1

Welcome – Thanks for joining us.
ITRC's Internet-based Training Program

What is Remediation Process Optimization and How Can It Help Me Identify Opportunities for Enhanced and More Efficient Site Remediation?

ITRC Technical and Regulatory Guidance Document:
Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation

This training is co-sponsored by the EPA Office of Superfund Remediation and Technology Innovation

Presentation Overview:

Remediation Process Optimization (RPO) is the systematic evaluation and enhancement of site remediation to ensure that human health and the environment are being protected over the long term at minimum risk and cost. Through this training, the ITRC RPO team intends to inform interested and affected parties about the value of optimization in efficiently and objectively setting and attaining remediation goals. Key elements of RPO that will be discussed in the training include:

Appropriate use of up-to-date conceptual site models (CSM),

Flexible Remedial Actions (RAs) operations considering technology limitations and risk assessments,

Use of treatment trains for each target zone, and developing performance objectives for each element

Developing an exit strategy for each remedy component considering life-cycle factors, and

Life-cycle cost analysis as a decision-making tool with the requirement that protectiveness must be maintained or improved.

This ITRC training will also identify and describe the applicability, advantages, and disadvantages of various approaches, as well as where they are most appropriate for use. The curriculum will conclude with a case study of an RPO conducted by members of the ITRC team at an Air Force installation to illustrate how an RPO is conducted and potentially findings. The ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation*" (RPO-1, 2004) serves as the basis for this training course and should be reviewed for additional information.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: EPA Office of Superfund Remediation and Technology Innovation (www.clu-in.org)

ITRC Course Moderator: Mary Yelken (myelken@earthlink.net)

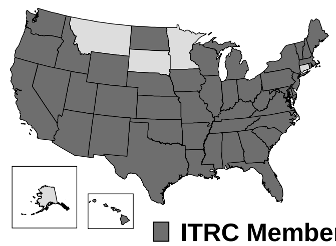
2

ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Network
  - State regulators
  - Federal government
  - Industry
  - Consultants
  - Academia
  - Community stakeholders
- Documents
  - Technical and regulatory guidance documents
  - Technology overviews
  - Case studies
- Training
  - Internet-based
  - Classroom

Host Organization

ITRC State Members



ITRC Member State

Federal Partners

DOE **DOD** **EPA**

The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of 45 states (and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network approaching 7,500 people from all aspects of the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

3

ITRC Course Topics Planned for 2006

Popular courses from 2005

- **Alternative Landfill Covers**
- **Constructed Treatment Wetlands**
- **Environmental Management at Operational Outdoor Small Arms Ranges**
- **DNAPL Performance Assessment**
- **Mitigation Wetlands**
- **Perchlorate Overview**
- **Permeable Reactive Barriers: Lessons Learn and New Direction**
- **Radiation Site Cleanup**
- **Remediation Process Optimization**
- **Site Investigation and Remediation for Munitions Response Projects**
- **Triad Approach**
- **What's New With In Situ Chem. Ox.**

New in 2006

- **Characterization, Design, Construction and Monitoring of Bioreactor Landfills**
- **Direct-Push Wells for Long-term Monitoring**
- **Ending Post Closure Care at Landfills**
- **Planning and Promoting of Ecological Re-use of Remediated Sites**
- **Rads Real-time Data Collection**
- **Remediation Process Optimization Advanced Training**
- **More in development…….**

Training dates/details at www.itrcweb.org
Training archives at http://cluin.org/live/archive.cfm

More details and schedules are available from www.itrcweb.org under "Internet-based Training."

4

Remediation Process Optimization

Logistical Reminders

- Phone line audience
  - ✓ Keep phone on mute
  - ✓ "*6" to mute, "*7" to un-mute to ask question during designated periods
  - ✓ Do NOT put call on hold
- Simulcast audience
  - ✓ Use ? at the top of each slide to submit questions
- Course time = 2¼ hours

Presentation Overview

- Introduction to RPO
- Regulatory overview of RPO
- Elements of RPO
- Evaluating performance and monitoring
- Questions and answers
- Remedy and monitoring optimization
- Cost benefit analysis
- Implementation and tracking
- Stakeholder and federal RPO programs
- Case study
- Summary/conclusions
- Links to additional resources
- Your feedback
- Questions and answers

No associated notes.

5

Meet the ITRC Instructors

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Christopher Hurst: Christopher Hurst is an environmental engineer with the Hazardous Waste Management Branch of the Georgia Environmental Protection Division based in Atlanta. He works in the DoD Remediation Unit in which he is assigned regulatory corrective action oversight tasks for several RCRA and CERCLA regulated military installations, and CERCLA regulated FUDS. Chris has been involved with the ITRC and the Remedial Process Optimization team since late 2002. Prior to working in the Hazardous Waste Management Branch, Chris spent some limited time working in the Engineering and Technical Support Program of the Water Protection Branch and was a compliance engineer in the VOC and Combustion Unit of the Air Protection Branch from 1996 through 2001. A significant portion of this work involved regulatory oversight of large scale printing operations and utility combustion sources. Chris has both a BS and M.Eng in Chemical Engineering from the University of Louisville. He recently served as Chair of the Atlanta section of the American Institute of Chemical Engineers and has been very active with this organization for six years. Chris is also a member of the local section of the Air and Waste Management Association.

Dave Becker: Dave Becker is a geologist with the Geoenvironmental and Process Engineering Branch at the US Army Corps of Engineers (USACE) Hazardous, Toxic and Radioactive Waste Center of Expertise (HTRW CX) in Omaha, Nebraska. At the HTRW CX, Dave is primarily involved with providing technical consultation (including optimization of systems), review of HTRW-related documents, teaching, and preparation of guidance relevant to field studies and *in-situ* remediation. He has strong interests in optimization of remediation systems, site characterization techniques for environmental restoration projects, and *in-situ* remediation technologies. Before coming to the HTRW CX in 1991, Dave was Chief, Geology Section at the Corps' Omaha District between March 1989 and December 1990. In that position, he supervised 16 geologists and engineers and 2 drill crews engaged in geological studies and designs related to civil, military, and environmental restoration projects. For 5 years prior to becoming a supervisor, Dave was a project geologist in Omaha District actively involved in many environmental restoration projects and performed numerous seismic hazard analyses for USACE dams in the North-central US. Dave has a BS in geology from the University of Nebraska at Omaha and a MS in geophysics from Southern Methodist University in Dallas, Texas. He is a registered professional geologist in Nebraska and is a member of the Nebraska Board of Geologists, Geological Society of America, the American Geophysical Union, the American Association of Petroleum Geologists, and the Nebraska Geological Society.

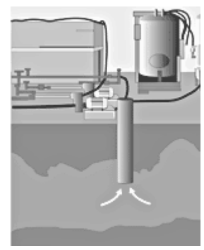
Karla J. Harre: Karla Harre is the Technology Transfer Team Lead in the Installation Restoration Division at the Naval Facilities Engineering Service Center (NFESC). She is responsible for managing NAVFAC's strategic plan to overcome barriers to the use innovative environmental remediation technologies. She facilitates the NAVFAC Alternative Restoration Technology Team (ARTT) and the NAVFAC Remedial Action Operations and Long Term Management (RAO/LTMgt) Optimization Workgroup. Ms. Harre is the principal investigator for a technology demonstration project to apply transport optimization codes to groundwater pump-and-treat systems. Previous experience includes leading the acquisition of innovative remediation technologies and services, managing the logic development of the cost-to-complete (CTC) environmental budgeting component in the NORM business management system, leading Clean Up Review Tiger Teams to identify improved remediation strategies, and managing an innovative technology demonstration program performed on Navy environmental sites in the San Francisco Bay Area. She holds a bachelor of engineering degree in civil and environmental engineering at Vanderbilt University and a master's of business administration at Pepperdine University.

Bud Johnson: Bud Johnson is the CEO of ROG a Superfund and industrial remediation contractor located in southeast Texas. Mr. Johnson is responsible for identifying, researching, implementing, and reporting on the application and use of alternative remedial technologies. ROG is a "field" orientated company working with owners and consultants to review remediation goals and appropriate remediation technologies. ROG has tested and implemented diverse in-situ and ex-situ technologies at Superfund sites and industrial facilities including pump and treat, SVE, dual phase extraction, bioremediation, chemical oxidation, electro-thermal stripping, phytoremediation, slurry walls, and other innovative treatment technologies. Mr. Johnson has been working as a consultant, field engineer and manager in the environmental field since 1972. Before joining ROG, Mr. Johnson worked for municipal utilities, environmental equipment manufacturers, and environmental design/build contractors. Mr. Johnson has a BS degree in chemistry/engineering from Loyola College and has completed the course work for an MS degree in Environmental Engineering from Rutgers University. Mr. Johnson is a current member of NGWA, TAEP, A&WMA and a past member of ACS, NAEP, WEF, ABC, GCA, DBIA and WWMEA.

6

What you will learn……

- RPO defined
- Regulatory environment
- Elements of RPO
- Agency perspectives on RPO
- Application presented in a case study



RPO is a common sense approach

7

What is RPO?

Remediation Process Optimization (RPO) is the systematic evaluation and enhancement of site remediation processes to ensure that human health and the environment are being protected over the long term at minimum risk and cost.

RPO is not a mechanism for assessing criticism

RPO is not a new process but it is a more detailed and thorough review than is often provided by other processes such as a five-year review

It is an opportunity to highlight what is being done well

Applicability to only large federal sites is not true

Optimization is a mechanism to achieve remedial goals faster without diminishing protectiveness

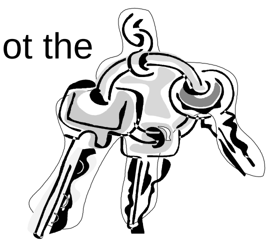
RPO for the purposes of this presentation is used in a broad sense and is not limited to detailed approaches such as mathematical optimization

8

What is RPO?

Some of the key underlying principles of RPO are

- Uncertainties are identified
- Protectiveness is the foremost objective
- A clear exit strategy is re-evaluated and articulated
- The assessment team is independent and multi-disciplined
- Cost efficiency is evaluated, but is not the primary goal
- Periodic updates occur



It is is important to identify an loose ends or unknowns about a site, since these often can become problems in completing the RPO or even eventually hold up the successful completion of the remedial project itself.

RPO team should be composed of several individuals that are knowledgeable and independent. These people should be independent from the site under review.

The exit strategy is simply the process/path which leads to achievement of the remedial goals.

Please note that more detailed and specific information on RPO can be found in the ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation*"

9

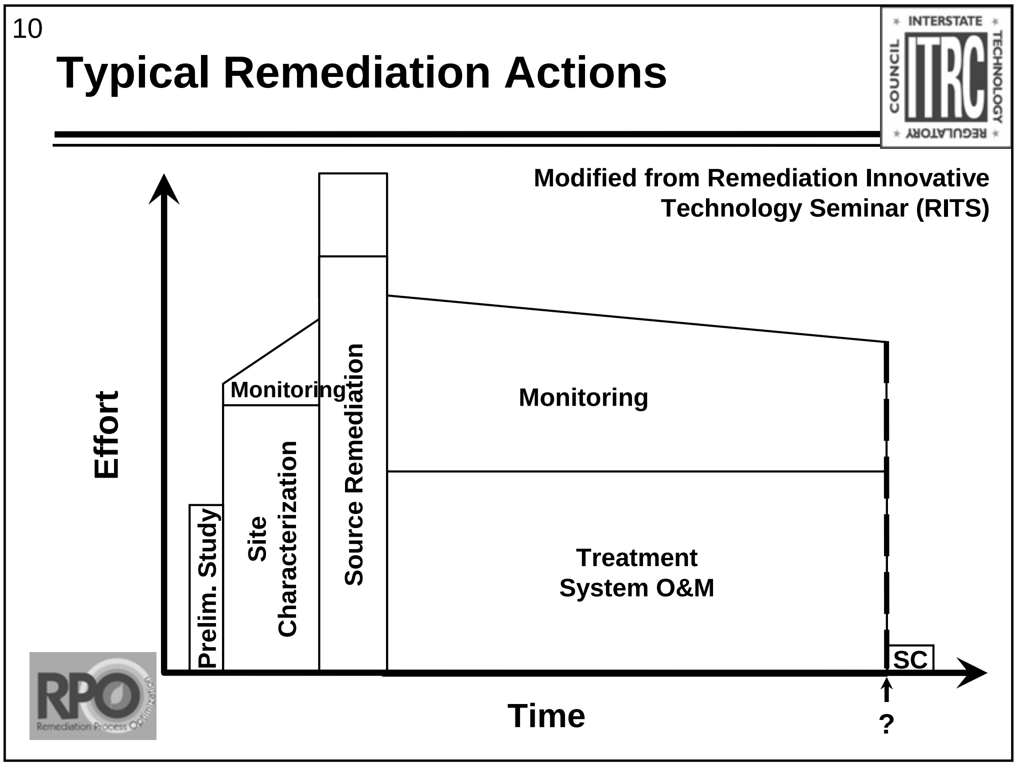
Why RPO?

- Federal, state, and private-sector organizations are spending billions of dollars to achieve cleanup
- Throughout the remedial process, environmental conditions become more apparent and resources continue to diminish
- New innovative remedial technologies are continuously being developed
- All parties have a strong desire to achieve clean closure

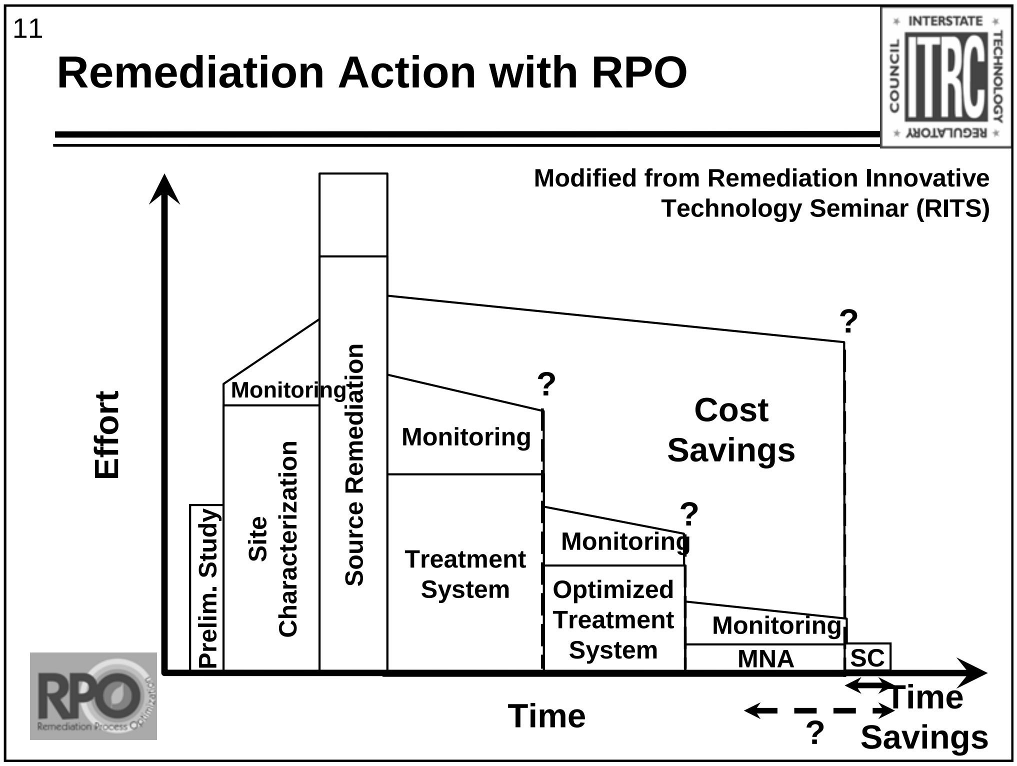
The states will be shouldering an increased work load (under O&M) due to site transfers from EPA to the states.

Many systems currently in place are old and out-dated technologies, and these sites are very likely to merit consideration for updated approaches.

Challenges to implementing RPO will be discussed later in this presentation


10
Typical Remediation Actions
Modified from Remediation Innovative Technology Seminar (RITS)
Effort
Prelim. Study
Site Characterization
Monitoring
Source Remediation
Monitoring
Treatment System O&M
SC
Time
?

Pre RPO



These figures demonstrate the stages/phases where time/cost savings can be achieved throughout the remedial process.

RPO is not limited to any specific phase.

12

Regulatory Overview of RPO

- RPO can be viewed from an engineering or process perspective
- The regulator or practitioner of RPO must take into account the regulatory environment
- CERCLA, RCRA, and state-equivalent programs all contain common elements that support RPO

All of these regulatory environments allow for RPO to occur. The question that needs to be addressed is how active a state or federal agency can be in supporting/directing RPO efforts.

The regulator must have input in the RPO process prior to implementing RPO recommendations. RPO should not be an attempt to short change remedial goals, unless the goals themselves merit review (e.g. risk approach is considered)

13

CERCLA and RPO

- Optimization is considered throughout each of the usual CERCLA phases and is implemented during subsequent phases
- RPO evaluations are often conducted during the Remedial Action (RA) operations and Long-Term Monitoring (LTM) phases
- ROD changes are sometimes needed to implement RPO recommendations and are often made when
  - There are changes in the understanding of site conditions
  - The understanding of the remedial technology changes
  - Costs can be reduced without effecting protectiveness

Should not be reluctant to review/modify RODs/CAP.

Sometimes these decision documents cannot be changes and therefore the only changes which can be made through a optimization review would be simple changes that have no bearing on the cleanup goals (e.g. change out of pumps to a more efficient model)

14

CERCLA and RPO

- Under CERCLA, fund-led sites have a limited time in which federal funds can be used, and afterwards the site costs are borne by the states as O&M
- Both the EPA and DOD have remedial optimization processes in place that are similar to RPO and are supported under CERCLA
  - EPA utilizes process called Remediation Systems Evaluation
  - DOE offers guidance on technology selection optimization
  - Each DOD component has its own specific program for implementation of optimization

Navy and Air Force have very strong optimization programs in place and have numerous success stories demonstrating benefits of such programs. Consult the tech reg guidance for case studies

DOD RPO programs occur in both RA and LTM phases

These federal programs will be discussed in more detail later in this presentation.

15

RCRA and RPO

- The value of RPO process applies both to the regulated community and to environmental regulators
- States may or may not be able to actively participate in or initiate RPO
- RCRA permitting framework contains provisions for periodic assessment, however, this is not as extensive as RPO
  - Careful review of semi-annual effectiveness reports
  - Facility initiated permit modifications
  - Incorporating flexibility into permit at beginning of the process

Since states have finite resources, RPO could greatly improve their ability to manage O&M costs.

Some states are pursuing formal agreements with EPA which will require EPA to perform RPO at a site prior to transferring the site to the state.

Flexibility in the RCRA permit is key to allowing RPO to take place.

16

State Regulatory Programs and RPO

- States often are delegated authority under RCRA or have lead roles under CERCLA to conduct site cleanup operations and often have their own specific regulatory framework. These operations may be either
  - Publicly funded site remediation, or
  - Through responsible party oversight
- As a result, states should have a high level of interest in the RPO process
- Limited references to RPO within state regulations, but many states have regulatory flexibility to pursue RPO

Although states may not be able to conduct/lead an RPO effort. They should be comfortable in allowing them to take place.

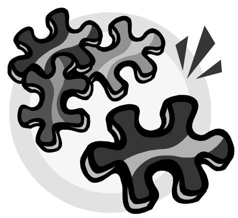
NJ has six Federal (Fund) Lead Superfund sites slated for turn over to the state over the next eight years. In addition, NJ has sixty-one State Lead remediation project underway and more than twenty in the planning stages. As a result, NJ is keenly interested in ensuring that site remediation in NJ is conducted effectively and efficiently. NJ recognizes that RPO can help to achieve effective and efficient clean ups. NJ has "Technical Requirements for Site Remediation", N.J.S.A 7:26E et seq., aka the Tech Rules. The Tech Rules call for "continuous effectiveness monitoring" and "periodic site condition reviews". These passages in the Tech Rules allow for, some might say, require, RPO and RPO-like reviews of all site remediation activity in NJ.

The Site Remediation & Waste Management Program has established an in house RPO team to evaluate RPO processes and contracting methods for use on the State Lead sites. A longer-term goal will be further outreach to the regulated community and NJ Case Managers to educate them about the benefits of RPO. Enforcing the requirement for RPO or strengthening the language covering RPO in the Tech Rules will be evaluated at a later date. Mention Links page

17

Elements of RPO

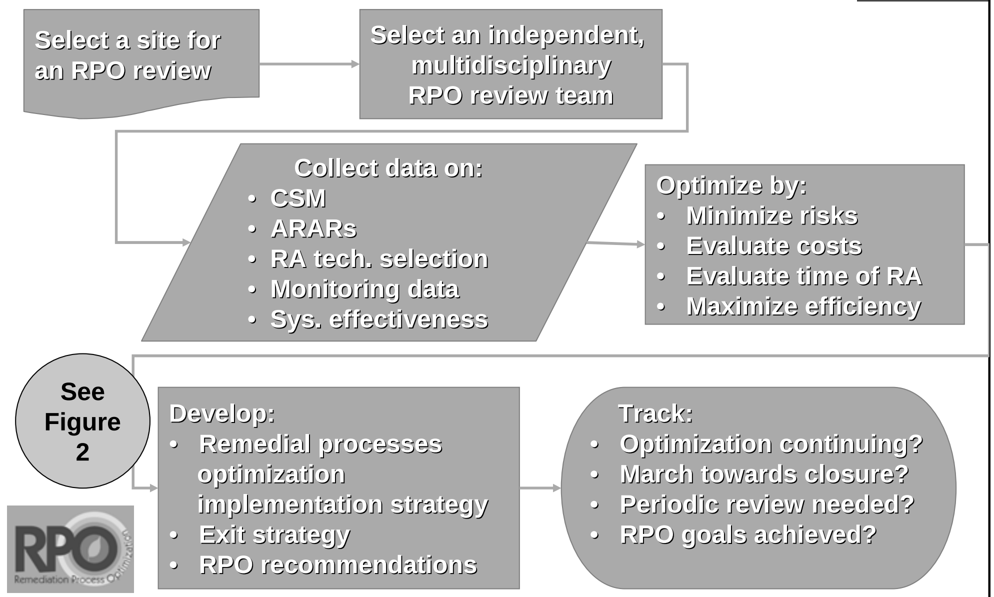
- Site selection
- Building the RPO team
- Evaluating the exit strategy
- Evaluating performance
- Evaluating cost efficiency
- Remedy optimization
- Monitoring optimization
- Cost benefit analysis
- Implementation and tracking



No associated notes.

18

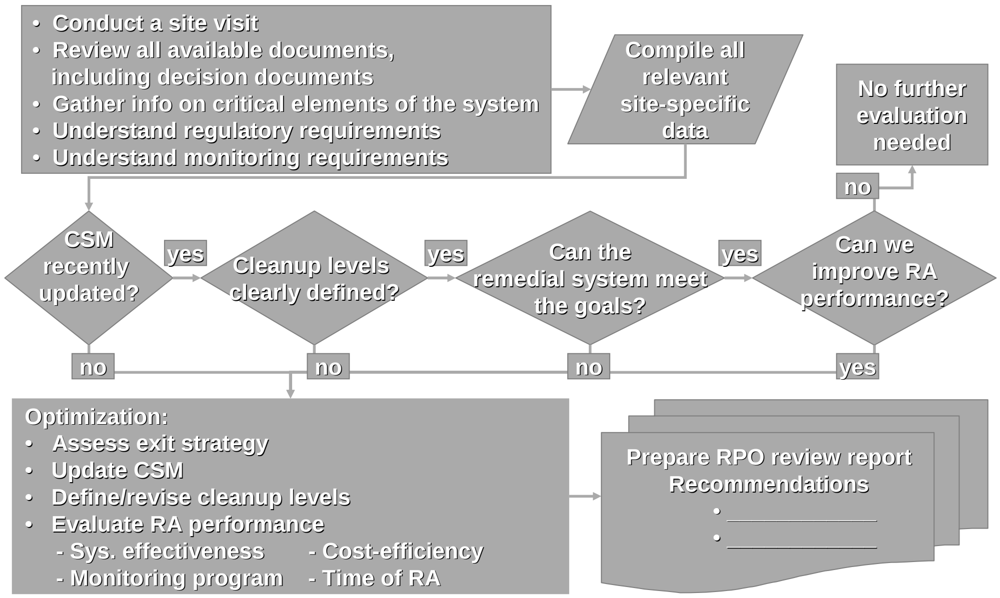
Figure 1: Overview of Conducting an RPO Evaluation



Applicable or relevant and appropriate requirement

19

Figure 2: Process Elements of an Optimization

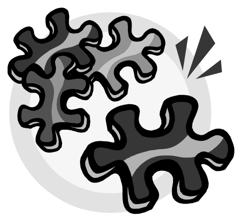


No associated notes.

20

Elements of RPO

- ▶ Site selection
- ▶ Building the RPO team
- ▶ Evaluating the exit strategy
- ▶ Evaluating performance
- ▶ Evaluating cost efficiency
- ▶ Remedy optimization
- ▶ Monitoring optimization
- ▶ Cost benefit analysis
- ▶ Implementation and tracking



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21

Site Selection Criteria - Overview

- Virtually all long-term remedial action sites can benefit from RPO
- RPO redirects attention to potentially overlooked O&M issues
- RPO reassures stakeholders
- RPO does have upfront costs
- RPO should help, not hinder, site managers and regulators

No associated notes.

22

Site Selection Criteria - Prioritization

- There are three primary criteria for prioritizing RPO
  - Concerns about the current system meeting its goals
  - Sites where major changes in management approach are imminent
  - High annual O&M costs
- Additional prioritization considerations
  - Persistent site contaminant sources
  - Complex site hydrogeology or geochemistry
  - Sites that have not been optimized in “X” years
  - Sites where clean-up is projected to take more than 10 years

First point, second bullet: Changes in lead agency or changes in land ownership

Prioritization is important and is required

23

Suggested Data to be Collected for Site Prioritization

- Remedial Action Objectives
- Primary contaminants of concern (COCs) and affected media
- Description of all RA components and related monitoring programs
- Date RA was implemented and current status of RA
- Documented RA performance metrics
- Conclusions from other performance reviews
- Historical and current annual operations and maintenance costs
- Long-term monitoring costs
- Historical and current operating data

Based on observations from conducting RPO or RPO-like reviews for hundreds of remedial components at more than 50 facilities nationwide, virtually all long-term remedial action sites can benefit from RPO.

24

Elements of RPO

- Site selection
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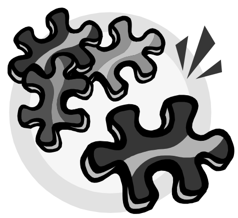


No associated notes.

25

Building the Team

- Diverse team of experts
- Regulatory specialists, engineers, geologists, risk assessors, chemists, modelers, statisticians, field experts, etc.
- Document review prior to site visit?
- Site consultant?
- Role of site regulator?
- Small or large team?

No associated notes.

26

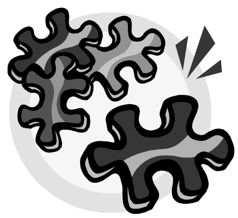
The Team

Now turn over to Dave Becker who will further discuss remaining elements of RPO

27

Elements of RPO

- Site selection
- Building the RPO team
- Evaluating the exit strategy
- Evaluating performance
- Evaluating cost efficiency
- Remedy optimization
- Monitoring optimization
- Cost benefit analysis
- Implementation and tracking



No associated notes.

28

Exit Strategy Assessment

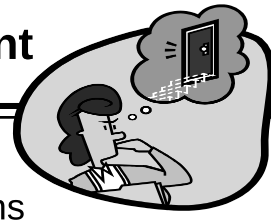
What is an Exit Strategy?

- A long-range, documented process for achieving remediation objectives
- Includes a decision framework for tailoring the remedy to
  - Reductions or increases in the extent or degree of contamination
  - Other unexpected changes
- Developed addressing stakeholder considerations
- Includes assigned responsibilities for assessing progress

An exit strategy is the DOCUMENTED plan to take the site from the state its in now to final closure or to its best end use. The plan includes logic for making changes due to the gradual reduction in the extent of contamination or to unexpected persistent contamination or plume growth. It must consider the wishes of the various stakeholders including the public and interested parties. There must be someone assigned the responsibility to assess the current monitoring data and historical trends and identify actions in accordance with the exit strategy.

29

Exit Strategy Assessment



- A good Exit Strategy contains
  - A statement of the remediation objectives and the basis for them
  - A summary of the conceptual site model
  - A decision tree or flow chart explaining the decision process
  - Provisions for periodic re-evaluation of project goals
  - Means to verify cleanup, including identification of concentration “rebound”
- Any RPO should include an assessment of the Exit Strategy

The exit strategy contains the components listed here. The first three items will be discussed in more detail in the next slides. The exit strategy recognizes the need to periodically revisit the project goals in light of site and technology changes. This can be done in conjunction with the five-year reviews (under CERCLA) or similar process. Decisions regarding the final shutdown of the system must consider the common occurrence of rebound of concentrations following cessation of active remediations (e.g., with pump and treat, SVE). Typically, there are provisions for restart of the remediation system if rebound occurs to some level that poses a risk or exceeds a specific standard. The optimization process should include some critical evaluation of the site exit strategy and recommend appropriate changes to it (or creation of one if none exist).

30

Exit Strategy Assessment

- Evaluating the Remediation Objectives
  - Found in site decision document
  - Verify goals are measurable and realistic given conceptual site model and remedy
  - Realistic goals are ones that can be achieved with current technology in a reasonable timeframe
  - Objectives may be based on defined standards (e.g., MCLs) or risk-based
  - Risk assumptions should be verified

The optimization process should look at the remedial objectives as documented in the exit strategy or decision document(s) for the site. The goals must make sense and represent a protective condition. They must be measurable and achievable with the current technology (perhaps with some enhancements) in some reasonable timeframe. “Reasonable” is somewhat subjective and should represent a consensus among the stakeholders and site managers. Note that in some cases, the timeframes for cleanup may be quite long regardless of the technologies. If the goals are based on assessment of site risks, the assumptions underlying the risk-based criteria should be compared to the current conditions at the site (and surrounding areas) to see if the assumptions are still valid.

31

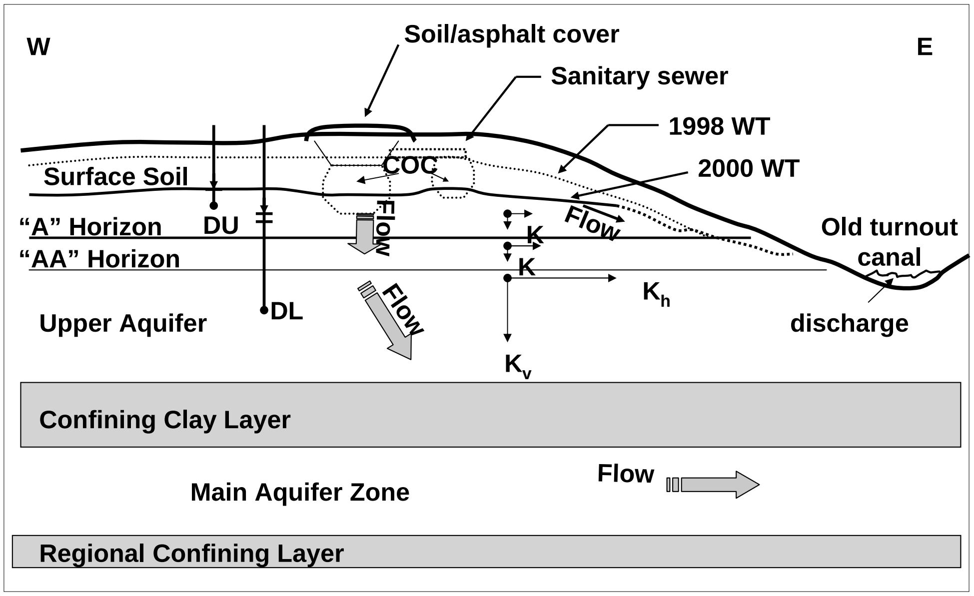
Exit Strategy Assessment

- Evaluating the Conceptual Site Model
  - A CSM includes: nature and extent of site contaminants and their fate and paths to reach receptors, the nature and location of possible receptors, effects of current or planned remediation activities, and future conditions (e.g., land use)
  - Is the current CSM consistent with the data recently collected as part of the remedy? Consistent with current land use?

The CSM is a mental picture of how the site "works" – how and where contaminants move from the release point to receptors or potential exposure points. The CSM in the exit strategy (or described elsewhere) needs to be reviewed to see if recently collected data (or subsurface information gathered during construction) would change the understanding of the site.

32

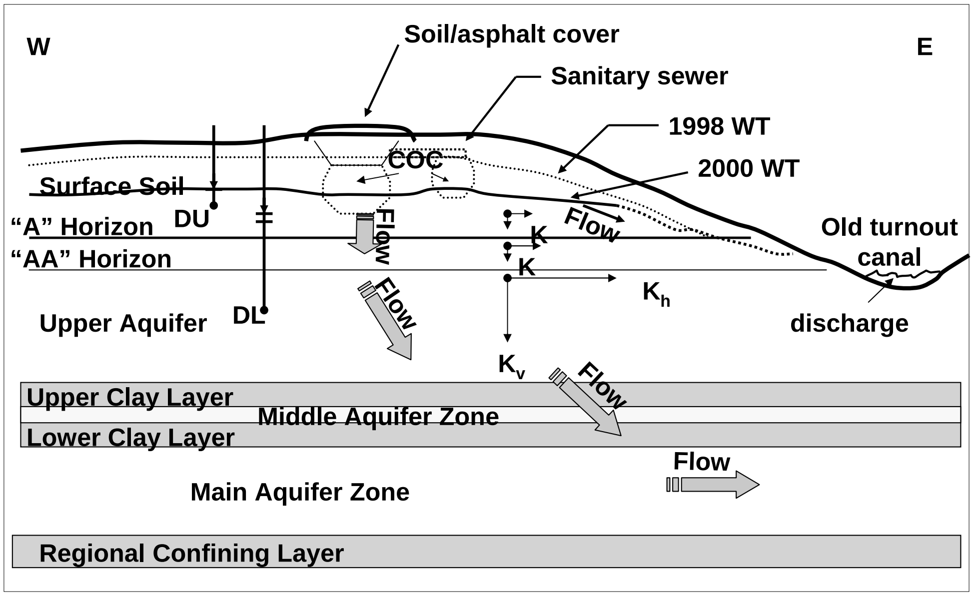
Example Conceptual Site Model



This picture is a graphical presentation of a CSM for a site where a leaking disposal facility was thought to impact only a shallow aquifer. Deeper aquifers were thought to be protected by a clay layer.

33

Example Conceptual Site Model



This picture shows a revised CSM recommended by a review considering new information about the integrity of the clay layer and suggests the potential for impacts to the deeper aquifer. This would potentially change the cleanup objectives and perhaps call for interim actions.

34

Exit Strategy Assessment

- Evaluating the completion strategy and decision logic
  - Is the remedy/approach appropriate for the goals?
  - Are there interim decision points for changing system and monitoring programs? Is the decision logic valid?
  - Are data collected to support evaluation of interim decisions and to assess progress toward clean up?
  - Is the end point clearly defined and is there a process to verify when this end point is achieved, including contingencies for any rebound?

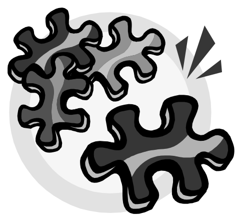
The key issues here – is the current technology the right choice (considering advancements in remedial techniques) and is the end point clearly defined. The evaluation should consider if the right data are collected to answer the questions in the decision tree and if the decision logic itself makes sense.

Now we will turn it over to Karla Harre of the US Navy's Naval Facilities Engineering Service Center to discuss performance evaluation.

35

Elements of RPO

- Site selection
- Building the RPO team
- Evaluating the exit strategy
- Evaluating performance
- Evaluating cost efficiency
- Remedy optimization
- Monitoring optimization
- Cost benefit analysis
- Implementation and tracking



No associated notes.

36

Evaluating Performance

- Remedial performance
  - Progress towards meeting cleanup goals
- System performance
  - Remedial component performance assessment
    - Evaluating performance data
    - Assessing remedial system effectiveness
- Monitoring programs
  - Number and locations of monitoring points
  - Monitoring frequency
  - Monitoring parameters and sampling procedures

Remedial performance refers to progress toward meeting cleanup goals; system performance refers to the degree to which a particular remedial component is meeting its design expectations

37

Evaluating Remedial Performance

- O&M data are analyzed and compared to cleanup criteria per the RA objectives
- Data used for performance evaluations
  - Contaminant concentrations
  - Groundwater elevations
  - Free-product thickness
  - Geochemical parameter concentrations
  - System operating parameters
  - Mass removal rates
  - Operational history

No associated notes.

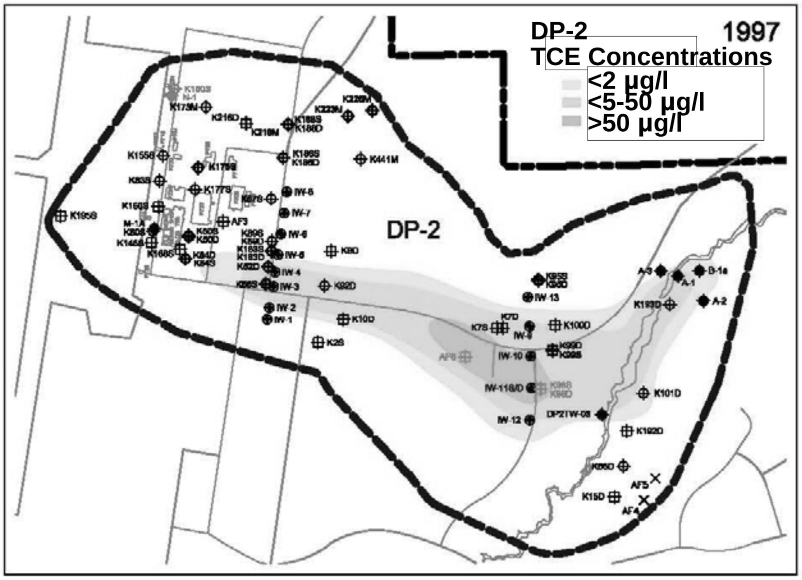
Analysis Tools

- Graphs or time-series plots
  - Analyze performance data for each extraction well
  - Plot contaminant or geochemical data over time
  - Compare influent and effluent concentrations over time
  - Evaluate mass removal rates
- Potentiometric surface maps
  - Analyze capture zones
  - Assess containment
- Maps and cross-sections
  - Show contaminant concentrations and distributions through time and space
- Statistical tools and GIS software
  - Enhance data visualization and analysis capabilities

Analysis tools help one to better visualize and interpret data.

39

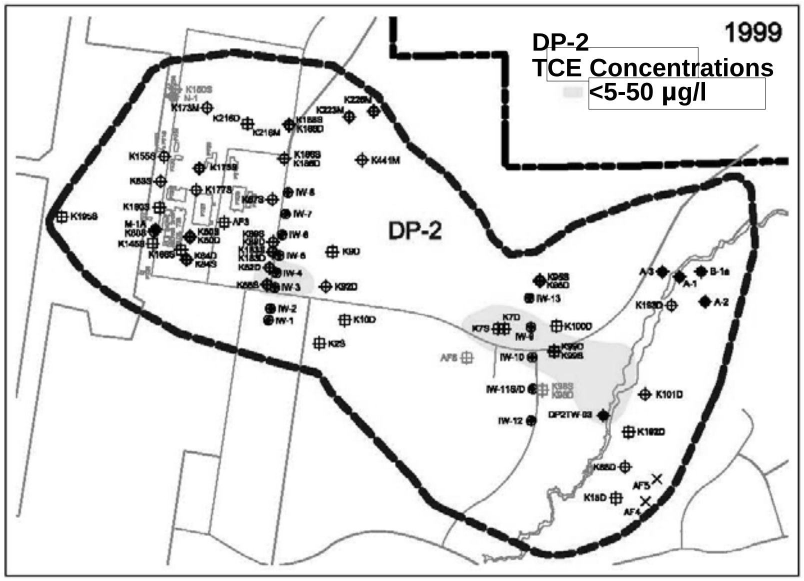
Analysis Tools – Plume Maps



The next 4 slides give an example of how using plume maps, showing concentrations over distance and time, can indicate progress of a remedial action.

40

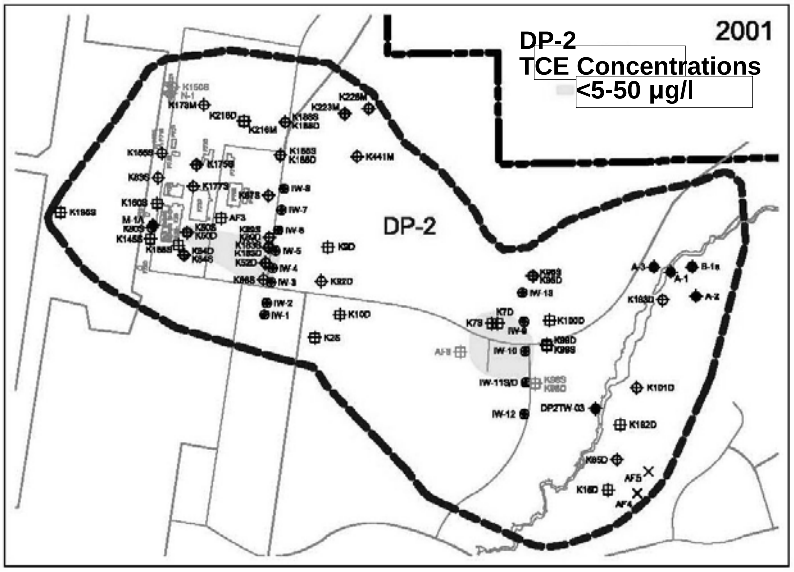
Analysis Tools – Plume Maps



No associated notes.

41

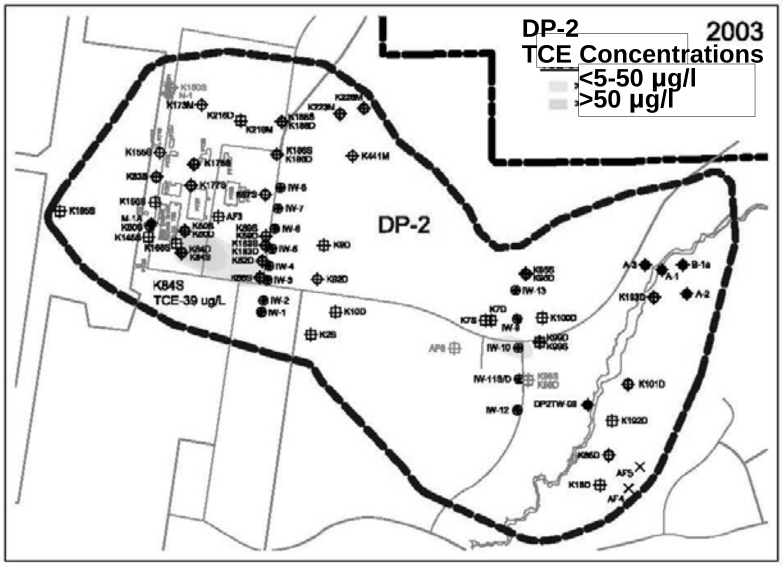
Analysis Tools – Plume Maps



No associated notes.

42

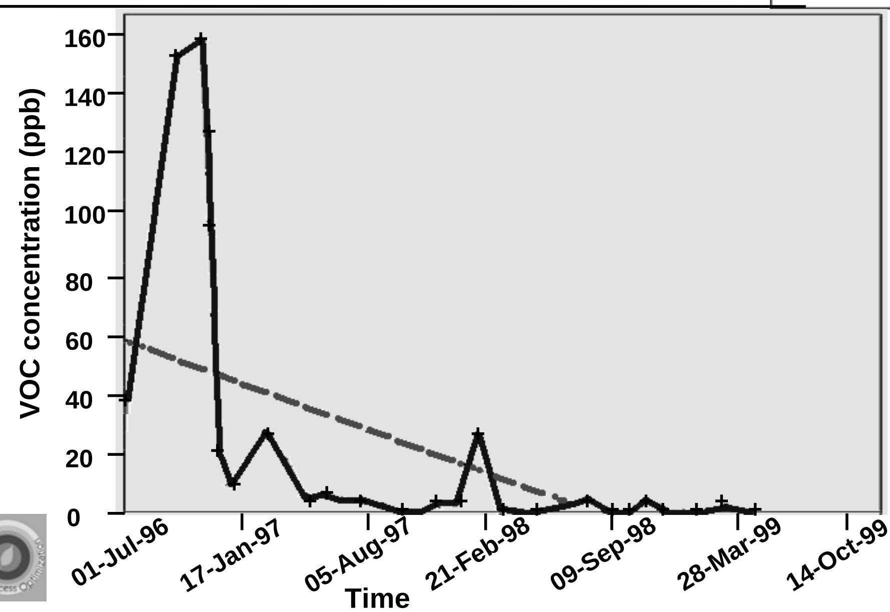
Analysis Tools – Plume Maps



No associated notes.

43

Analysis Tools – Time Series Plot



Time series plots help to identify trends, and are better communication tools than volumes of data in a spreadsheet.

44

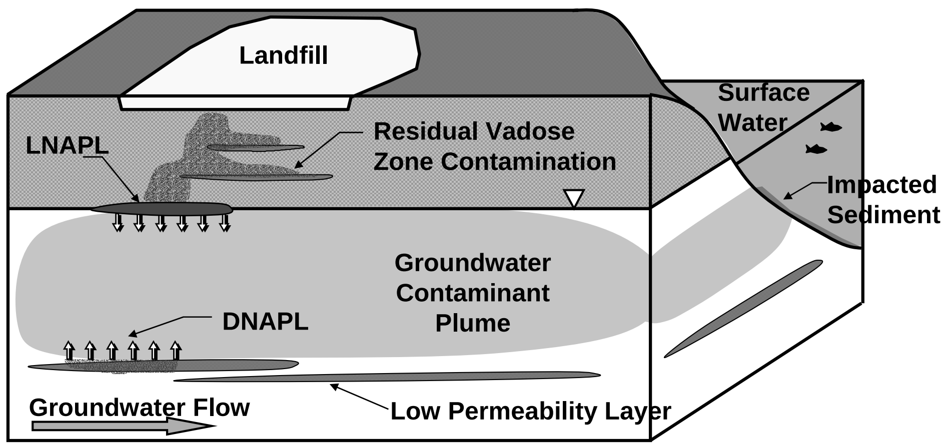
Evaluating System Performance

- Evaluate the performance of individual components of the remedy
- Identify performance objectives
  - Criteria to measure the operational efficiency of each technology
  - Used to demonstrate that the remedial component operates efficiently, which is a necessary element of many exit strategies
  - May trigger operational adjustments or design modifications

No associated notes.

45

Performance Objectives



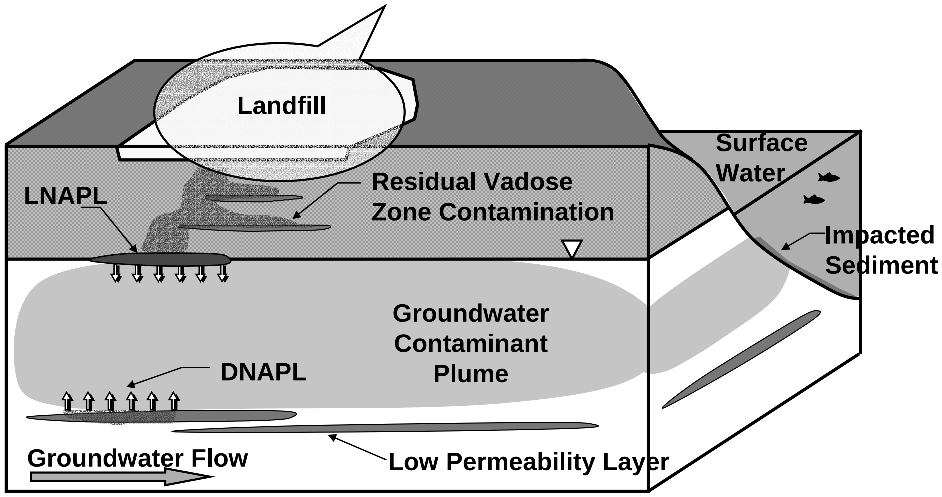
Modified from Remediation Innovative Technology Seminar (RITS)

This slide shows a simplified conceptual site model. The site is comprised of several different areas of concern, that will each require a unique remedial technology. For example, the appropriate remedy for a landfill is a cap or cover, whereas the appropriate remedy for the LNAPL area is a multi-phase extraction system. To reach cleanup goals, it is likely that several remedial technologies will be utilized at different locations, or perhaps several remedial technologies will be utilized over time (i.e.., switching from multi-phase extraction to bailing to monitored natural attenuation).

Each technology serves a different purpose, and metrics (performance objectives) should be established that are technology specific, taking into consideration current technology advantages and limitations.

The next 5 slides gives examples of performance objectives. The types of data collected at the site should help to assess if performance objectives are being met, as well as indicate when operational adjustments or design modifications are needed.

Performance Objectives - Cap or Cover:
1. **Minimize infiltration of contaminants**
2. **Eliminate surface exposure**



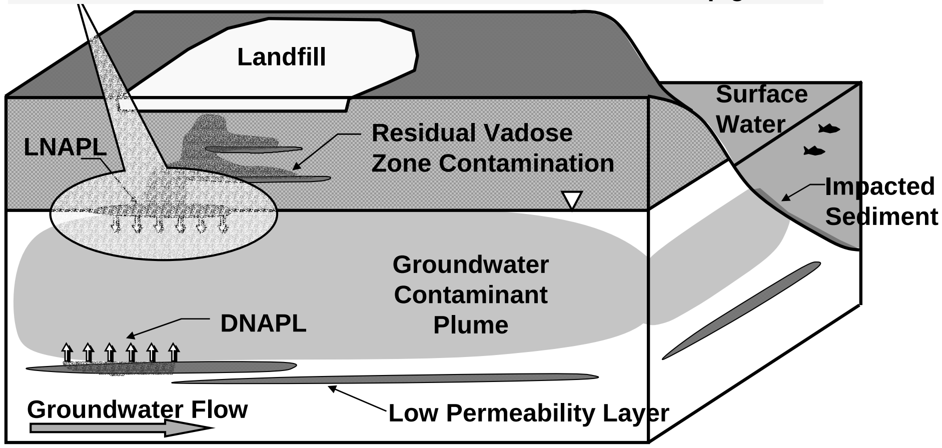
Modified from RITS

No associated notes.

47

Performance Objectives - Bioslurping to Bailing to Monitored Natural Attenuation (MNA):

1. **Remove LNAPL to the extent practicable**
2. **Operate while cost effective by considering other components of treatment train and ability of MNA to reduce contaminant levels that are above cleanup goals**

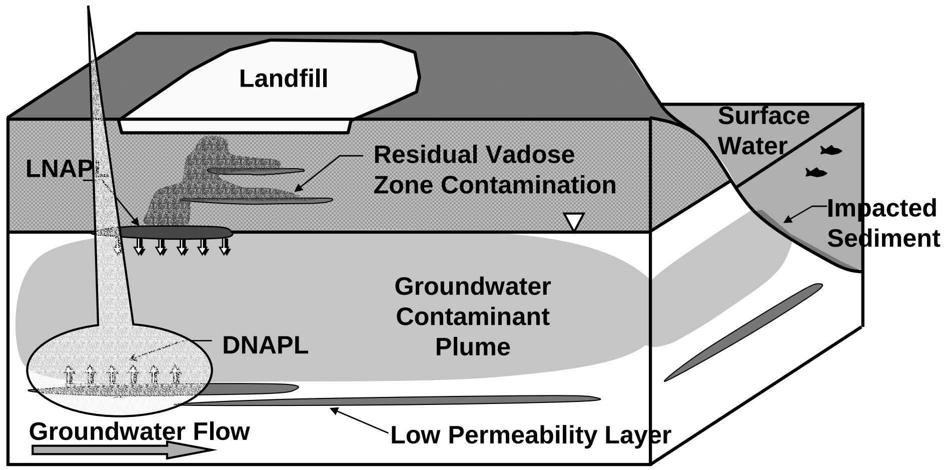


Modified from RITS

No associated notes.

Performance Objectives - Chemical Oxidation to Monitored Natural Attenuation:

1. **Mass reduction in source area**
2. **Operate while cost effective**



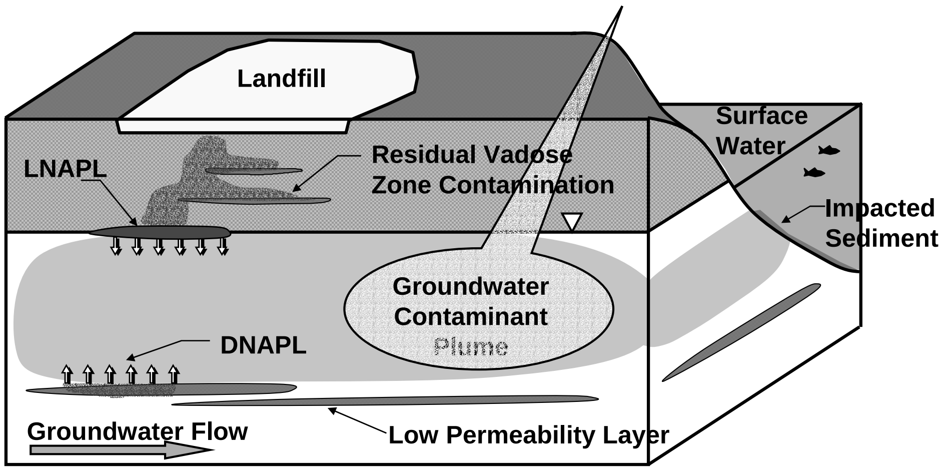
Modified from RITS

No associated notes.

49

Performance Objectives - Permeable Reactive Barrier to Phytoremediation to Monitored Natural Attenuation:

1. **Monitor and prevent migration of contaminants to surface water that are above action levels**



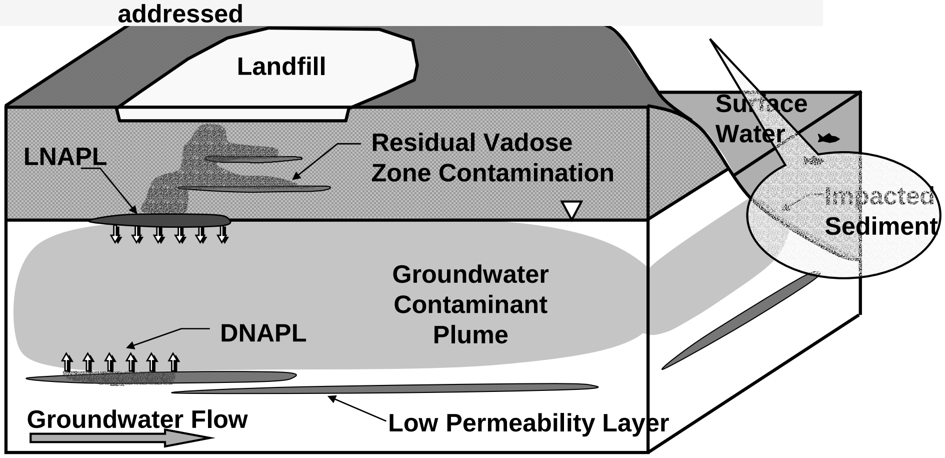
Modified from RITS

No associated notes.

50

Performance Objectives – Dredging or Capping to Natural Recovery:

1. **Monitor for natural recovery**
2. **If natural recovery is ineffective, remove or cap sediments as applicable after upgradient source is addressed**

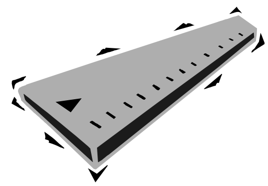


Modified from RITS

No associated notes.

51

Remedial Component Performance Assessment



Evaluating Performance Data

- Extraction and ex situ treatment
  - Extraction and infiltration rates
  - Concentrations at each extraction point
  - Influent/effluent concentrations
  - Operating parameters (e.g., temperature, residence time, chemical feed rates)
  - Waste generation rates
- In situ remediation
  - Injection rates and volumes
  - Radius of influence measurements around injection points
  - Plume capture (e.g., passive barriers)

No associated notes.

52

Evaluating System Up-time/Down-time

- Evaluate causes of system malfunctions
  - Is it a recurring problem?
- Evaluate reaction time
  - Utilize telemetry units
- Review preventative maintenance program
- Effective system operation does not just require a high up-time, but also an effective system performance

No associated notes.

53

Assessing Remedial System Effectiveness

- Overall progress towards achieving RA objectives
  - Evaluate results of remedial component performance assessment
  - Compare to metrics identified in exit strategy
- Is current remedy suitable?
  - Technical limitations on remedy performance
    - e.g., low-permeability aquifer, unaddressed preferential pathways, presence of DNAPL in saturated zone
  - Adequacy of remedy design
  - Life-cycle design limitations

Examples of when a current remedy is not suitable:

- Technical Limitations: (see slide)

- Adequacy of remedy design: injection or extraction well network must have adequate radius of influence to cover the targeted treatment zone or capture the extent of contamination required to achieve cleanup goals.

Also, as emerging issues arise, treatment strategies may need to be reassessed for new COCs or different contaminant migration pathways.

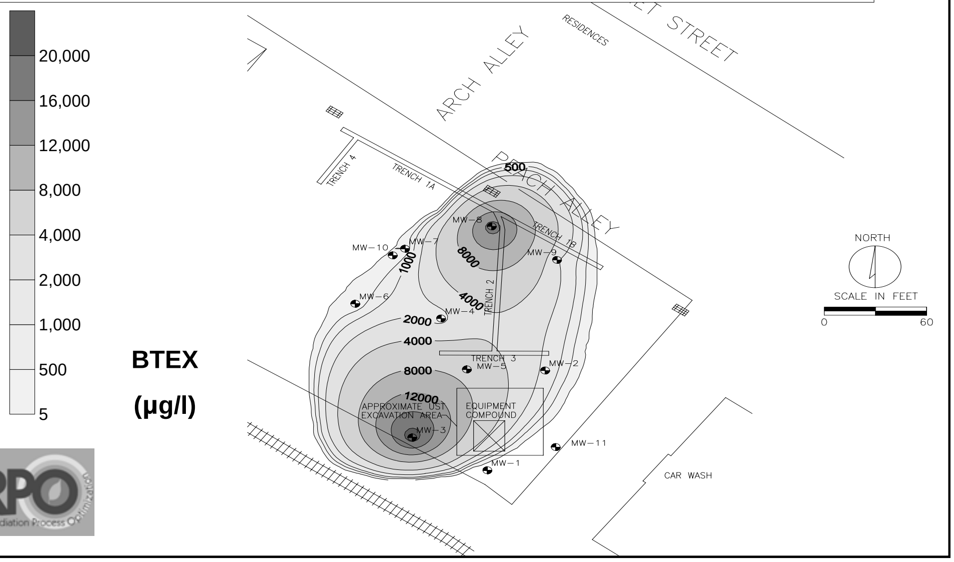
- Life-cycle design limitation: remedial progress for systems designed for mass removal will become increasingly limited at sites in the diffusion-limited phase of the life-cycle design. Such systems may reach asymptotic mass-recovery rates after relatively short periods of operation; the exit strategy should clearly define triggers for implementation of contingency action or of rebound testing.

At sites where systems fail the suitability analysis, alternative remedial actions should be explored. As sites with complex problems, careful review of remedial action objectives and the underlying assumptions will be important.

54

Example – Assessing Remedial System Effectiveness

Determine the Degree of Hydraulic/Plume Capture

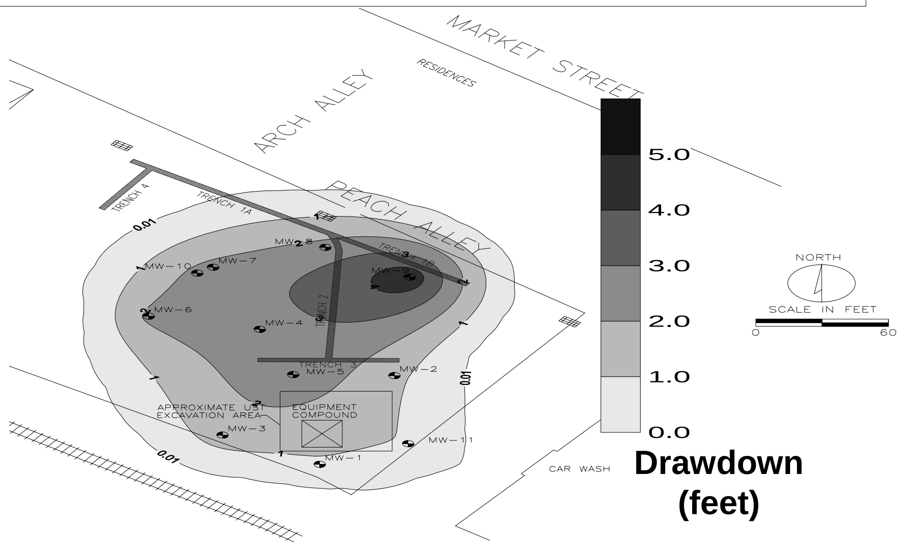


These two slides demonstrate how using concentration data plotted as a plume map, and drawndown data also plotted on a map, can help to determine remedial system effectiveness. In this case, the maps indicate that the one extraction well may not have adequate radius of influence to largely effect the southern area of high concentration. The adequacy of the remedial design should be revisited.

55

Example – Assessing Remedial System Effectiveness

Determine the Degree of Hydraulic/Plume Capture

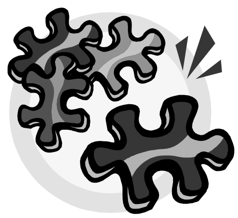


No associated notes.

56

Elements of RPO

- Site selection
- Building the RPO team
- Evaluating the exit strategy
- Evaluating performance
- Evaluating cost efficiency
- Remedy optimization
- Monitoring optimization
- Cost benefit analysis
- Implementation and tracking



No associated notes.

57

Remedy Cost Efficiency Assessment

Evaluate Cost and System Performance Data

- Compare projected and actual costs during O&M
- Identify capital costs for upgrades and modifications
- Determine the degree of hydraulic/plume capture
- Assess mass of contaminant removed
- Evaluate system up-time/down-time

The remedy cost efficiency assessment compares the actual O&M cost of a remediation system against projected cost - which was one of the criteria used to select the remedy instead of other alternatives - and its progress toward achieving the RA objectives (e.g., containment or contaminant mass removal).

Effective system optimization efforts can reduce the O&M duration by months or years, saving thousands of dollars in the project life-cycle.

58

O&M Costs to Consider

- Labor (field and office)
- Materials (sediment filters, activated carbon, oil for equipment, heat tracing in winter months, …)
- Utilities and fuel
- Monitoring including sampling and analysis
- Equipment lease/rental
- Offsite disposal fees (e.g., for sludges)
- Administrative costs (e.g., permitting fees, meetings, reporting, fines for violations)

O&M costs should be tracked monthly, as fluctuations or upward trends may indicate a potential inefficiency, or opportunity for optimization.

59

Remedy Cost Efficiency Assessment

Compare Projected and Actual Costs During O&M

JOB#02-00223

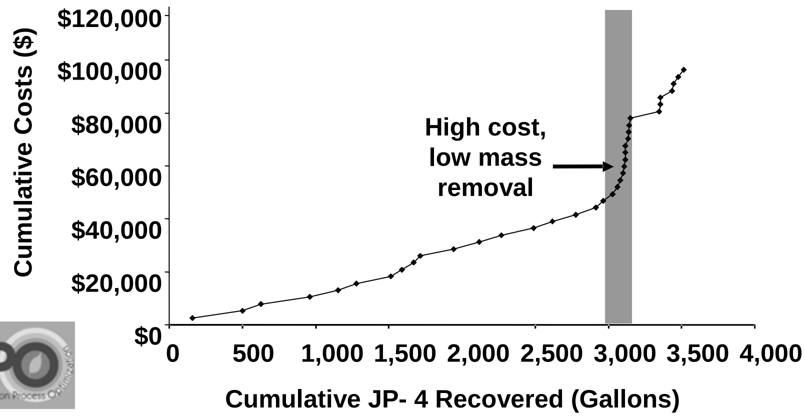
Task	Budgeted Amount	Monthly Billings (Actual Costs)					Total ACTUAL	Total Budgeted
		08/28-10/01	10/02-10/29	10/30-11/26	11/27-12/31	01/01-01/28		
Utility Mark-out	$ 3,574	$ 1,506	$ 1,506				$ 3,011	$ 3,574
Pre-construction meeting	$ 2,000						$ 2,381	$ 2,000
Well Installation	$ 49,580	$ 43	$ 203	$ 956			$ 43,541	$ 49,580
Equipment Procurement	$ 7,583	$ 23	$ 1,063				$ 2,440	$ 7,583
Trenching	$ 116,745	$ 16,396	$ 39,283	$ 101	$ 22,858		$ 110,032	$ 116,745
Wellhead Modifications	$ 7,785	$ 6,500	$ 505				$ 6,765	$ 7,785
HVIPE Recovery Sys.	$ 141,072	$ 484	$ 73,593	$ 9,606	$ 680		$ 150,226	$ 141,072
Groundwater Treatment Sys.	$ 33,575		$ 1,843	$ 1,961	$ 2,141	$ 2,154	$ 8,216	$ 33,575
Pre-operation System Check	$ 3,656		$ 275	$ 363	$ 400	$ 68	$ 1,105	$ 3,656
System Start-up	$ 3,697			$ 1,564	$ 121	$ 3,625	$ 4,357	$ 3,697
Site Survey	$ 2,634			$ 108	$ 289	$ 2,345	$ 4,771	$ 2,634
AW Report	$ 5,538			$ 68		$ 865	$ 8,412	$ 5,538
Total	$ 377,439	$ 24,950	$ 118,269	$ 14,725	$ 26,489	$ 9,056	$ 345,257	$ 377,439

No associated notes.

60

Cost-efficiency Plots

- Plot cost and performance data
  - Cumulative cost vs. cumulative mass removed
  - Cost per unit mass removed vs. time



A near vertical slope indicates poor system efficiency.

61

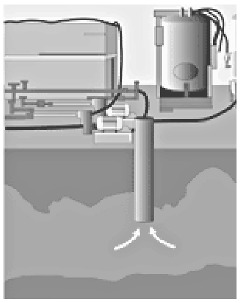
Cost-efficiency Plots

- Conclusions to be drawn include
  - Efficient system operation
    - Low O&M costs
    - High mass-removal rate
  - Decreasing system efficiency
    - Increasing O&M costs
    - Decreasing mass-removal rates
    - Frequent system shutdowns
  - Poor system efficiency
    - Asymptotic conditions

No associated notes.

62

Questions and Answers



The ITRC Document:
“Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation” available on www.itrcweb.org

No associated notes.

63

Elements of RPO

- Site selection
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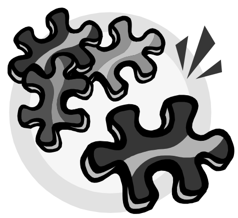
- Evaluating performance
- Evaluating cost efficiency
- Remedy optimization
- Monitoring optimization
- Cost benefit analysis
- Implementation and tracking



No associated notes.

64

Remedy Optimization

- Optimizing the exit strategy
- Optimizing the remedial system
- Optimizing the monitoring program

No associated notes.

65

Optimizing the Exit Strategy

- The RPO review report should address
  - Overall protectiveness of the remedy and likelihood of attaining the cleanup goals
  - Recommendations to enhance protectiveness
  - Measures to increase the likelihood of achieving the RA objectives
  - Means to reduce time required to complete the RA
  - Opportunities for cost reduction without compromising remedy effectiveness

All recommendations should be made within the context of the exit strategy. The RPO team may want to recommend refinement of the exit strategy based on their overall remedy review.

66

Optimizing the Exit Strategy

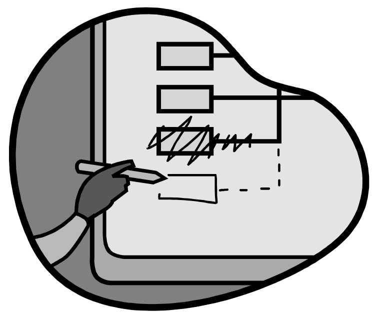
- Recommended actions
  - Revise RA objectives based on updated site conditions and/or ARAR analysis
  - Further refine the CSM
  - Suggest new technologies
  - Optimize monitoring program
  - Provide results of cost benefit analysis to justify optimization recommendations
  - Identify an implementation strategy

No associated notes.

67

Optimizing the Remedial System

- System optimization may include modifications to
  - Extraction systems
  - Treatment systems
  - Monitoring programs
- Alternative remedial systems



An alternative remedial system can be considered when the current remediation system is not appropriate for reaching remedial goals at the site.

68

Optimizing the Remedial System

- Modifications can be classified as
  - Minor modifications to existing systems
  - Adding to or removing from or replacing the existing system components
- Updating the overall remedial strategy such as
  - Perform hotspot remediation
  - Replace/supplement the technology with a new technology
  - Use of institutional controls to achieve protection

No associated notes.

69

Optimization Recommendations Balanced Between Performance and Cost

- Based on 27 remediation system evaluations conducted for EPA Superfund sites – of 251 total recommendations
  - 76 addressed effectiveness issues
  - 75 identified potential cost reductions
  - 69 suggested technical improvements in the operations
  - 31 addressed means to facilitate site cleanup/close-out
- Balance between effectiveness and cost is a key issue

No associated notes.

Elements of RPO

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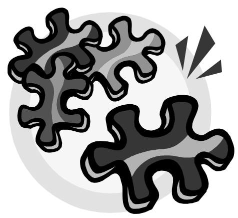

No associated notes.

Monitoring Optimization

- Monitoring optimization applies to
  - Site-specific or installation-wide monitoring programs
  - Vadose zone or groundwater
  - Process monitoring
- Monitoring optimization
  - Ensures every sampling point fills a specific need
  - Does not compromise overall protectiveness of remedy to reduce costs
  - Enhances data quality while reducing resources
  - Is a systematic, iterative process

No associated notes.

72

Evaluating Monitoring Programs

But we've always done it this way…

- Number and locations of monitoring points
  - Role of each monitoring well
  - Redundancy and optimization analyses
- Monitoring frequency
  - Change in the frequency of sampling
  - Adequate frequency for long-term monitoring
- Monitoring parameters
  - Add or remove target analytes based on site-specific conditions
- Sampling and analysis procedures
  - Use improved and efficient procedures

Diffusion bag samples are one example of a new sampling procedure. They give a high quality, representative sample and minimal resources are required compared to a traditional sampling approach. Other sampling considerations are low-flow purging or the use of dedicated equipment.

73

Elements of RPO

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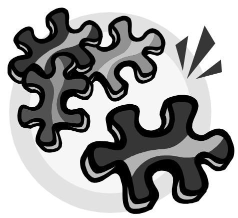


In this next section we will present an overview of tools that should be used to make better decisions.

The tools help us evaluate different pathways available in meeting the Exit Strategy.

74

Remedy Cost Efficiency Assessment

Identify capital costs for upgrades and modifications

- Identify upgrades/modification that can be made to improve system operation (more extraction/ injection wells, upgrade equipment, install more efficient wells, reduce pipe headloss, change recovery or treatment technologies, etc.)
- Perform a life-cycle cost evaluation to see if the modification will reduce the project life-cycle cost
- In some instances, additional site characterization or feasibility testing can be performed to identify if upgrades and modifications are beneficial
- Modeling may be performed to help justify if upgrades are needed

Are we meeting our Goal?

And even if we are meeting the original Goal set years ago can we do better with newer technology that is now available?

Can we automate processes?

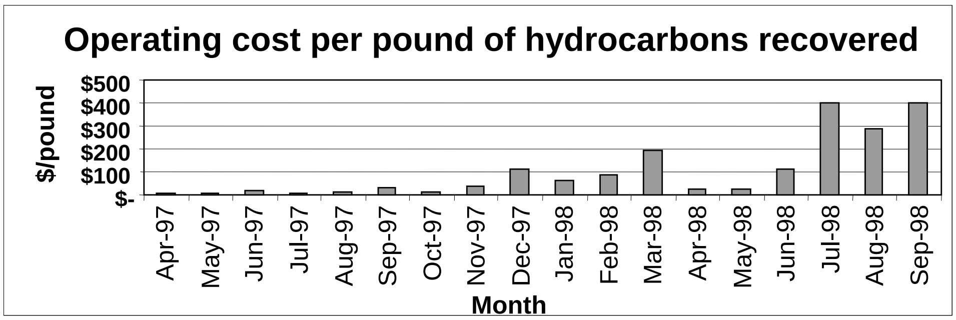
Should we change technologies?

There are three (3) parts to cost – capital, O&M, and management/consulting/regulatory.

75

Remedy Cost Efficiency Assessment

Mass recovery data and system cost information should be used to determine operating cost per pound (or gallon) of contaminant recovered. If system optimization adjustments are effective, the graph of cost per pound of contaminant over time should show frequent fluctuations (as efficiencies are realized following adjustments).



This is a tool to measure the past operation and the effect of recommended optimization changes.

By knowing the level of contaminate recovered and the total cost of recovery you can visually see if progress is being made.

76

Life-cycle Costing

- According to EPA and Army Corps of Engineers (2002) A Guide to Developing and Documenting Cost Estimates during the Feasibility Study (EPA 540-R-00-002. July 2002), the term “life-cycle cost” refers to the total project cost across the lifespan of a project, including design, construction, O&M, and closeout activities
- The cost estimate developed during the RPO is a projection of the life-cycle cost of an RA from design through response completion

Life-cycle costing is a useful tool for determining a course of action today and the costs associated with that action.

Included in a life-cycle cost are all the project costs – capital equipment and construction, O&M for the entire project, management (time), engineering, and all other costs.

The ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation*" lists references in the appendices for you to use.

77

Life-cycle Costing

- Present-value analysis is a method to evaluate expenditures—either capital or O&M—that occur over different time periods
  - Define the period of analysis
  - Calculate the cash outflows
  - Select a discount rate
  - Calculate present value

This standard methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative.

This single number is the amount of funding that must be set aside at the initial point in time (base year) to ensure that funds will be available in the future as they are needed, assuming certain economic conditions.

What is the length of each alternative in years?

What and when are the cash requirements?

What discount rate is to be used?

What is the calculated present worth?

78

Life-cycle Costing

Cost-estimating summaries should address the following

- The key cost components/elements for both RA and O&M activities
- The major sources of uncertainty in the cost estimate
- Either discount rates or scale-up factors
- The time expected to achieve RA objectives
- Periodic capital or O&M costs anticipated in future years of the project (e.g., remedy replacement or rebuilt)
- The methods and resources used for preparing the cost estimate (e.g., estimating guides, vendor quotes, computer cost models)
- Treatability study costs, when applicable

This is broad summary check list.

For more detail you should review the checklists in EPA document 540-R-00-002.

79

Life-cycle Costing

Tools that can be used to develop life-cycle costs

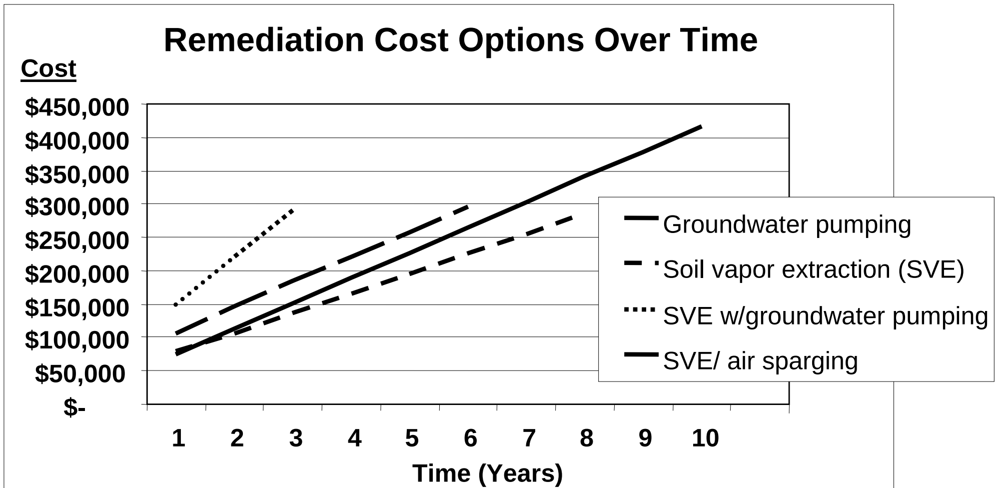
- Site characterization data
- Pilot test data
- Life-cycle costing spreadsheets/software
- Predictive models to assess remedial duration

Historical data and progress charts are used to project the future cost of current operations.

Alternative technologies and changes use a predictive model to forecast the cost of changes.

80

Life-cycle Costing



You've done the work and now it is time to present the forecasts for the alternatives.

Using a chart is a very good visual tool.

If time is important then SVE with groundwater pumping is the best choice.

If time for this contaminate is not going to reduce the overall projects time then SVE may be the prudent choice.

81

Elements of RPO

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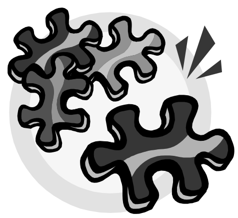


It is necessary to measure the progress of the changes and determine if they are meeting the projects Goal.

82

Implementing the Optimization Strategy

- Create an implementation strategy to facilitate optimization recommendations
- Some recommendations may be contingent on results of implementation of other recommendations
- Consider a sequencing strategy that will maximize the desired improvements
- Base strategy largely on the potential for each recommendation to improve performance and reduce time and costs

The case studies in the ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation*" and at the end of this presentation are good examples of implementing an optimization strategy.

Now is the time to write a plan to implement recommended changes.

Those that fail to plan, plan to fail.

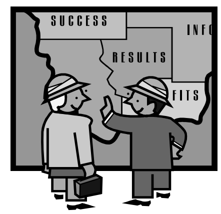
Important to include all personnel that will be involved in the plan to write the plan.

BUY IN!!

83

Implementation Tracking

- RPO findings and recommendations should be monitored and tracked by senior management
- RPO review report should include: probable future actions and schedule for such actions
- Minimum tracking requirements include
  - Who is responsible for implementation
  - What the recommendations are to be implemented
  - How implementation will occur
  - Time frame for implementation
  - Cost and time savings
  - Expected outcome



Once the implementation plan has been developed AND ACCEPTED BY THOSE IMPLEMENTING THE PLAN you need to track key measurements.

Be careful with selecting measured parameters.

Be sure the selected parameters measured are consistent with the Goal – achieve the exit strategy in the shortest time for the lowest cost.

84

Challenges in the RPO Process and Possible Solutions

- Several hurdles may exist for implementing RPO activities
  - Technical
  - Institutional
  - Contractual
  - Regulatory
- Technical issues
  - Uncertainties and heterogeneities
  - Dynamic nature of remediation – things change
  - Consider alternative technologies if appropriate
  - Conduct reliability assessment, stochastic modeling

Change is not easy!

85

Challenges in the RPO Process and Possible Solutions

- Institutional issues
  - “Inertia” of project team, no motivation to change, admit “failure”
  - No formal policies or tracking system for optimization
  - Skeptical stakeholders – balance between protectiveness, cost
  - Staff turnover
  - Need to publicize successes, provide guidance
- Contractual challenges
  - Contractors view of optimization: reduced income
  - Tie payment to cost-effective progress toward achieving goals
  - Metrics include: discharge violations or treatment efficiency, maintaining plume capture, plant up-time, reduction in plume size or concentrations
  - Fixed-price contract with some cost reimbursable expendable items

No associated notes

86

Challenges in the RPO Process and Possible Solutions

- Regulatory challenges
  - Multiple regulatory frameworks applied to the facility
  - Multiple regulatory agencies or branches of the same agency with different perspectives
  - Changing regulations, new contaminants of concern
  - Credible guidance on optimization approaches, education would help acceptance
  - Integrate optimization and performance reviews in regulatory requirements

No associated notes.

87

Stakeholder Considerations

- Stakeholder participation is highly recommended by the ITRC in all phases of cleanup
- Outreach to stakeholders, at a minimum must address regulatory and policy requirements for community involvement
- Stakeholders should be educated about the purpose of an RPO and notified of the review findings
- Evidence has shown optimization process can be enhanced by active stakeholder participation

No associated notes.

88

Overview of Federal RPO Programs

Department of Defense

- Air Force
- Army
- Navy
- Defense Logistics Agency (DLA)

A common driver for the RPO initiatives within these DOD components has been the 2001 DOD Management Guidance for the Environmental Restoration Program

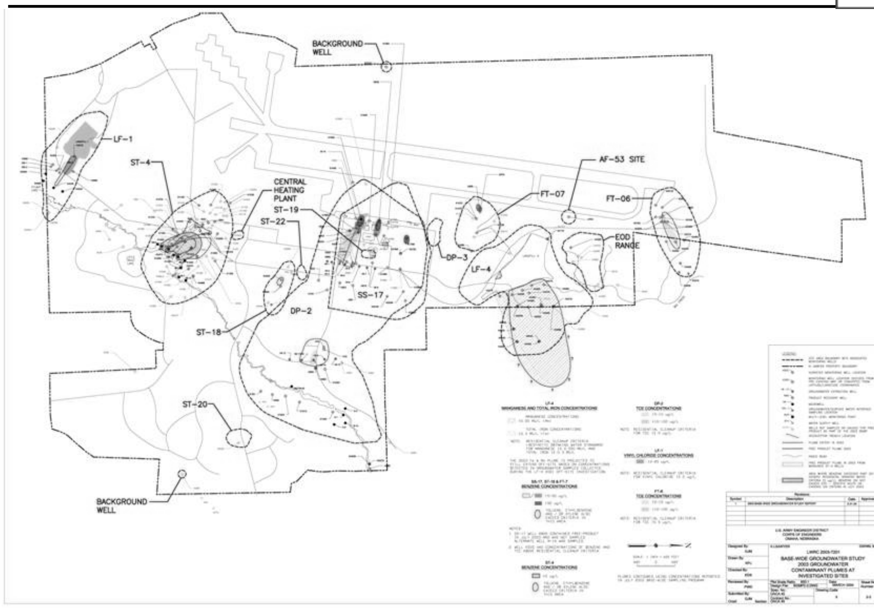
Department of Energy

Environmental Protection Agency

The ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation*" contains descriptions of the various optimization processes developed and used by the various federal agencies including those shown here.

89

Case Study – Former Air Force Base



To illustrate the thought processes and kinds of conclusions, we’ll discuss a case study. This figure shows various environmental restoration project sites at an airport (and former Air Force facility). We’ll focus on the largest of the sites located in the east-central portion (note that north is toward the right) of the airport, the DP-2 plume.

90

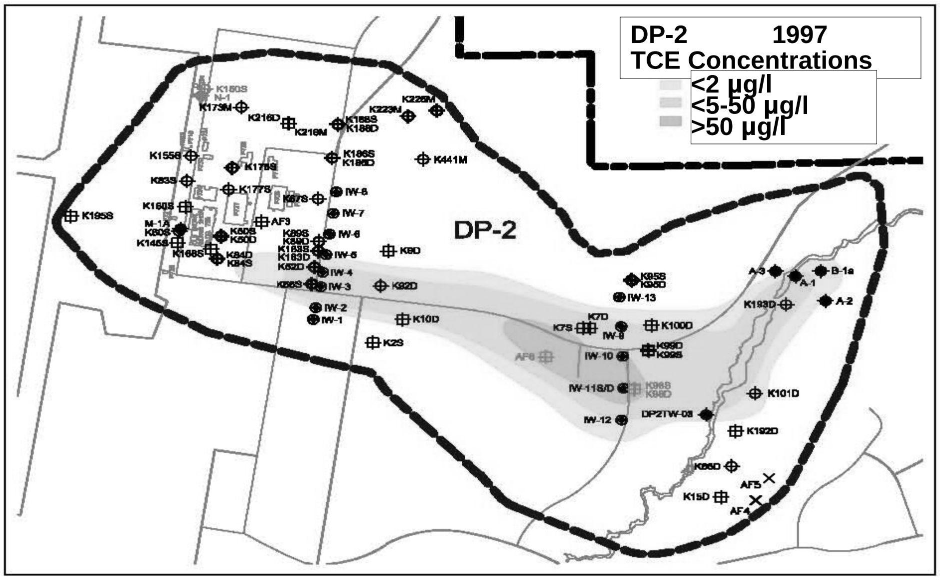
Case Study

- DP-2
- TCE plume (PCE and VC)
- Groundwater extraction system
  - Evaluation of RAOs
  - Evaluation of system
  - Performance evaluation
  - Model evaluation
  - Recommendations

The DP-2 site consists of a groundwater contaminant plume. The primary contaminants at the site are chlorinated organics, trichloroethene and perchloroethene, and their breakdown products. The optimization team evaluated the project objectives, system performance, and groundwater model used for decision making. Specific recommendations were made – we'll talk about each of these topics.

91

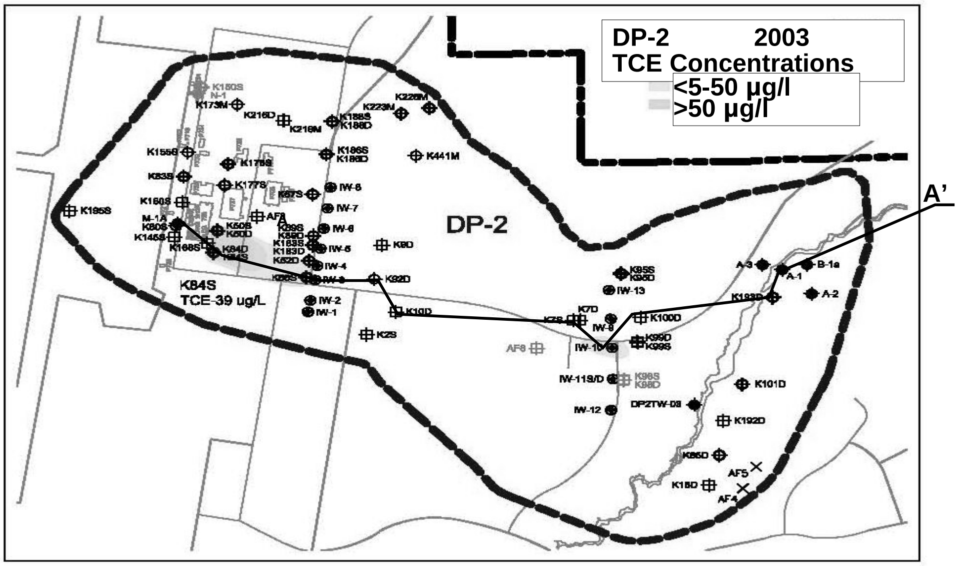
Case Study - 1997 Plume Map



This figure shows the DP-2 plume as it existed in 1997 not long after initiation of the pump and treat system operations. The colors indicate concentration ranges and the brighter the color, the higher the concentrations. Groundwater flows from left to right. The source is located at the left (upgradient) end of the plume and was believed to be related to an aircraft engine maintenance facility. The plume extended to the valley of a stream where the plume turned to flow along the stream valley. Two important municipal production wells are situated on the other side of the stream. The protection of these wells was a critical motivation for remediation at the site. Sentinel monitoring wells were installed between the plume and the production wells. The extraction system included two north-south lines of extraction wells (indicated by the "IW" prefix), one nearer the source, and one farther downgradient, but upgradient of the stream valley. A treatment plant consisting of two large air strippers and thermal treatment of the offgas was constructed at the site, though the thermal treatment was terminated after a period of time.

92

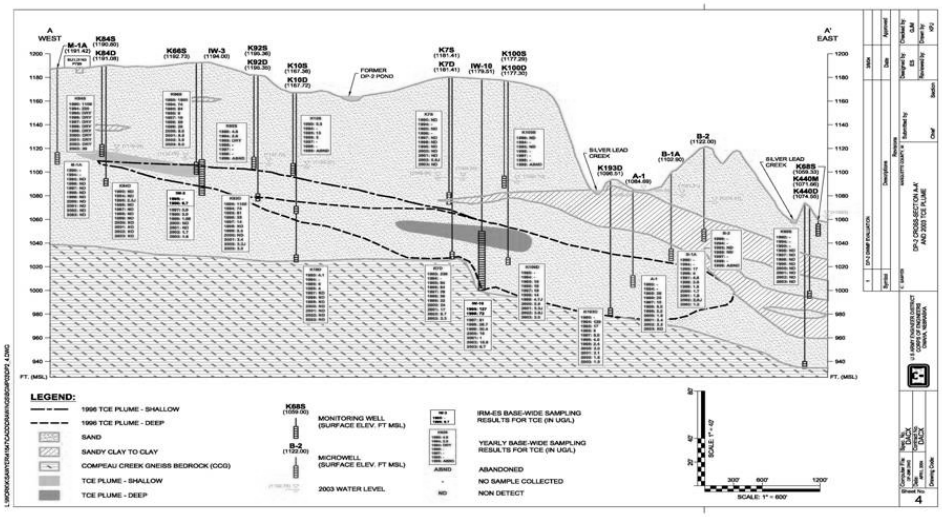
Case Study - 2003 Plume Map



This figure shows the 2003 contaminant concentration distribution. Clearly, the plume concentrations have significantly diminished and only two hot spots remain, one near the source and the other near the downgradient extraction well line. It may be possible to achieve cleanup at this site. Over the past several years, the operation of a few extraction wells, particularly on the upgradient line, has been terminated, but most were still running at the time of the optimization study. The RED lines indicate the location of a hydrogeologic cross section I'll show next.

93

Case Study – Cross Section Through Axis of Plume



This diagram shows current and past vertical locations of the contaminant plumes, including the well screens for the extraction wells. The contaminant source is located on the left side of the diagram. Note the colors for the plume here are shades of orange instead of green. The aquifer is largely sand, though the aquifer if divided vertically by some low-permeability layers farther downgradient. The plume is shallow near the source and is gradually buried by infiltration such that is found under a clay layer near the stream. Recent monitoring near the downgradient line of extraction wells suggests there is a shallow portion of the plume there that may be above the screened interval of the extraction wells. This is an example of graphics that would support a conceptual site model.

94

Case Study – Evaluation

Evaluation

- Adequacy of existing extraction system plume capture
  - Contour 2003 water levels and contaminant concentrations
  - Estimated site-specific hydraulic conductivity
  - Compute capture zone widths for typical extraction well and compare to plume width
- Treatment plant/process
  - Site visit
  - Interviews with operator and designer
- Adequacy of current and proposed monitoring program
- Adequacy of existing groundwater flow and transport model

The optimization study considered the performance of the extraction system to contain and remediate the plume and to protect the municipal wells. This involved the actions shown here. Capture zones were estimated based on hydraulic conductivities determined by pump tests and observed specific capacities of the extraction wells. The predicted capture zone widths for each of the extraction wells were compared to the observed contaminant plume width.

The treatment plant performance was considered by observations during the site visit and discussions with the operator and designer. Alternative treatment processes were considered that would be more appropriate to the current conditions. The study also considered the current monitoring programs. The site team was in the process of proposing a modified monitoring program to the stakeholders at the time of the optimization visit. Lastly, the optimization team considered the adequacy of the existing site groundwater flow and transport model for making predictions in support of decision making at the site.

95

Case Study – Conclusions

- Capture zone
  - Current system capturing plume
  - Extent of downgradient shallow plume not clear, but impact negligible
  - Single well capture zone adequate for current plume capture
- Model may require further evaluation for use in making decisions about fate of remaining plume
- Existing treatment plant
  - Oversized for current conditions
  - Savings of over $50,000/year possible
- Monitoring program as proposed is appropriate, with minor revision

Based on the evaluation, it was concluded the current system is capturing the plumes, but the same result could be accomplished with as few as one well pumping on each line. Any shallow portion of the plume near the downgradient line of extraction wells would have little downgradient impact. It was also concluded the existing model may need updating to improve its utility. The treatment plant was determined to be oversized for current flow rates and concentrations and cheaper alternatives exist. The monitoring program as proposed was deemed quite appropriate and only minor changes would be suggested.

96

Case Study – Monitoring Wells in Sampling Program

Rationale	Location	Included Wells	Frequency
Background control	**Up gradient**	**K80S**	**Annual**
Plume monitoring (remedy effectiveness)	**Source area**	**K50S, K84S**	**Annual**
	Downgradient	**K7S, K7D, K10D, K92D, AF8, K98D, K100D, K193D, A-1, B-1a**	**Annual**
	Cross gradient	**K66S, K183S, A-2, A-3**	**Annual**
Creek monitoring	**Downgradient**	**K98S, K99S, DP2TW03**	**Annual**
Off-site migration monitoring	**Property boundary**	**K68S, K440M, K440D**	**Annual**
Public water supply system	**Between AF-4 & AF-5 and plume**	**K15D, K65D, K101D, K192D, contingency well**	**Biannual**
Interim remedial measure extraction system (remedy effectiveness opt.)	**Extraction wells**	**IW-1 through IW-13**	**Biannual**

This table shows the analysis of the existing monitoring program. This type of table is good to focus the analysis of the monitoring program on the use of the generated data and to identify data gaps or redundancies. The rationale topics would be developed considering the remedial objectives and then the wells in the program would be assigned to each.

97

Case Study – Estimated Capture Zone Widths

Hydraulic Conductivity	Width	Estimated Zone
Avenue B wells		
K = 0.1 cm/sec	150 feet	Approximately 500 feet
K = 0.01 cm/sec	1,500 feet	
K = 0.001 cm/sec	15,000 feet	
Avenue BB wells		
K = 0.1 cm/sec	240 feet	Approximately 750 feet
K = 0.01 cm/sec	2,400 feet	
K = 0.001 cm/sec	24,000 feet	

This is a table constructed based on the calculations done to assess capture zone width and shows the capture zone widths expected at the observed pumping rates. The best estimates were compared against the plume widths which were in each case less than the projected capture zone widths for a single well.

98

Case Study – Recommendations

- Reduce or eliminate pumping on both extraction lines
  - If pumping needed, extract from IW-10, IW-11S, and IW-4 or –5
- Replace existing treatment plant
  - Low-maintenance carbon system
- Critically evaluate groundwater flow/transport model
- Reduce monitoring at inactive extraction wells IW-1, -7, and -8

This slide summarizes the recommendations for the DP-2 site. The combination of reduction in number of operating wells (and the associated drop in total influent flow rates) and change in treatment technology to carbon adsorption, would save approximately $50,000/year while maintaining equal protectiveness. The groundwater model should be revisited to more fully assess the proposed changes. The minor changes in monitoring program would include reductions in monitoring in certain inactive extraction wells. Hopefully, this brief case study illustrates the typical activities and provides a sampling of the kinds of recommendations that may come from an optimization. There are other case study synopses in the ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation.*"

99

Summary and Conclusions

- RPO evaluates performance, cost savings secondary goal
- Common sense applied to periodic evaluation of remedies
- States can apply to state-funded remediation programs and can use in evaluating proposed optimization by regulated parties
- Steps for RPO
  - Right sites, right team
  - Evaluate exit strategy, performance, costs
- Reduction of costs and time of remediation
  - Optimize exit strategy, operations, monitoring program
- Periodic RPO reviews may be appropriate
- Challenges include technical, institutional, contractual, regulatory hurdles
- Guidance discusses all these topics

Now to summarize the key points of today's seminar – RPO focuses on the performance of the system relative to its objectives, cost savings is a secondary objective. It really is application of common sense to on-going operation of these long-term remedial systems. The materials we covered today matter to our state representatives as there are state-funded programs that can benefit from the process and because the state regulatory agencies will be approached by the site teams with proposals to perform these RPOs and implement the recommendations.

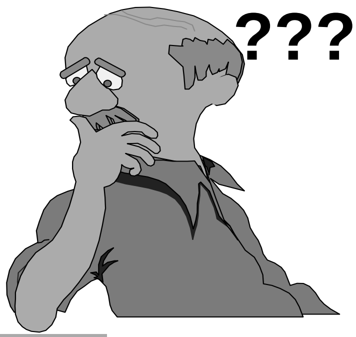
The RPO process are best applied to the sites that will potentially benefit (sites with long-term operations, significant costs, and identified or suspected problems) and should be conducted with an independent multi-disciplinary team of experts. The process musts include assessment of system performance, cost, and maintenance, as well as the appropriateness of the system objectives and monitoring program. Such RPOs should be done periodically as the site progresses and circumstances change.

There are challenges to the success of optimization, not the least of which is institutional on the part of the project team and responsible agency. Contractual approaches may limit the motivation for routine improvement.

100

Thank you for participating

- **Links to additional resources**
- **2nd question and answer session**



The ITRC Document: "Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation"

Thanks for joining today's training session. For information other ITRC courses go to: www.itrcweb.org

Links to additional resources:
http://www.clu-in.org/conf/itrc/rpo/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/rpo

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities

✓Be an official state member by appointing a POC (State Point of Contact) to the State Engagement Team

✓Use ITRC products and attend training courses

✓Submit proposals for new technical teams and projects