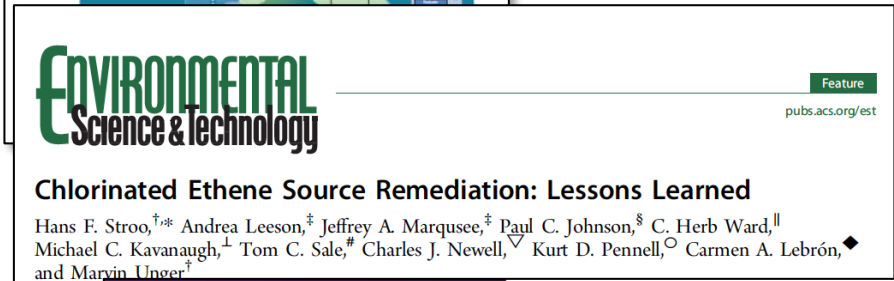


7. What is the predicted performance for available remedial technologies?



2011

2012

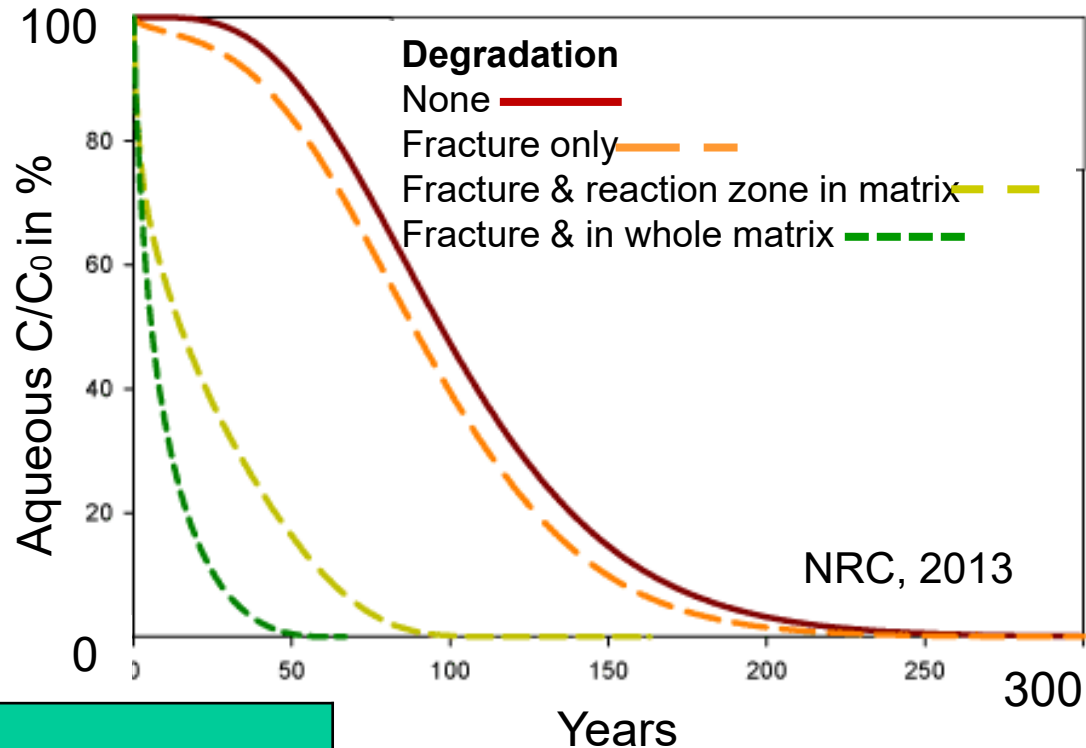


2015

Remediation Potential Assessment

Key Criteria (Pre-Remedy)

8. What is the predicted time frame for achieving interim and site objectives?



Model/Analysis

USEPA REMChlor or REMFuel Model

Natural Attenuation Software

Matrix diffusion

Concentration vs. time

First order rate calculations

Remediation Potential Assessment Matrix of Evaluation Criteria



- ▶ Evaluate each criteria as high, moderate or low
- ▶ Weight criteria to reflect relative importance
- ▶ Assess conclusion

Evaluation Criteria	Likelihood of Achieving Remediation Objectives		
	High	Moderate	Low
Access	✓		
Drilling feasibility	✓		
Scale		✓	
Concentration reduction			✓
Attenuation	✓		
Difficult-to-remove mass			✓
Technology performance	✓		
Time frame		✓	
Total checked:	4	2	2

Remediation Potential Assessment Matrix of Evaluation Criteria

- ▶ Evaluate each criteria as high, moderate or low
- ▶ Weight criteria to reflect relative importance
- ▶ Assess conclusion

Evaluation Criteria	Likelihood of Achieving Remediation Objectives		
	High	Moderate	Low
Access		✓	
Drilling feasibility	✓		
Scale		✓	
Concentration reduction			✓
Attenuation		✓	
Difficult-to-remove mass			✓
Technology performance			✓
Time frame			✓
Total checked:	1	3	4

Remediation Potential Assessment

Key Criteria (Post-Remedy)

- ▶ Has the existing remedy been effectively operated and maintained?
- ▶ Are aquifer conditions or contaminant sources adequately characterized? Have they changed?
- ▶ Are concentrations reductions occurring at the rate anticipated?
- ▶ Does the selected remedy adequately address contaminants and/or hydrogeologic conditions?
- ▶ Can interim and/or site objectives (and contaminant-specific cleanup levels) be met with other technologies within a reasonable time frame?

Remediation Potential Assessment Summary

- ▶ Screening tool - provides a valuable process; does not produce a default decision
- ▶ You answer eight technical questions and use Weight-of-evidence to assess if site is likely to achieve remediation objectives
- ▶ Allows flexibility and site-specific input in an iterative process
- ▶ Goal: Determine if...
 - Site objectives are likely attainable OR
 - Remediation potential is low – Adaptive Site Management will be important

Q&A Break

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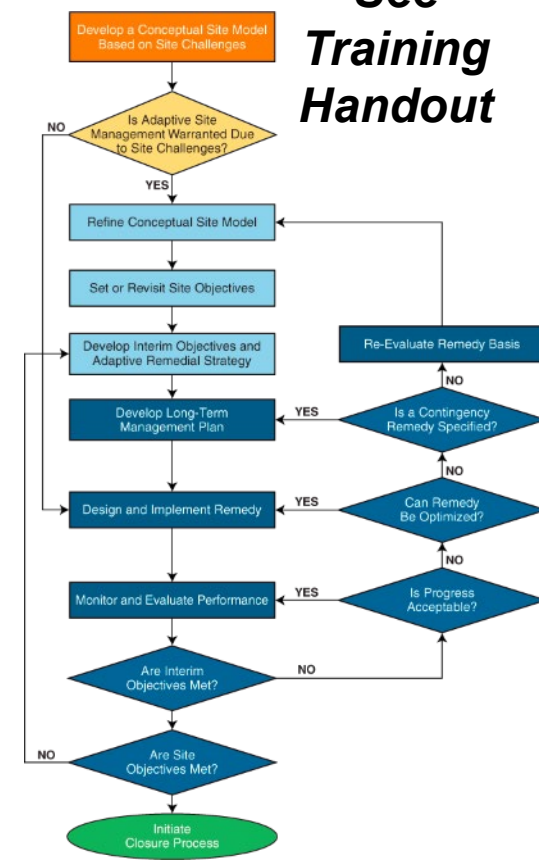
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

See **Training Handout**



Today's Road Map

- ▶ Site challenges
- ▶ Remediation Potential Assessment
- ▶ Questions and answers
- ▶ Adaptive remedy selection
- ▶ Long-term management
- ▶ Preparing you to take action
- ▶ Questions and answers

Learning Objective

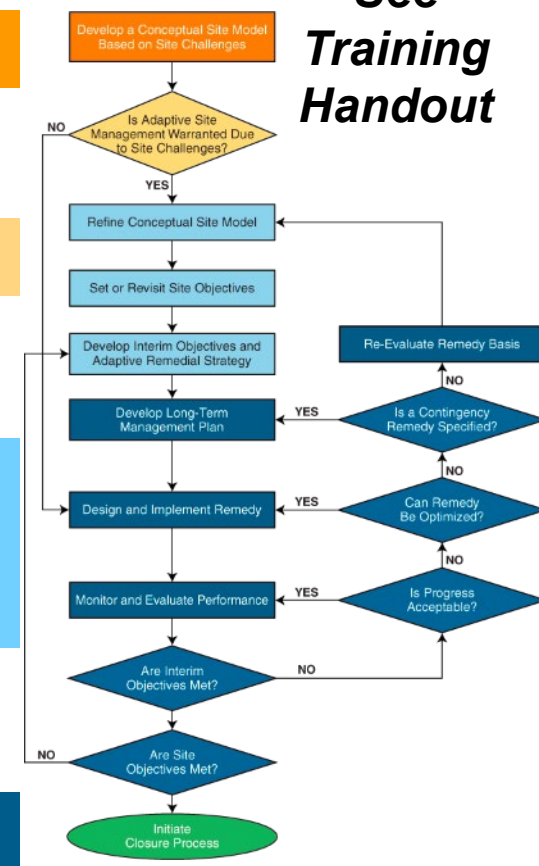
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection
Understand and apply adaptive site management principles

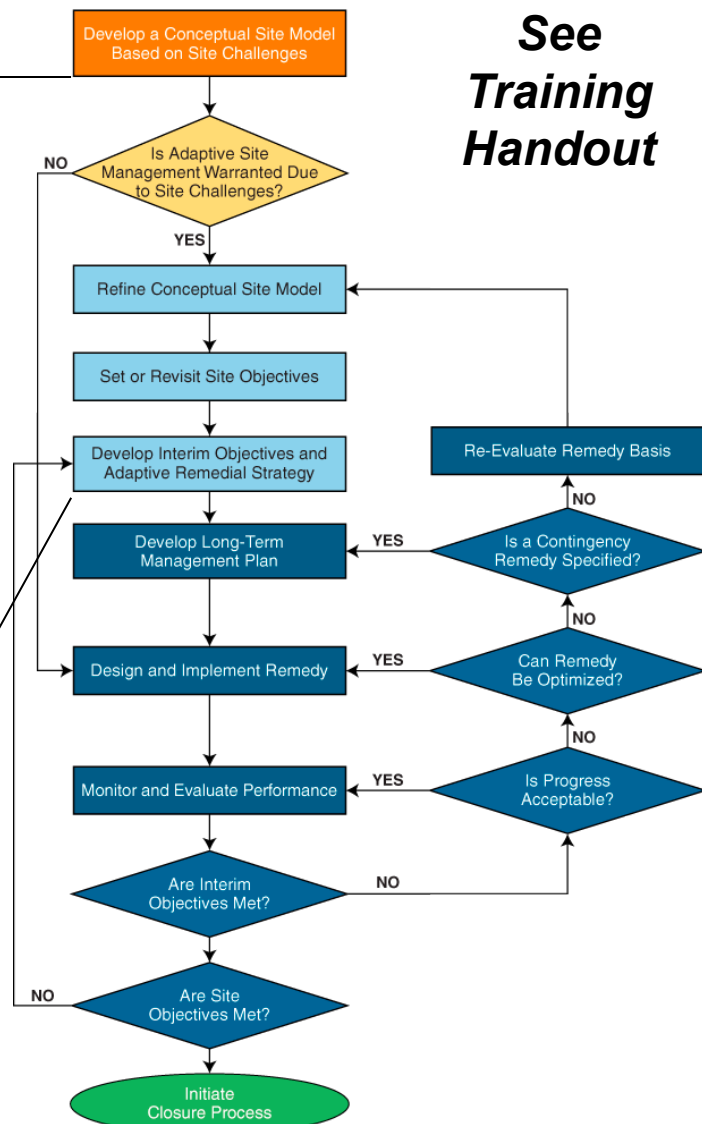
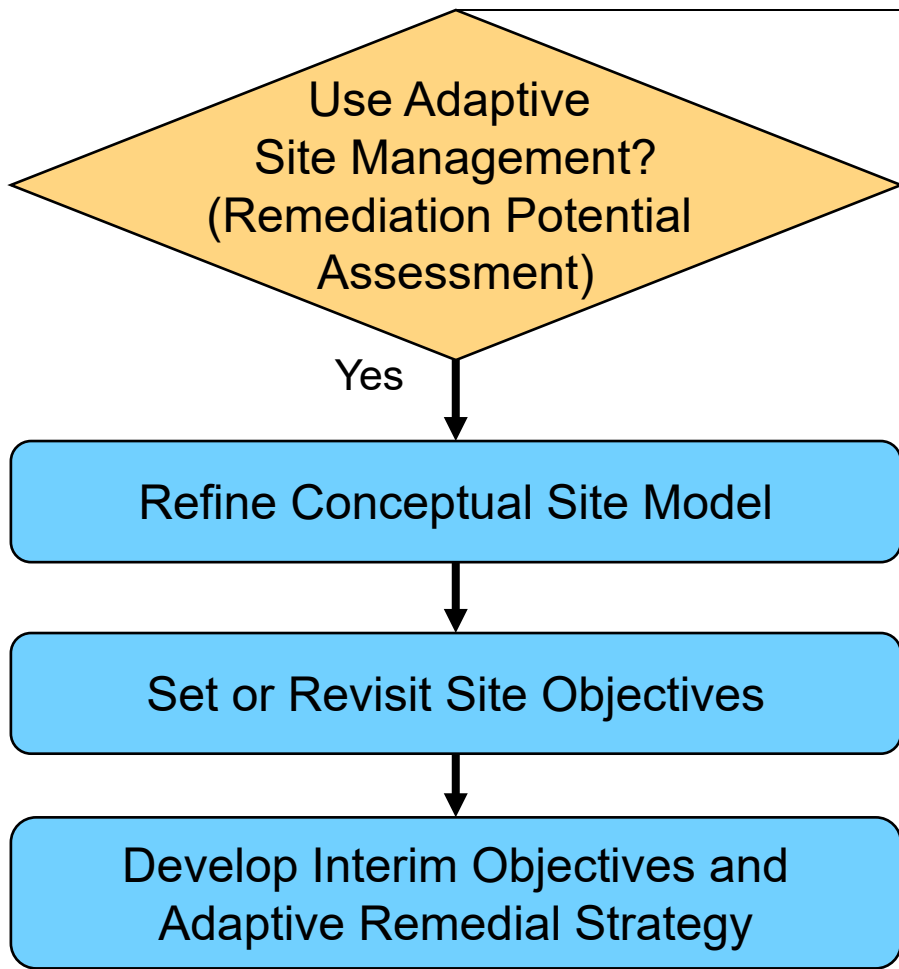
Chapter 5. Long-Term Management

See
**Training
Handout**



Adaptive Remedy Selection

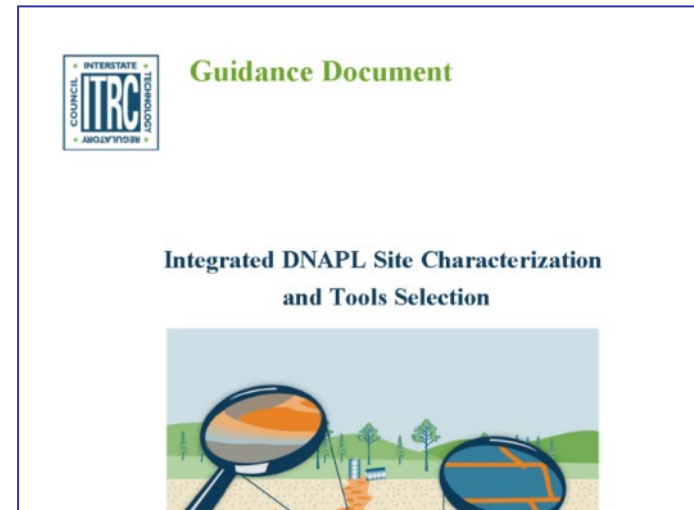
Poll Question



See Training Handout

Refine Conceptual Site Model

- ▶ Prior to revisiting remedy
 - Are site challenges described?
 - What inhibited remediation progress?
 - What are data gaps?
- ▶ Tools for remedy evaluation



ITRC ISC-1 2015

http://www.itrcweb.org/DNAPL-ISC_tools-selection/

Conceptual Site Model

Australia Case Study

Phase	Source		Proximal Plume		Distal Plume	
	Low	High	Low	High	Low	High
Permeability/ Transmissivity	Low	High	Low	High	Low	High
Soil vapor	High (>1,000)	Moderate (10-100)	Moderate (10-100)	Moderate (10-100)	Low (1-10)	Low (1-10)
DNAPL	High (>1,000)	High (>1,000)	NA	NA	NA	NA
Groundwater	Moderate/High (100-1,000)	Moderate/High (100-1,000)	Moderate/High (100-1,000)	Moderate/High (100-1,000)	Moderate (10-100)	Moderate (10-100)
Sorbed	Moderate (10-100)	Low (1-10)	Low (1-10)	Low (1-10)	Low (1-10)	Low (1-10)

LEGEND

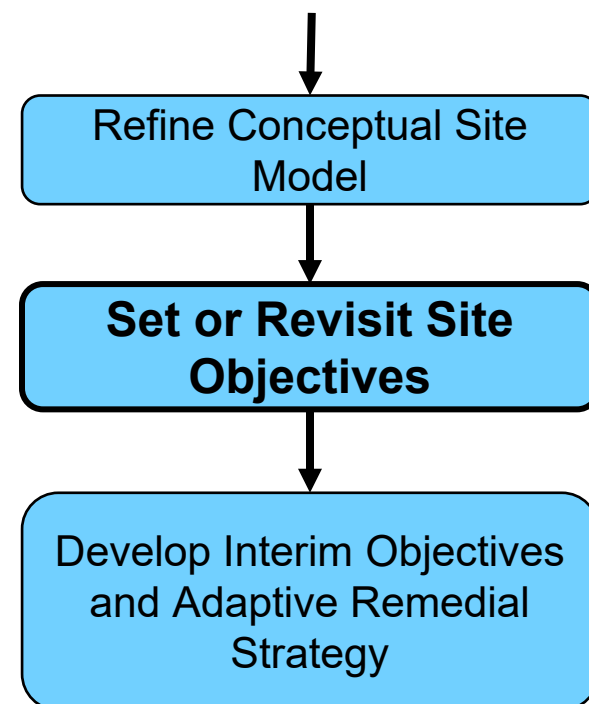
Equivalent aqueous concentration (mg/L)

High (>1,000)	HIGH (>1,000)
Moderate/High (100-1,000)	MODERATE/HIGH (100-1,000)
Moderate (10-100)	MODERATE (10-100)
Low (1-10)	LOW (1-10)
Not Applicable (NA)	NOT APPLICABLE (NA)

20-Compartment model summarizing the conceptual site model of contaminant mass at the site. ITRC RMCS-1, Figure 69 and Appendix B

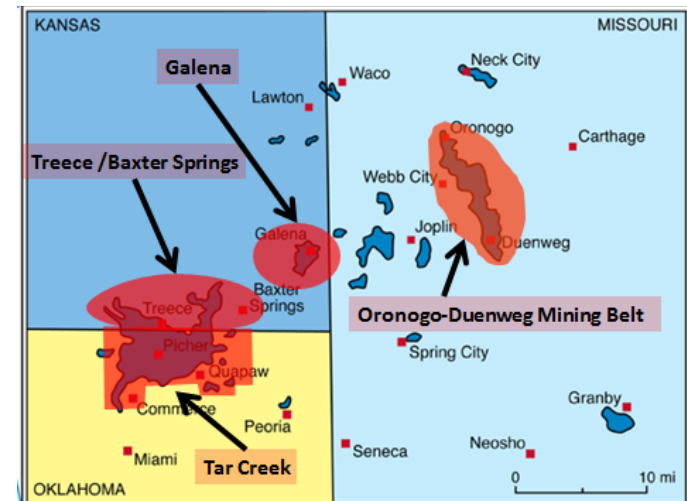
Set or Revisit Site Objectives

- ▶ **Site objectives** are overall remedial expectations, including protecting public health and the environment
- ▶ **Set** site objectives
 - Consider complexities
 - Consider different geologic or operable units, source area and plume -- “site segments”
- ▶ **Revisit** site objectives
 - If progress is insufficient despite optimization



Site Objectives at Complex CERCLA Sites

- ▶ Protect human health and environment
- ▶ Meet Applicable or Relevant and Appropriate Requirements (ARARs) or criteria for ARAR waiver
 - Inconsistent application of state standards
 - Fund balancing
 - Equivalent performance
 - Interim measures
 - Greater risk
 - Technical impracticability (TI)



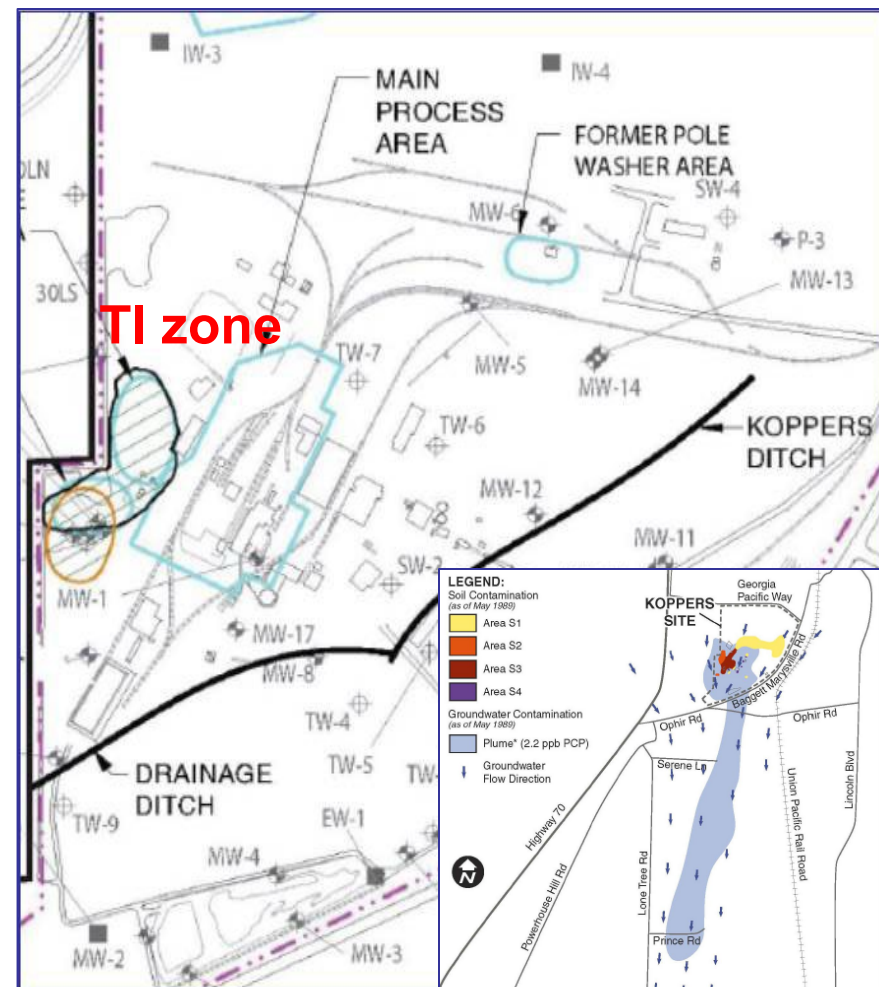
TI waiver at Tri-State Mining District (Oklahoma, Kansas, Missouri)

CERCLA - Comprehensive Environmental Response, Compensation and Liability Act

ITRC RMCS-1 Chapter 4, 40 CFR 300.430(f)(1)(ii)(C), USEPA 1993, 2012

Case Study: ARAR Waiver at a Wood Treatment Facility, Oroville, California

- ▶ Complexities
 - Recalcitrant creosote and pentachlorophenol DNAPL
 - Drinking water aquifer
- ▶ Record of Decision amendment included TI waiver
 - Groundwater goal within 4-acre area is containment, not restoration



TI zone at the Koppers Oroville, California wood treatment facility

CERCLA Sites

Alternate Concentration Limits

- ▶ Alternate concentration limits can be used in groundwater only if
 - Groundwater discharges to surface water
 - No statistically significant increase in concentrations downstream
 - No exposure to off-site contaminated groundwater prior to discharge
- ▶ No recent case studies identified

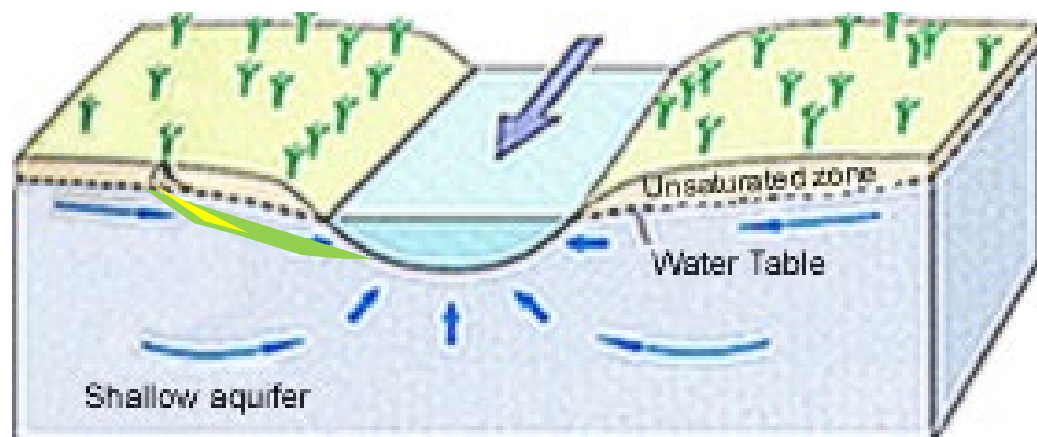


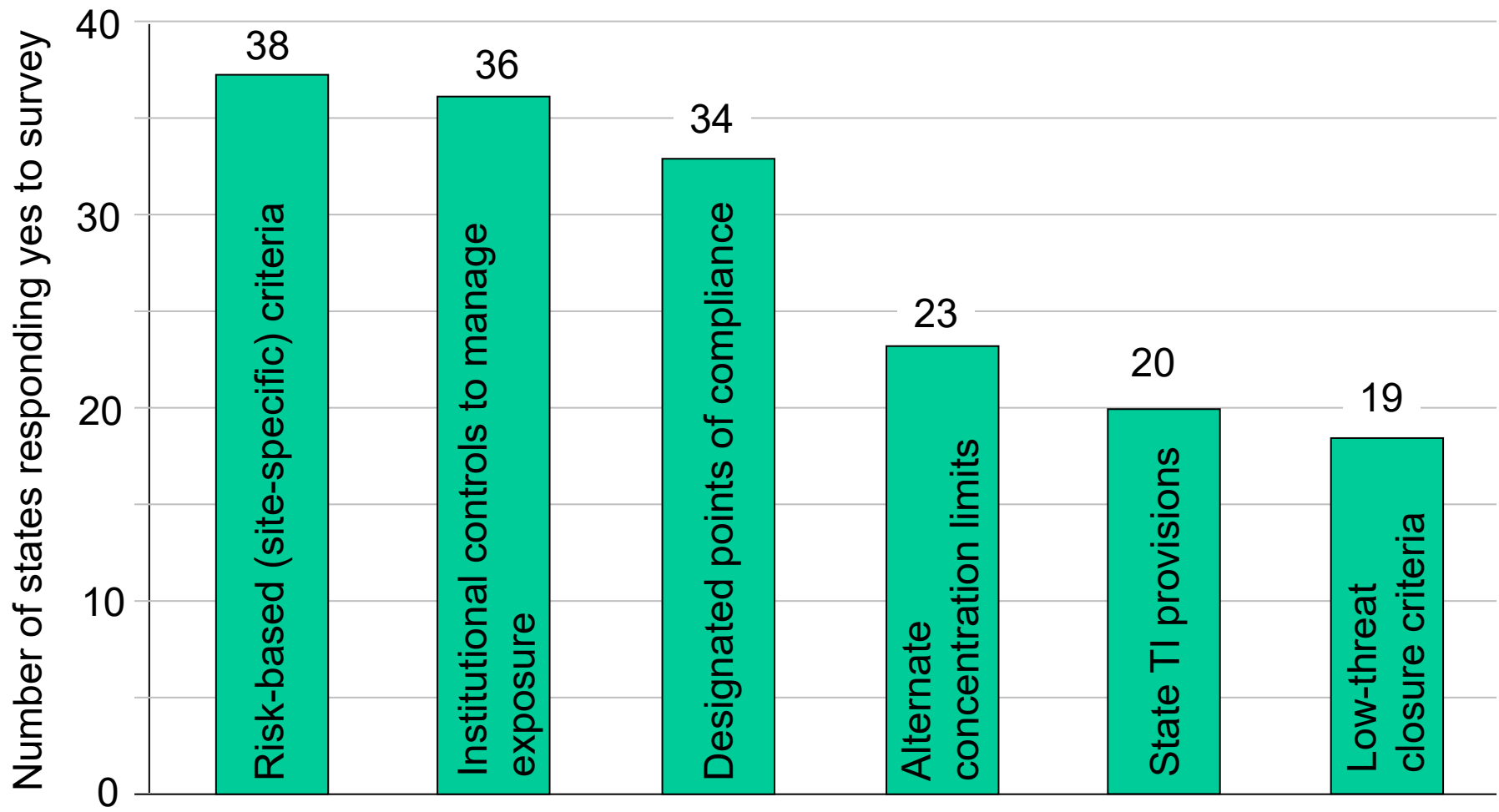
Image from U.S. Geological Survey

RCRA and Other State Programs

ITRC Survey

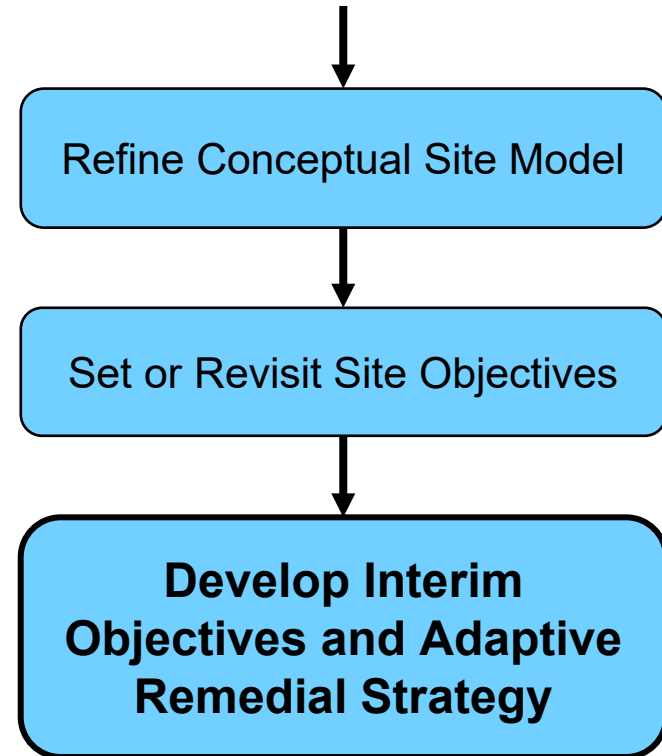
- ▶ Team surveyed states about their approaches
 - RCRA, Brownfields, Underground Storage Tank programs
 - Responses from 40 states
- ▶ Does your state allow the following to meet site objectives...
 - ...as a primary means?
 - ...after the original selected remedy fails to reach site objectives within the planned remedial time frame?

RCRA and Other State Programs



Develop Interim Objectives and Adaptive Remedial Strategy

- ▶ **Interim objectives** are intermediary goals that guide progress towards achieving site objectives
- ▶ **Adaptive remedial strategy** is a combination of technologies and approaches to meet interim objectives



Interim Objectives

- ▶ Should be Specific Measurable Attainable Relevant and Timebound (SMART)
 - Contaminant mass flux or discharge decrease by [x]% within [#] years
 - Target degradation rates met within [#] years
 - Capping to prevent direct exposure
- ▶ Guide short-term decisions and actions
 - Optimization
 - Technology transitions
- ▶ Meeting interim objectives → progress

Select Adaptive Remedial Strategy

Step 1. Identify Options

- ▶ Biological treatment
- ▶ Chemical treatment
- ▶ Thermal treatment
- ▶ Removal
- ▶ Enhanced extraction
- ▶ Source flux reduction
- ▶ Contaminant mass flux reduction
- ▶ Pump and treat
- ▶ Permeable reactive barriers
- ▶ Enhanced attenuation
- ▶ Monitored natural attenuation
- ▶ Hydraulic containment
- ▶ Passive hydraulic barrier
- ▶ Discharge zone treatment
- ▶ Vapor intrusion mitigation
- ▶ Institutional controls
- ▶ Alternative water supply

Options	Description and References
In situ biological treatment	Applying an amendment into the aquifer to bioremediate a targeted volume (ITRC 2002, 2008, Parsons 2004, USEPA 2000, DOE 2002)
Source flux reduction	Applying remediation or containment to reduce the flux of contaminants moving from the source zone to the plume (ITRC 2008b, 2010b, Looney et al., 2006)
Institutional controls	Applying administrative restrictions to prevent contaminant exposure or other actions that would negatively impact contamination (USEPA 1997a, 2009b, 2010a, ITRC 2016b)

Select Adaptive Remedial Strategy

Step 2. Compare Remedial Approaches

- ▶ Follow regulatory process
 - Assess using threshold and balancing criteria for CERCLA, RCRA sites

- ▶ Additional considerations due to complexities
 - How does each remedial approach address complexities?

CERCLA Nine Criteria

Threshold Criteria

1. Overall protection of human health and the environment
2. Compliance with ARARs

Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria

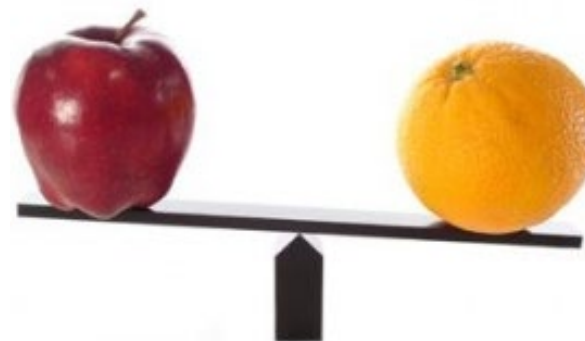
8. State acceptance
9. Community acceptance

Select Adaptive Remedial Strategy

Step 2. Compare Remedial Approaches

► Additional considerations

- Level of confidence in ability to implement remedy
- Synergy with other technologies/approaches
- Adaptability over time
- Information gained to improve future decisions
- Robustness of design including interim objectives, metrics, and performance monitoring data
- Other



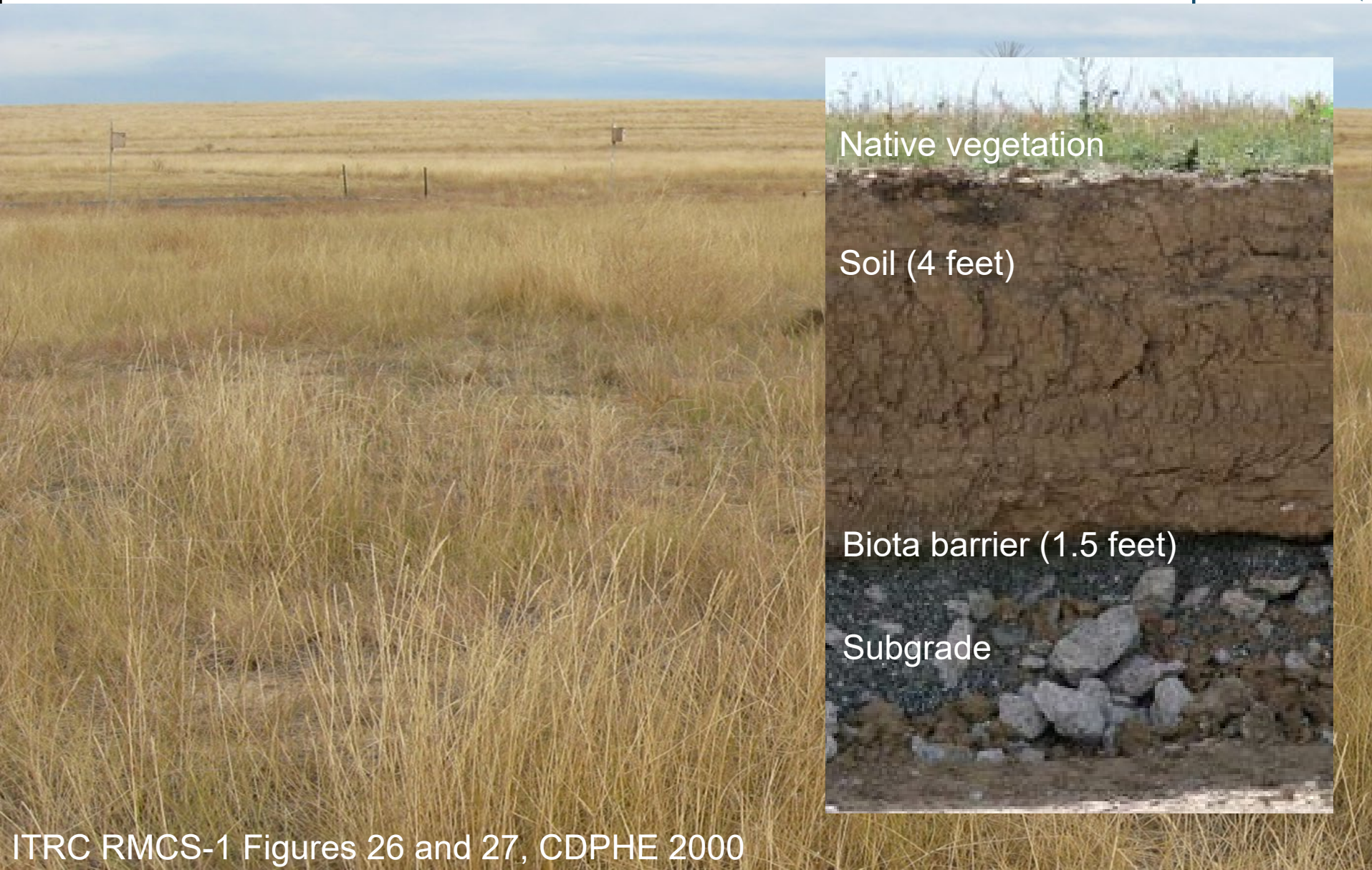
Select Adaptive Remedial Strategy

Step 3. Remedy Selection

- ▶ Prepare a matrix of site objectives and remedies for each area of the site

Site Objectives	Selected Remedy	
	Source	Plume
Objective #1	Technology 1 Technology 2	Technology 1 Technology 3
Objective #2		
Objective #3		

Case Study: Rocky Mountain Arsenal, Colorado



Rocky Mountain Arsenal, Colorado

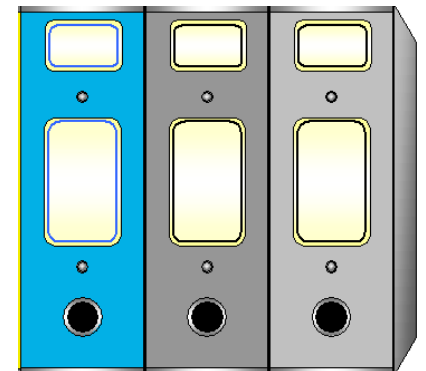
Remedy Components



Site Objectives	Selected Remedy	
	On-Site	Off-Site
Source removal and treatment	Waste and soil treatment, stabilization Excavation Groundwater extraction and treatment	Off-post groundwater intercept and treatment system
Containment	Boundary treatment systems Slurry walls Stabilization/capping	Boundary treatment systems
Protection of human health and ecology	Capping Land use restrictions Unexploded ordnance disposal Alternate water supply	National wildlife refuge Deed restrictions Long-term monitoring Five-year reviews Trust for potable water supply and distribution Medical monitoring Biomonitoring Trust for long-term O&M

Document Remedial Approach

- ▶ Articulate how components work together
- ▶ For each component of the remedial approach
 - Describe technology
 - State interim objectives
 - State how the performance will be evaluated (performance metrics)
- ▶ Follow regulatory program requirements for documentation
- ▶ Can facilitate remedy transitions



Engaging Stakeholders and Tribes

Stakeholder and Tribal Perspectives

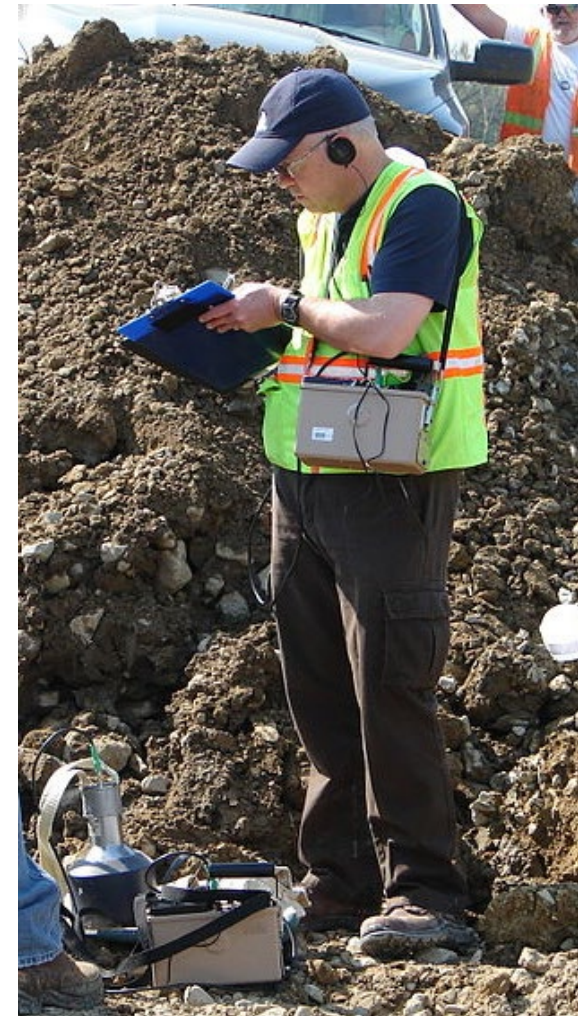
- ▶ Stakeholder and Tribal concerns and values
- ▶ Gathering and organizing information
- ▶ Creating a forum
- ▶ Influencing decisions
- ▶ Advisory boards
- ▶ Technical assistance



SanjibLemar / Wikimedia Commons

Engaging Stakeholders and Tribes Responsible Party Perspectives

- ▶ Seek out community members
- ▶ Provide them with tools to participate constructively
- ▶ Build trust for effective outreach
- ▶ Organize public meetings
- ▶ Share technical documents, information
- ▶ Work with media



Energy.gov / Wikimedia Commons

Summary

Adaptive Site Management Principles

- ▶ Refine conceptual site model
- ▶ Set or revisit site objectives
 - Survey highlights flexibility of some state programs in setting or revisiting site objectives
- ▶ Build adaptive remedial strategy
 - May need multiple technologies, phases for each site area
 - Set interim objectives to guide remedial progress
- ▶ Repeat process if remedy is not on track



Today's Road Map

- ▶ Site challenges
- ▶ Remediation Potential Assessment
- ▶ Questions and answers
- ▶ Adaptive remedy selection
- ▶ Long-term management
- ▶ Preparing you to take action
- ▶ Questions and answers

Learning Objective



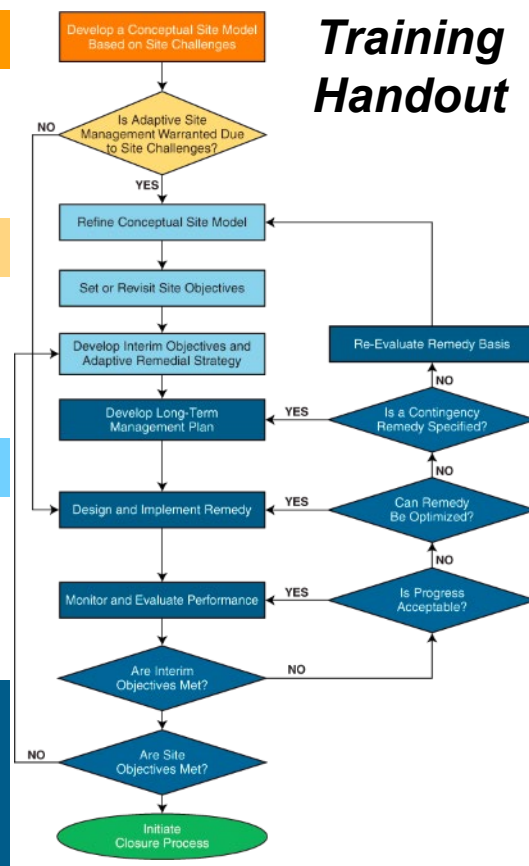
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

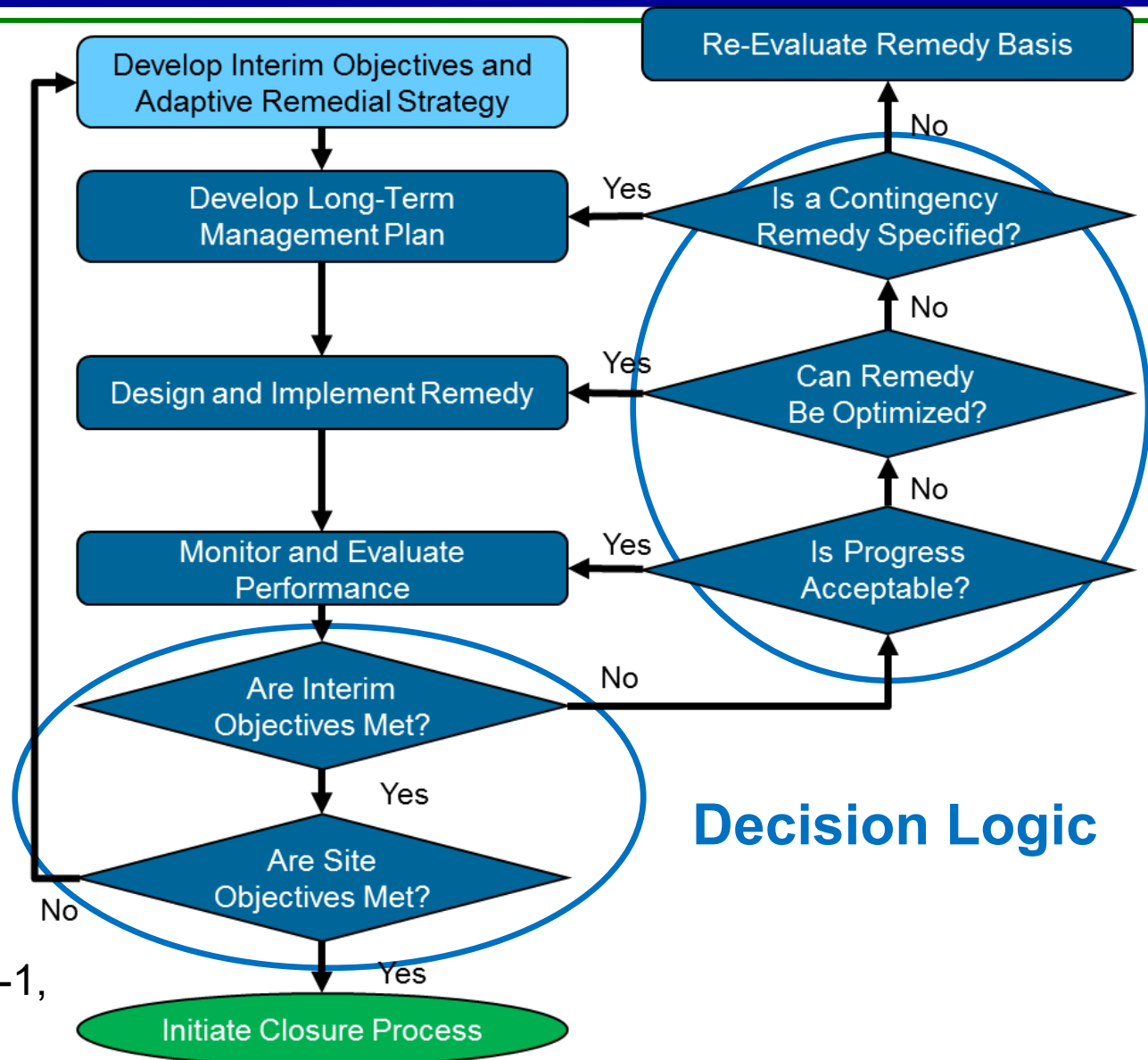
Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management
Develop a long-term performance-based action plan

See Training Handout



Adaptive Site Management



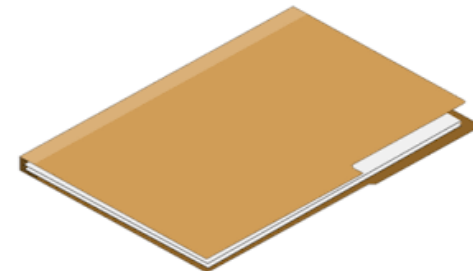
Decision Logic

ITRC RMCS-1, Figure 1

Develop Long-Term Management Plan

Purpose and Value

- ▶ Learn via process (living site-specific document)
 - Identify weak links
 - Inform decision makers
 - Engage stakeholders
- ▶ Provide a completion strategy (many decades)
- ▶ Document remedy expectations and progress
- ▶ Expedite remedy re-evaluations and transitions
- ▶ Make timely remediation management decisions

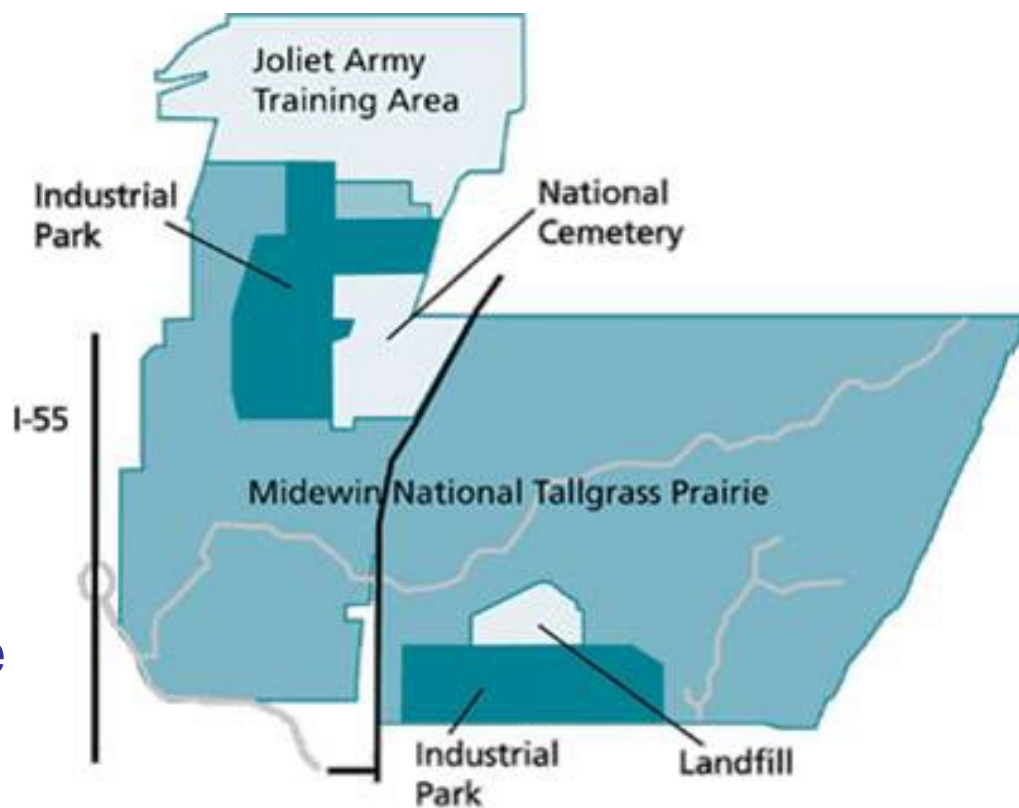


Develop Long-Term Management Plan Plan Components

- ▶ Completion strategy
- ▶ Description of the selected remedy
- ▶ Expected performance over time
 - Performance model predictions
- ▶ Timeline and criteria for monitoring and periodic evaluations
- ▶ Decision logic for remedy transitions
- ▶ Project risks and uncertainty

Develop Long-Term Management Plan Completion Strategy

- ▶ Path to achieve site objectives
 - Likely iterative for complex sites
 - Collaborative process
- ▶ Consider options to maximize future land use
- ▶ Consult relevant guidance



Map of proposed future uses for Joliet Army Ammunition Plant, Illinois (ITRC RMCS-1 Figure 36)

Develop Long-Term Management Plan

Project Risks and Uncertainty

- ▶ Process to identify and respond to key project risk events
 - Identify and assess potential project risks
 - Actions to reduce risk (e.g., filling a data gap)
 - Use contingency planning tools



Technical/Regulatory Guidance

Project Risk Management for Site Remediation



March 2011

ITRC RRM-1, 2011

<http://www.itrcweb.org/GuidanceDocuments/RRM-1.pdf>

Download risk register template:
[https://clu-in.org/conf/itrc/rrm/
ExampleRRMForms.docx](https://clu-in.org/conf/itrc/rrm/ExampleRRMForms.docx)

Develop Long-Term Management Plan

Describe the Selected Remedy

- ▶ Remedy for each site segment (e.g., plume, source area, off-site plume)
- ▶ Interim objectives, performance metrics
 - May need to set these during long-term management phase
 - Time frame predicted to meet interim objectives
- ▶ Maintenance and monitoring considerations

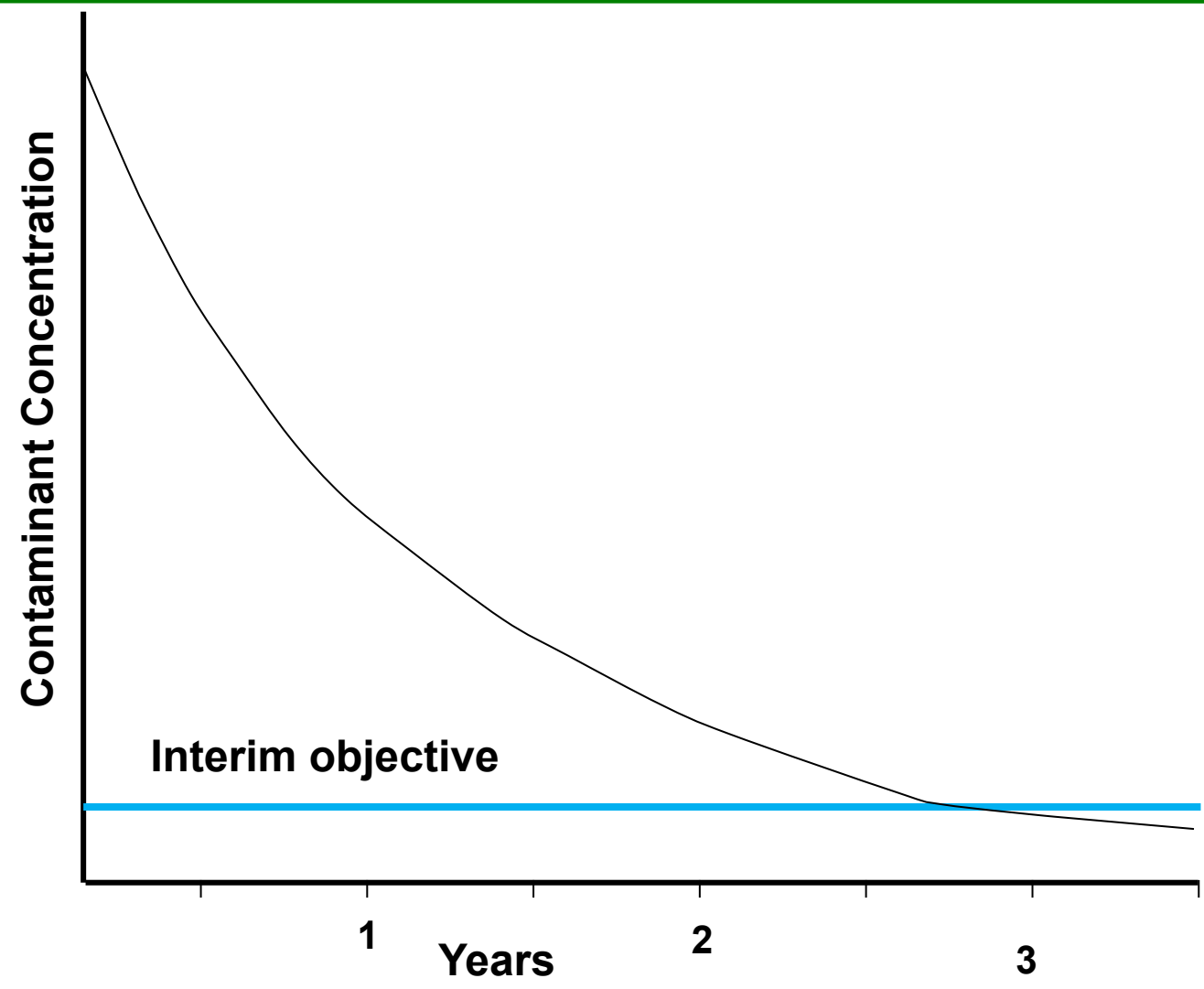
Develop Long-Term Management Plan

Example Description - Selected Remedy

Site Objective	Remedy Component	Interim Objective/ Performance Metric
Remediate contamination	In situ treatment	Reduce contaminant concentrations by 1 order of magnitude
Control migration	In situ treatment	Reduce mass flux from the source area by 80%
	Pump and treat	Demonstrate capture using multiple lines of evidence
Prevent exposure	Engineering controls	Maintain engineering controls and fencing per operation and maintenance plan
	Institutional controls	Deed restriction for land and groundwater use

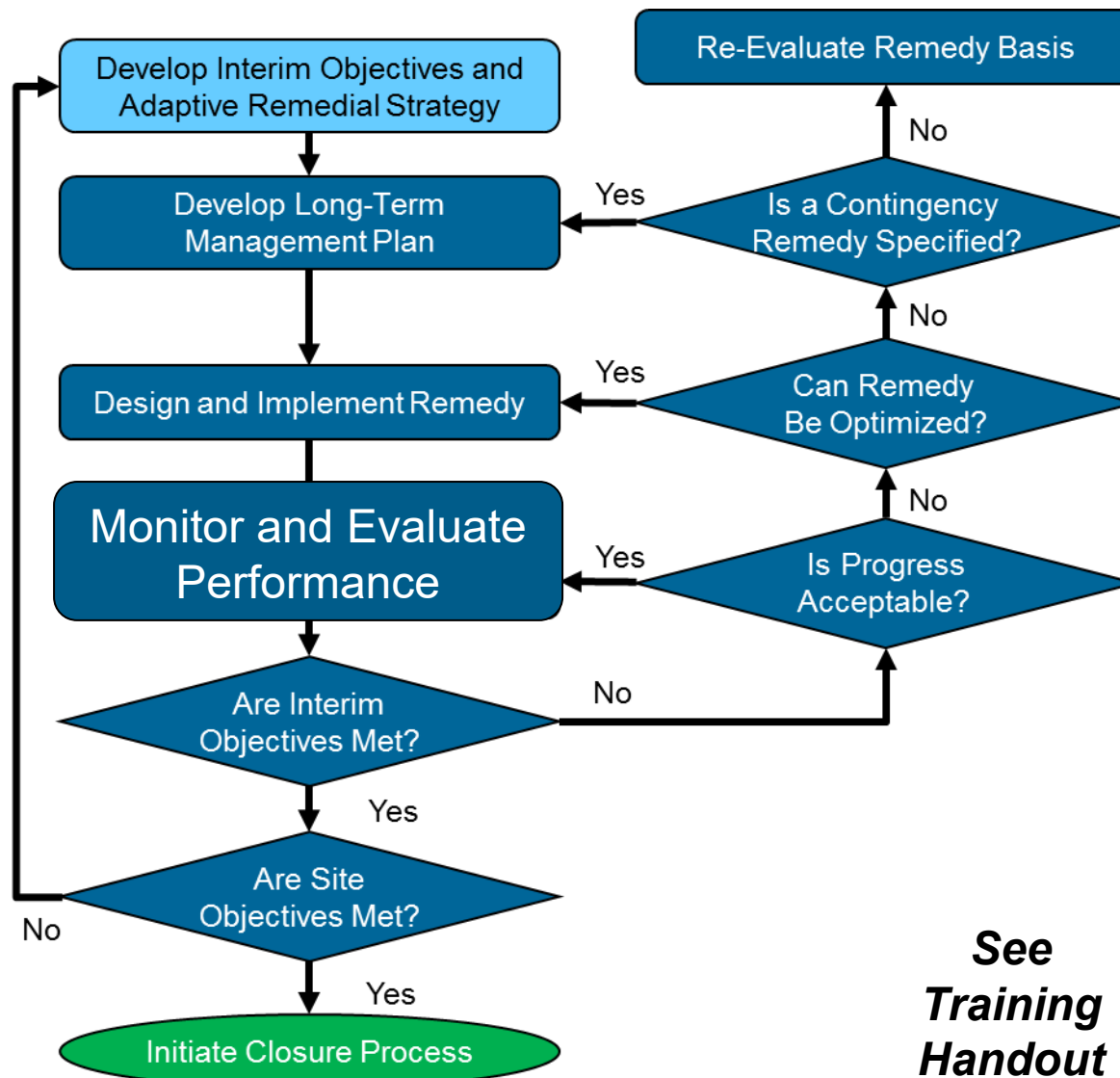
Develop Long-Term Management Plan

Example - Performance Model Prediction



Monitor and Evaluate Performance

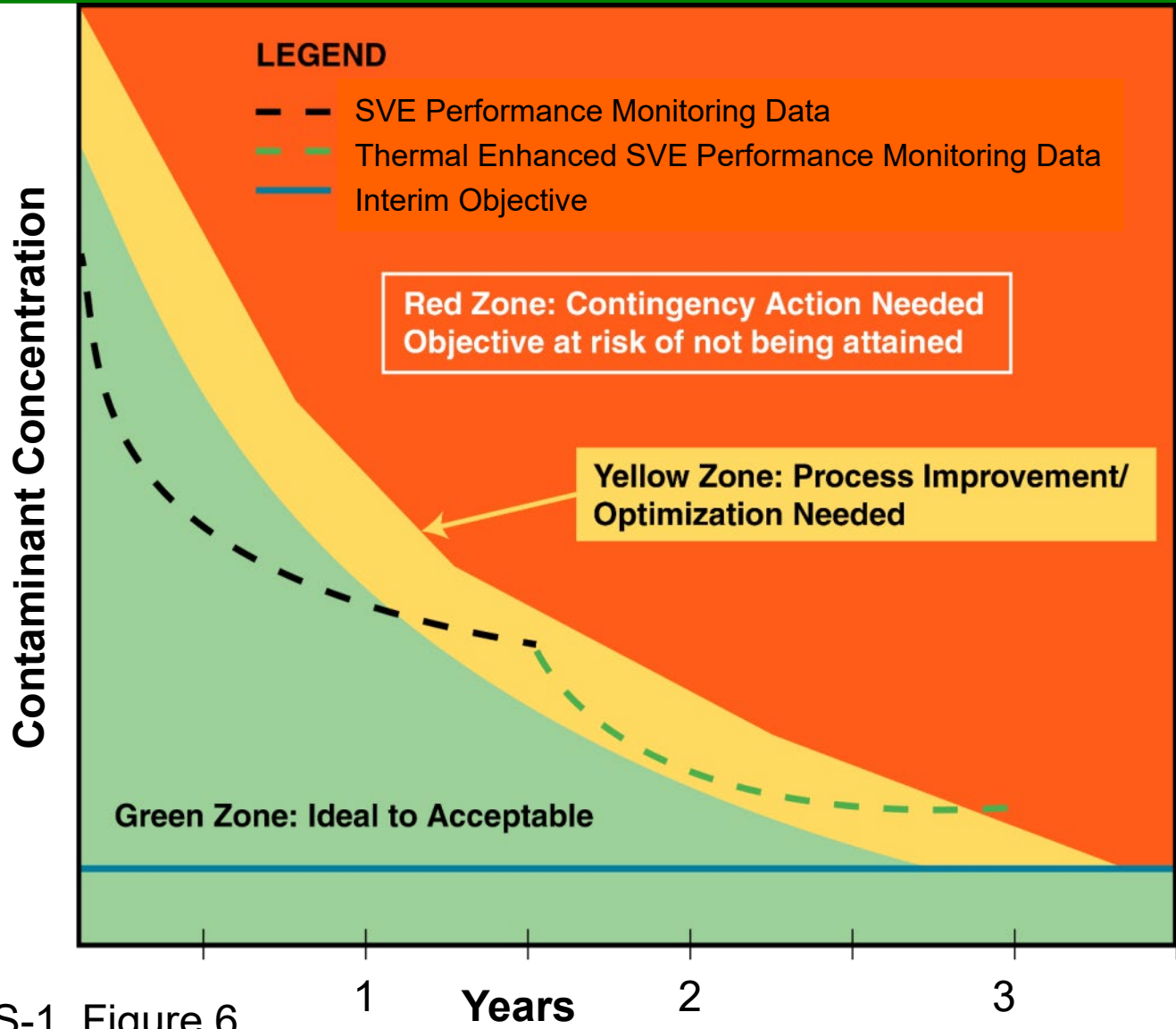
- Schedule for monitoring and periodic evaluations stated in long-term management plan
- Monitoring program aligned with performance objectives



See
*Training
Handout*

Monitor and Evaluate Performance

Compare Actual and Predicted Performance



Monitor and Evaluate Performance

Periodic Evaluation Checklist Example

**See
Training
Handout**

► Site

- Contaminant properties known and considered?
- Has source mass been evaluated?
- Are plume dynamics well understood, increasing, shrinking or stable?
- Are contaminant concentrations decreasing and on target to achieve objectives?

► Technology

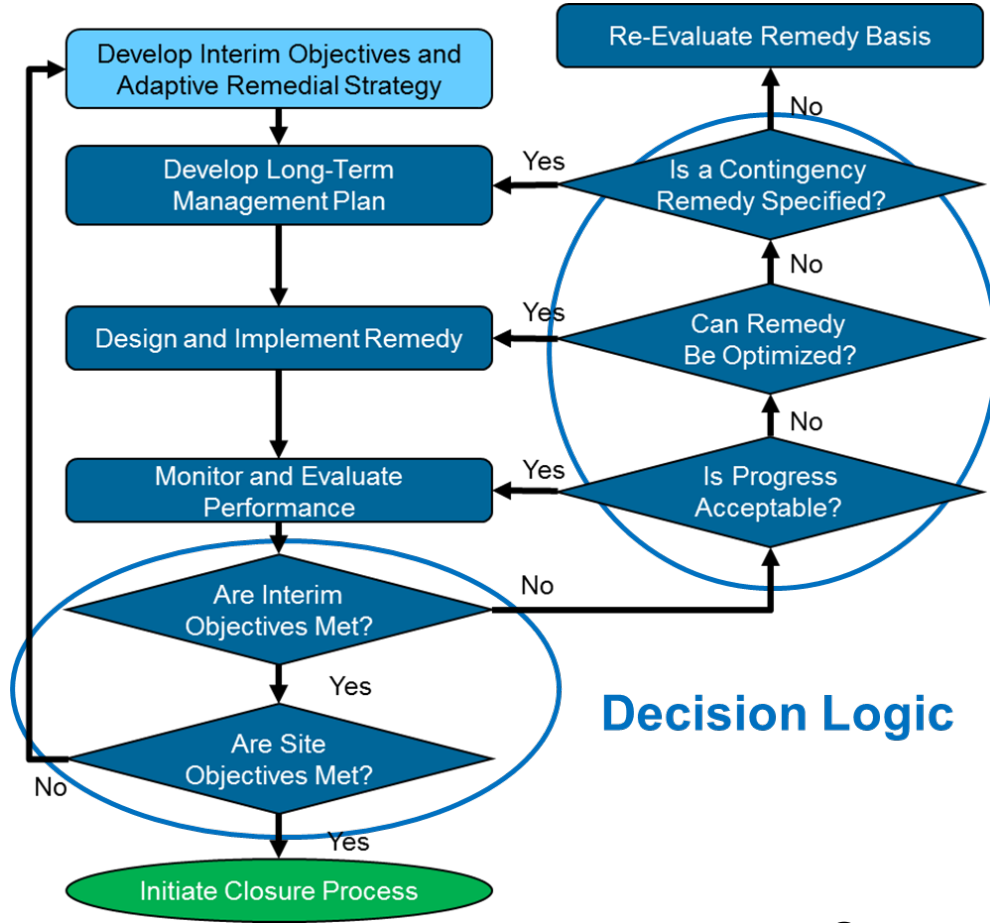
- Performance evaluation
- Technology alternatives cost/benefit analysis

Decision Logic

Potential Outcomes of Periodic Evaluations



- ▶ Remedy/remedy phase is complete OR
- ▶ Remedy is on track OR
- ▶ Optimization is needed OR
- ▶ Revised remedial approach is warranted

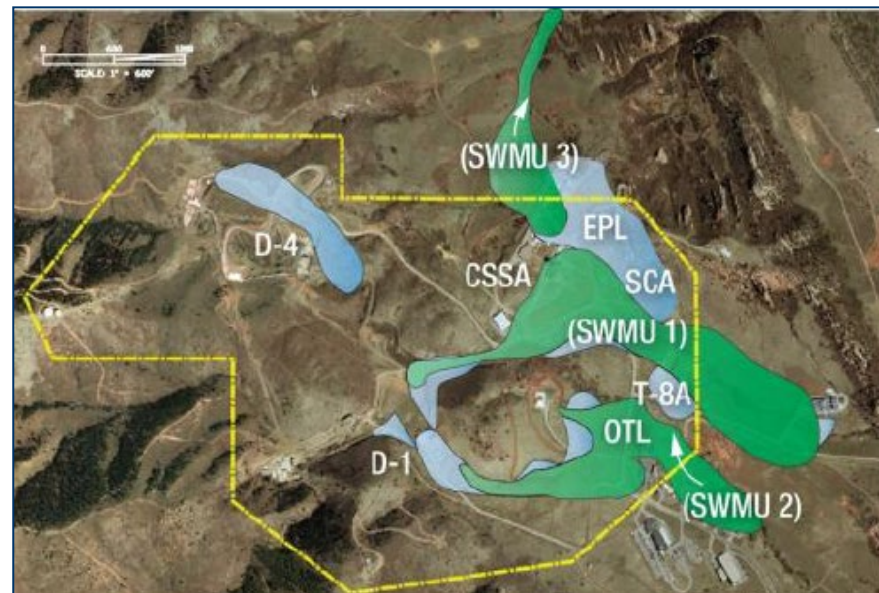


Decision Logic

See Training Handout

Example: Reaching Technology Limits at a Colorado Site

- ▶ TCE and NDMA in fractured rock 125 feet deep
- ▶ Enhanced in situ bioremediation for TCE
 - Reached asymptotic concentrations above action levels
- ▶ Pilot studies of other technologies ineffective
- ▶ Transitioned to MNA and institutional controls



Trichloroethylene (TCE) in bedrock (blue) and alluvial (green) aquifers after in situ bioremediation (Image from Brock 2012)

Long Term Management Summary

- ▶ Value of a plan
- ▶ Plan components
- ▶ Monitor and evaluate performance
- ▶ Follow decision logic

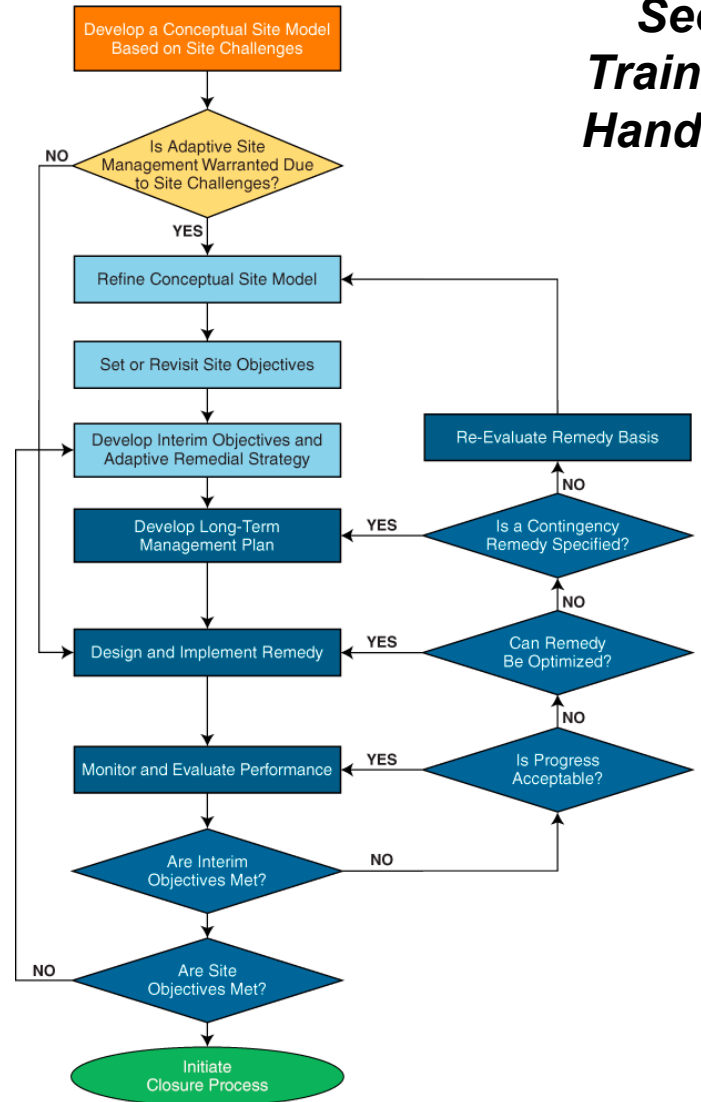
Today's Road Map

- ▶ Site challenges
- ▶ Remediation Potential Assessment
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- ▶ Adaptive remedy selection
- ▶ Long-term management
- ▶ Preparing you to take action
- ▶ Questions and answers

Our Opportunity to Improve

- ▶ Science and technology give us options for challenging sites
- ▶ A robust and iterative conceptual site model is key to success
- ▶ Consensus-driven interim objectives help us make progress
- ▶ Adaptive site management facilitates finding an achievable path to common goal

**See
 Training
 Handout**



Poll Question

What Actions Can You Take To Make Progress at Complex Sites?

- ▶ Use and encourage use of the ITRC Guidance
- ▶ Know your site – technical and non-technical challenges
- ▶ Assess the remediation potential at your site(s)
- ▶ Apply adaptive site management principles
- ▶ Get your stakeholders involved early and develop consensus-based interim objectives
- ▶ Schedule periodic evaluations of remedy performance to track remedy progress and make improvements

Thank You

Follow ITRC



Poll Question

▶ 2nd question and answer break

▶ Links to additional resources

- <http://www.clu-in.org/conf/itrc/RMCS/resource.cfm>

▶ Feedback form – *please complete*

- <http://www.clu-in.org/conf/itrc/RMCS/feedback.cfm>

EPA United States Environmental Protection Agency **Technology Innovation Program**

U.S. EPA Technical Support Project Engineering Forum
Green Remediation: Opening the Door to Field Use Session C (Green Remediation Tools and Examples)
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