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

Remediation Process Optimization Advanced Training

Based on ITRC RPO Fact Sheets:

- Performance-based Management
- Exit Strategy
- Data Management, Analysis, and Visualization Techniques
- Above Ground Treatment Technologies
- Life-Cycle Cost Analysis

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

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. Successful remediation managers understand not only technologies to be deployed at sites, but also the underlying technical basis that supports the decision-making process. An understanding of these management methods and techniques taken together will serve as an excellent resource for moving forward on RPO projects.

The purpose of this ITRC training is to present an overview of the material covered in five technical fact sheets that ITRC's RPO Team produced to enhance site remediation optimization and decision-making. The training modules provide additional information and techniques to improve project schedules, effectively manage resources, emphasize risk, and discuss tools to efficiently cleanup contaminated sites. The ITRC RPO Fact Sheets provide detailed information on the following topics:

•Performance-based Management (PBM)

•Exit Strategy

•Data Management, Analysis, and Visualization Techniques

•Above Ground Treatment Technologies

•Life-Cycle Cost Analysis

These fact sheets were developed following the feedback to the RPO team's Technical and Regulatory Guidance Document *Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation* (RPO-1, September 2004) and training, "What is Remediation Process Optimization And How Can It Help Me Identify Opportunities for Enhanced and More Efficient Site Remediation?" (training archive available at http://www.clu-in.org/conf/itrc/rpo_092804/). The document and training archive are recommended as prerequisites for this RPO Fact Sheet Internet-based training course.

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)

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

- Host organization (ECOS)
- Network
  - State regulators
    - All 50 states and DC
  - Federal partners

    DOE DOD EPA
  - ITRC Industry Affiliates Program (IAP)
  - Academia
  - Community stakeholders
- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Documents
    - Technical and regulatory guidance documents
    - Technology overviews
    - Case studies
  - Training
    - Internet-based
    - Classroom

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 all 50 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 of organizations and individuals throughout 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.

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•We try to be as accurate and reliable as possible, but we do not warrantee this material.

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ITRC Course Topics Planned for 2008 – More information at www.itrcweb.org

Popular courses from 2007

- Characterization, Design, Construction, and Monitoring of Bioreactor Landfills
- Direct Push Well Technology for Long-term Monitoring
- Evaluate, Optimize, or End Post-Closure Care at MSW Landfills
- Perchlorate: Overview of Issues, Status and Remedial Options
- Performance-based Environmental Management
- Planning & Promoting Ecological Re-use of Remediated Sites
- Protocol for Use of Five Passive Samplers
- Real-Time Measurement of Radionuclides in Soil
- Remediation Process Optimization Advanced Training
- Risk Assessment and Risk Management
- Vapor Intrusion Pathway: A Practical Guideline

New in 2008

- Bioremediation of DNAPLs
- Decontamination and Decommissioning of Radiologically-Contaminated Facilities
- Enhanced Attenuation: Chlorinated Solvents
- Phytotechnology
- Quality Consideration for Munitions Response
- Remediation Technologies for Perchlorate Contamination
- Sensors
- Survey of Munitions Response Technologies
- More in development…

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

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Remediation Process Optimization (RPO) Advanced Training

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
- Performance-based management
- Exit strategy
- Questions and answers
- Data management, analysis, and visualization techniques
- Above ground treatment technologies
- Life-cycle cost analysis
- Links to additional resources
- Your feedback
- Questions and answers

No associated notes.

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Meet the ITRC Instructors

Tom O'Neill
NJ Dept of Env. Protection
Trenton, New Jersey
609-292-2150
tom.o'neill@ dep.state.nj.us

Javier Santillan
AFCEE
San Antonio, Texas
210-536-4366
Javier.santillan@ brooks.af.mil

Sriram Madabhushi
SC Dept of Health and Env. Control
Columbia, South Carolina
803-896-4085
madabhs@dhec.sc.gov

Richard Hammond
US EPA Region 4
Atlanta, Georgia
404-562-8535
hammond.richard@epa.gov

Dave Becker
US Army Corps of Engineers
Omaha, Nebraska
402-697-2655
Dave.J.Becker@ usace.army.mil

Tom O'Neill is a Section Chief with the New Jersey Department of Environmental Protection's (NJDEP's) Site Remediation and Waste Management Program. Tom joined the NJDEP in 1983 as an On Scene Coordinator overseeing a wide variety of publicly funded (State funds and Superfund) removal actions and planned site remediations including: drum and soil removals, laboratory clean-ups, landfill gas remediation, groundwater investigations, and pump and treat systems. In 1994 Tom was responsible for the formation of the Operations and Maintenance Section that is currently responsible for the NJDEP's publicly funded long term remediation and monitoring sites, his Section is also responsible for the Deed Notice Inspection Program. His prior work includes design engineering with The Lummus Company, designing pollution control (air, water, and noise) systems for chemical and petrochemical facilities. He earned a Master of Science Degree from the New Jersey Institute of Technology - Newark College of Engineering, and a Bachelor of Science degree in Environmental Science from Rutgers University - Cook College.

Dr. Javier Santillan is a member of the Engineering Science Division at the Air Force Center for Engineering and the Environment (AFCEE). His area of expertise includes Analytical Chemistry, Geochemistry, Environmental Engineering, Streamlined Site Characterization, and Performance-based Management. Dr. Santillan joined AFCEE in 1993, served as Chemistry Group leader in 1995. He is the Team Leader of the Technology Transfer Group. The Engineering Science Division provides technical support to Major Commands and Air Force Installation Commanders for evaluating, demonstrating, and applying existing and innovative technologies. Dr. Santillan holds a BS in Chemistry (University of Arizona-1968), M.S. in Agricultural Chemistry (University of Arizona-1971), and a Ph.D. in Soils Chemistry and Irrigation Engineering (Utah State University-1974).

Sriram Madabhushi is a hydrogeologist with the Underground Storage Tank (UST) Program in the Bureau of Land and Waste Management (BLWM), South Carolina Department of Health and Environmental Control (SCDHEC) in Columbia, South Carolina. He is a Project Manager directing technical and financial aspects of site remediation activities at contaminated UST sites. Sriram worked for three years in the Federal Facilities Agreement - Superfund Section reviewing the site rehabilitation activities at the Savannah River site and three years in the RCRA section providing technical review of project documents related to Shaw and Charleston Air Force Bases. Recently he returned to the UST Program where he worked the first eight years of his career with the SCDHEC. Sriram was integral in the implementation of the risk-based corrective action and performance-based management processes in the UST Program. He has strong interests in statistical decision making techniques in remedy selection, optimization of remediation technologies, groundwater fate and transport modeling, application of innovative technologies in site investigations and rehabilitation, etc. Since 2004, Sriram has been the co-leader of the ITRC Remediation Process Optimization (RPO) team and he is an instructor on the team's advanced RPO training course and Performance-based Environmental Management course. He earned a bachelor's degree in physics from Andhra University, Waltair, India in 1981 and a master's degree in exploration geophysics from Indian Institute of Technology, Kharagpur in 1984. Currently he is working on his Ph.D. in geology at the University of South Carolina. Sriram is a certified Professional Geologist in the state of South Carolina.

Richard Hammond has worked in the environmental restoration industry as a field geologist and Geographic Information Systems specialist for nearly 25 years. In 1997, Richard formed and still heads the US EPA Region 4 (Atlanta, GA) Electronic Knowledge Management (EKM) Team. In this capacity, Richard has specialized in visualization of technical and scientific data to a variety of audiences. In 2005, Richard received his Masters degree in Organizational Management which has reinforced his idea that human capital far outweighs all other factors in successful project management, particularly environmental restoration projects.

Dave Becker is a geologist with the Geoenvironmental and Process Engineering Branch at the US Army Corps of Engineers (USACE) in Omaha, Nebraska. Since 1991 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 been a member of the ITRC RPO team since 2002 and is an instructor on the team's Internet-based training courses. Dave earned a bachelor's degree in geology from the University of Nebraska at Omaha in 1981 and a master's degree in geophysics from Southern Methodist University in Dallas, Texas in 1985 . He is a registered professional geologist in Nebraska and is a member of the Geological Society of America, the American Geophysical Union, the American Association of Petroleum Geologists, and the Nebraska Geological Society.

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What You Will Learn…

- Advanced concepts in Remediation Process Optimization (RPO) and Performance-based Management (PBM)
  - Being implemented at many sites
  - Knowledge to equip for better and faster cleanups
- Why should you care?
  - You will receive or prepare PBM and RPO proposals for your sites
  - Improve project management
- Five Fact Sheets based on *Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation* (RPO-1, September 2004)
  - Response to requests from RPO-1 training participants

ITRC Technical and Regulatory Guidance Document: "*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation.*" (RPO-1, September 2004) available at www.itrcweb.org under "Guidance Documents" and "Remediation Process Optimization."

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RPO Advanced Training

- RPO Advanced Training will help your program advance your clean up objectives - let you see the light at the end of the tunnel!
- Underlying benefits
  - Improve quality of decisions
  - Save time
  - Save money
- Personal benefits
  - Improve job performance
  - Keep current
  - Add skills
  - Prepare to be proactive
  - Lead innovation

No associated notes.

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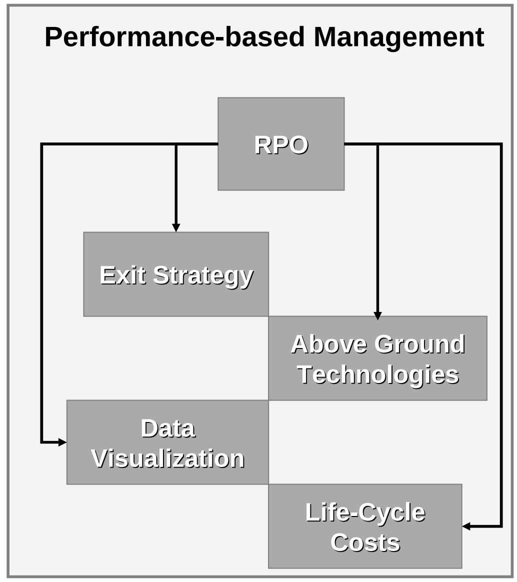
Presentation Overview

- Performance-based management
- Exit strategy
- Data visualization
- Above ground technologies
- Life-cycle costs



Issues raising from the RPO trainings. List of the five. All the fact sheets are within the scope of PBM

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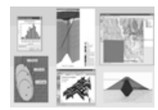
Performance-based Management

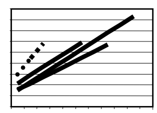
Exit Strategy

Data Management, Analysis, and Visualization Techniques



Above Ground Treatment Technologies

Life-Cycle Cost Analysis



RPO team's fact sheet on *Performance-based Management* (RPO-6, March 2006) is available at www.itrcweb.org under "Guidance Documents" and "Remediation Process Optimization."

PBM is the holistic management of a program. It is an approach that guides the practitioner on procedures that will maximizing confidence of decision derived form limited data. Systematic Planning using the Data Quality Objectives Process (QA/G-4) http://www.epa.gov/quality/qa_docs.html#G-4 is a primary concept of PBM. A very critical principle of PBM is its persistence on maintaining a focus on the final goal or product. In Environmental Restoration, the PBM goal is beneficial reuse of compromised sites. The reuse may be restricted or unrestricted that would depend on its intended use (residential, industrial, recreational, wild-life reserve, etc.)

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Performance-based Management: Definition

- What is Performance-based Management (PBM)
  - PBM is a strategic, goal-oriented uncertainty management methodology that is implemented through effective planning and timely decision-logic that focuses on the desired end results
  - Promotes accelerated attainment of cleanup objective in an efficient process
- Relationship of PBM to
  - RPO
  - Performance-based contracting (PBC)

Basic introduction to PBM.

How PBM is related to RPO and particular emphasis on PBC. Clarifying that PBM is not PBC and PBC is a part of overall PBM process.

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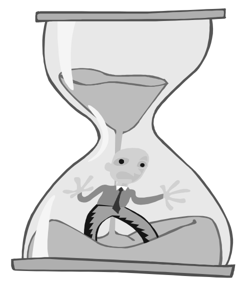
Performance-based Management: Goals and Benefits

- Goals of the fact sheet
  - Explain relationship to RPO
  - Describe what PBM encompasses
  - Discuss value of implementation
- Benefits
  - Promotes cleanup efficiencies
  - Expedites decision-making and minimizes risks
  - Rate of cleanups may increase
  - Site goals reached



Highlights of the fact sheet.

We are introducing the concept of PBM in this document, how it relates with RPO process, what it all constitutes and what we get out of doing a PBM.

Make our goal of cleanup complete approach in a systematic and clear way.

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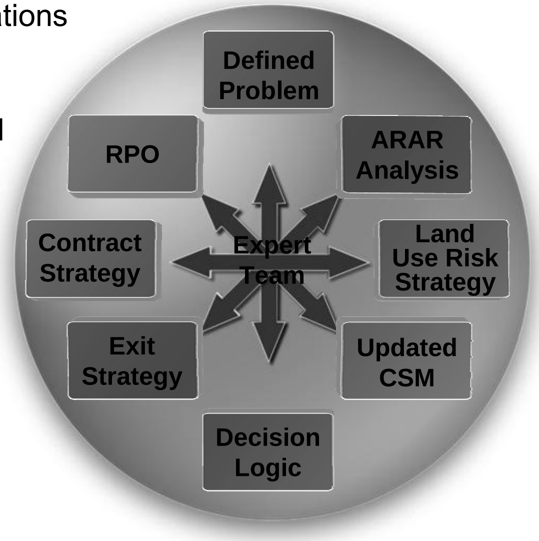
Project Management Components of PBM

Expert team and communications

- Defined problem and objectives
- Applicable or relevant and appropriate requirements (ARAR) analysis
- Land use risk strategy
- Updated conceptual site model (CSM)
- Decision logic
- Exit strategy
- Contracting Strategy
- RPO



ARAR – Applicable or Relevant and Appropriate Requirements

CSM – Conceptual Site Model

PBC – Performance-based Contracting

RPO – Remediation Process Optimization

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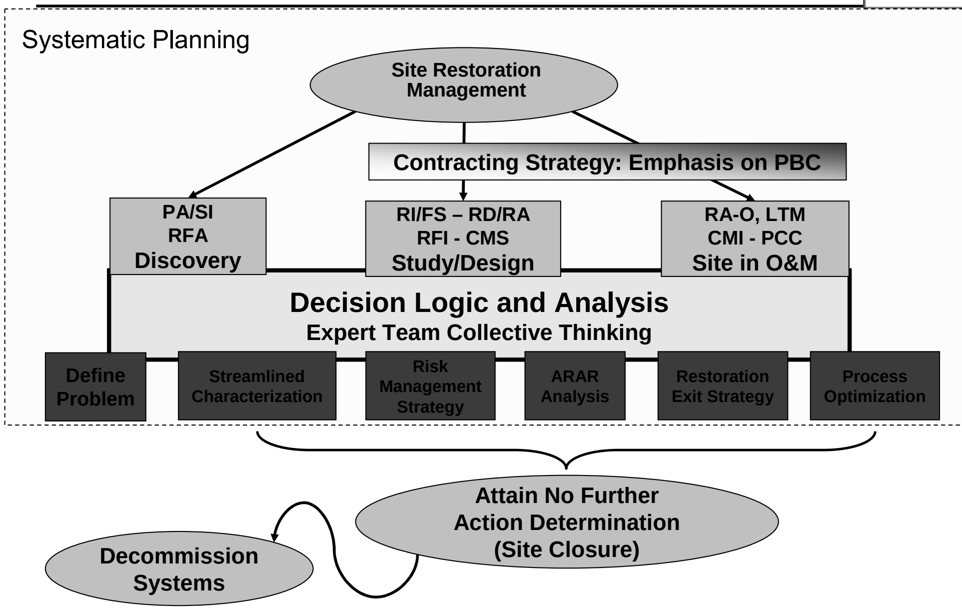
PBM Relationship to CERCLA/RCRA



PBM is an interactive multilevel component process that is applicable to CERCLA and RCRA regulated sites. It is not necessarily linear. PBM is founded on continuous feedback that is used to update the understanding of the process for the purpose of making the best decisions possible. Following the arrows, we can see that a site under LTM that is optimized would have a direct connection to updating the Exit Strategy, CSM, and potentially the risk and ARARs. The decision analysis and logic link optimization with the other activities. It is obvious that a modified CSM could change the risk management, and require ARAR re-analysis.

ARAR – Applicable or Relevant and Appropriate Requirements

CSM – Conceptual Site Model

LTM – Long-Term Monitoring

LUC/IC – Land Use Controls/Institutional Controls

O&M – Operations & Maintenance

PBC – Performance-based Contracting

PA/SI – Preliminary Assessment/Site Investigation

RA O – Remedial Action Operation

RCRA – Resource Conservation and Recovery Act

RD/RA – Remedial Design/Remedial Action

RFA – RCRA Facility Assessment

RFI – RCRA Facility Investigation

RI/FS – Remedial Investigation/Feasibility Study

RPO – Remediation Process Optimization

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PBM – Team and Communications

- Expert Team
  - Interdisciplinary senior team with field experience in remediation
  - Support from senior management, regulators, and potential stakeholders
- Communications
  - Ensure timeliness and accuracy
  - Promote trust between management, team, and stakeholders
  - Use best available communications technologies

Having a good expert team is critical to PBM.

Get regulators involved early and keep the communication flowing.

Buy in by the upper management is critical.

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PBM – Land Use and Problem Statement

- Defined land use
  - Current and future land uses considered
  - Identification of exposure pathways and hazards from cleanup
- Problem statement and objectives
  - Chemical and physical hazards, statutory, and perception issues addressed

Land use controls are very critical in defining the problem.

To what extent the cleanup is needed will depend on how the land is being used at present and will be used in the future.

Limitations, identification of exposure pathways, how hazards are defined and addressed in the overall process

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PBM – Conceptual Site Model

- Updated conceptual site model (CSM)
  - Comprehensive description of all available site conditions that influence
    - Design
    - Selection
    - Performance of remedies
- Streamlined, timely characterization
  - ASTM – Active Standard E1912-98 (2004)

CSM is fundamental to the entire process.

Need for updating continuously and with data gathered from the field operations.

More information in the Exit Strategy section

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PBM – Risk Management

- Remedial solution based on risk management strategy
  - Application of land use controls
    - Physical (institutional controls)
    - Legal
    - Administrative

Model Deed Notice

The model document in this appendix contains blanks and matter in brackets [ ]. These blanks shall be replaced with the appropriate information prior to submission to the Department for approval. The model document in this appendix is not subject to the variance provisions of N.J.A.C. 7:26E-1.6.

Matter bracketed [ ] is not intended for deletion, but rather is intended to be descriptive of the variable information that may be contained in the final document.

IN ACCORDANCE WITH N.J.S.A. 58:10B-13, THIS DOCUMENT IS TO BE RECORDED IN THE SAME MANNER AS ARE DEEDS AND OTHER INTERESTS IN REAL PROPERTY.

There are several options that may be applicable to manage risk. When clean up to unrestricted use is not feasible than some form of restrictions have to be placed on the use of the site. Managing and enforcing these restrictions are not always easy or assured in the long term.

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PBM – ARARs

- Regulatory requirements assessment
  - Applicable, or relevant and appropriate federal and state requirements (ARARs) must be considered initially during remedy selection and periodically revised

N.J.A.C. 7:26E Technical Requirements for Site Remediation ("Tech Rule")

Deed Notice Guidance

Example of how it is done in New Jersey.

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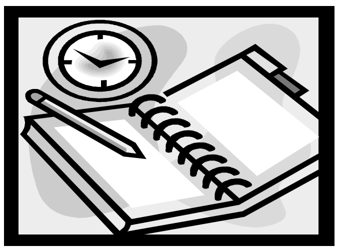
PBM – Restoration Decision Logic

- Restoration decision logic
  - Retain institutional memory
    - Decision trees or similar tools encouraged
    - Flexibility necessary
    - Stakeholder buy-in supported
  - Well distributed



Decision logic represents and documents the history and corporate knowledge of the site. It is generally represented graphically as decision trees with explanations as to how decisions were reached and explaining the reasons and justifications. Decision logic documentation is useful to in-brief new (in-coming) members of the restoration team.

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PBM – Contracting Strategy

- Contracting vehicles
  - Cost plus fixed fee (CPFF)
  - Time and materials (T&M)
  - Others
- Performance-based contracting (PBC)
  - Achieves clearly defined cleanup goals and milestones
  - Incentives for performance
  - Allowances for flexibility
- There are several types of PBC
- Privatized restoration

Performance-based Contracting (PBC) is a strategy to achieve clearly defined cleanup goals and milestones through use of incentives for performance and allowance of flexibilities. Privatized restoration is the contractual transfer of the restoration responsibilities along with the ownership of the land and applicable resources.

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PBM – Regulatory Concerns

- Unknown process with limited assurances
- Government staff shortages to provide rapid responses
- Loss of government oversight
- Lack of consensus on exit strategy
- Perception issue – sidelines for regulators
- Ineffective communications
- Need for PBM Memorandum of Agreement (MOA) with regulators

There are regulatory issues to be kept in mind when implementing a PBM. Success of PBM depends on understanding these issues and making sure the regulator's are properly included in the process. These issues should be considered before and during planning and during PBM implementation.

By clearly identifying these issues and putting options in place to open a dialogue as needed will result in successful PBM implementation.

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PBM – Case Study at Arctic Surplus Salvage Yard in Fairbanks, Alaska

- Privately owned 24-acre Superfund site
- US Army owned in 1944-1947
- Contamination included
  - Bulk asbestos
  - Liquid waste drums
  - TCE in groundwater
  - PCBs
  - Lead
  - Industrial solvents in soils
- No offsite migration but health risks within the fenced area

Before PBM

Successfully conducted case study using the PBM process.

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PBM – Case Study Results

- Record of Decision (1995)
  - Thermal extraction
  - US EPA's estimate
    - $38M
    - 4 years to complete
- PBM expert team visit
  - Updated CSM
  - Recommended alternate technology
    - PBM cost $3.5M
    - 1 year to complete

Overall a success story that resulted in a faster, better, and cheaper cleanup.

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PBM – Case Study Closeout of Arctic Surplus Site

- Final closure report presented in 2003
- PBC included
  - Cleanup in one year
  - Maintenance of landfill cap
  - Annual groundwater monitoring for five years
- Removed from National Priorities List (NPL) in 2006

No associated notes.

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Performance-based Management: Summary

- Summary
  - Risks minimized
  - Rate of cleanups may increase
  - Cost efficiencies achieved
- References
  - ITRC RPO Fact Sheet on Performance-based Management
  - Association of State and Territorial Solid Waste Management Officials (ASTSWMO) White Paper on PBM
  - US Air Force and US Army Corps of Engineers Policies and Guidance documents
  - http://www.afcee.brooks.af.mil/products/techtrans/pbm/default.asp

No associated notes.

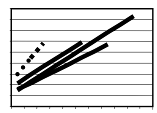
Performance-based Management

Exit Strategy

Data Management, Analysis, and Visualization Techniques

Above Ground Treatment Technologies

Life-Cycle Cost Analysis



RPO team's fact sheet on *Exit Strategy – Seeing the Forest Beyond the Trees* (RPO-3, March 2006) is available at www.itrcweb.org under "Guidance Documents" and "Remediation Process Optimization."

http://www.itrcweb.org/Documents/RPO-3.pdf

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Exit Strategy: Definition

- Detailed and dynamic cleanup plan to reach site closeout within a defined period of time
- Describes how progress toward performance expectations and goals will be pursued and measured
- Documents the pathway leading to no further action status
- Identifies alternative actions

A multi-site facility should develop an exit strategy for each site and a comprehensive exit strategy for the facility

An exit strategy is a detailed, dynamic, clear, and succinct plan that documents, in an auditable fashion, why actions will be taken based on the understanding of the restoration problem and cleanup objectives based on the future land or resource use. The exit strategy as a plan must specify goals and schedules to meet those goals. The ultimate goal being clean closure of the site, delisting from the National Priorities List (NPL), or de-permitting when appropriate. The exit strategy identifies the parameters or metrics that will be used to measure the progress, evaluate performance, and the probability of the remedial action to meet its goals. The decision logic or concurred pathway should be documented in the most suitable fashion which usually takes the form of a decision tree. The pathway should identify milestones and trigger points that may require alternate restoration, operation, and/or monitoring actions. In extreme cases when it is demonstrated that the remedial action in place cannot meet the cleanup goals, an alternate technology will have to be selected and implemented. The decision logic must incorporate all these possibilities. Complex facilities like refineries or military installation with multiple contaminated sites should develop a comprehensive exit strategy and an exit strategy for each individual site.

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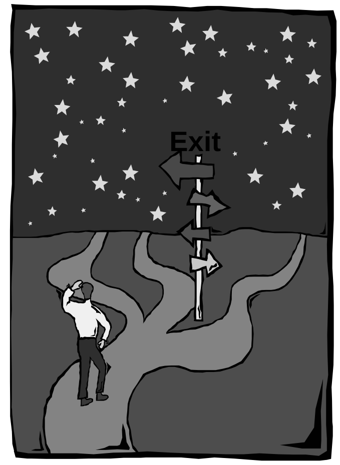
Exit Strategy: Overview

- Functional restoration team
  - Composition
  - Develops site exit strategy
- Goals of the exit strategy fact sheet
  - Define
  - Identify components
  - How to develop
  - Criteria to evaluate
- Benefits of exit strategy development
  - Promotes concurrence among all stakeholders on the final goal
  - Provides basis for effective decisions
  - Accelerates risk reduction maximizing restoration resources
  - Promotes dynamic system optimization through performance tracking thus minimizing restoration time



"… and if you don't know where you're going; any road will take you there"

The document on exit strategy clarifies some of the questions raised from the RPO initial training.

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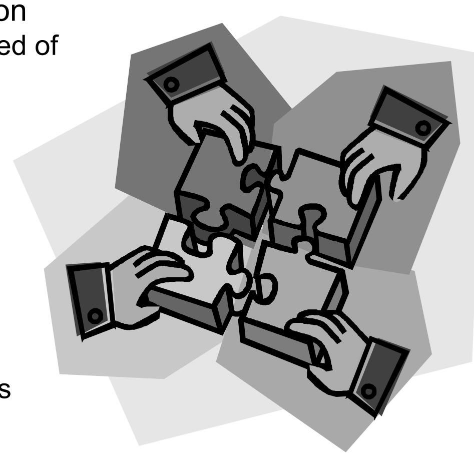
Functional Team

- Team composition and function
  - The team should be composed of
    - Regulated community
    - Regulators
    - Consultants
- Team function
  - Develop the exit strategy
- Essential team qualities
  - Effective communication
  - Trust
  - Common interest and goals
  - Expertise in appropriate fields



Similar to what Javier said before. This team should be of regulators, regulated community and consultants.

Purpose of function of the team is develop an exit strategy.

In order to do this, the team should be a pool of interested experts in appropriate fields. They should compliment one another.

Free flow of communication and well defined roles – who make what decision, etc.

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An Exit Strategy, as a Minimum, Should Include…

- Accurate conceptual site model (CSM)
- Planned future resource use
- A statement of
  - Stakeholder expectations
  - Remediation objectives
  - Clean-up goals
  - Compliance criteria
- Documentation of the approved decision logic
  - Decision tree or flow chart
- Identification of the performance metrics
- Acceptable schedule for site closure

At a minimum there are a few items which should be contained in the exit strategy document.

A well defined CSM – you will be surprised how many times we were told that a site has not looked at a CSM for awhile.

Plan A and Plan B as needed.

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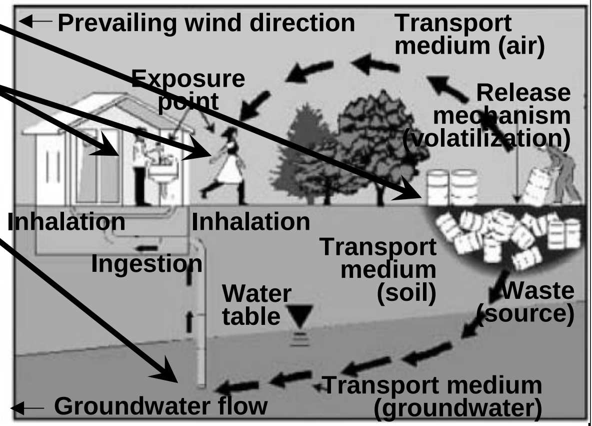
Conceptual Site Models (CSM)

- Site contaminants
- Possible receptors including future land use
- Contaminant
  - Fate
  - Transport
  - Paths to receptors
- Incorporate recently collected data
- Consistent with potential land use



Nature and sources of site contaminants

Nature and location of possible receptors including future land use

Contaminant fate, transport, and paths to receptors

The CSM must incorporate recently collected data and be consistent with potential land use

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Clean-up Goals

- Must be consistent with future land use
- Should be risk-based where applicable
- Must be applicable or relevant and appropriate
- Require periodic review
- Clearly specify how clean-up goals attainment will be demonstrated

Cleanup goals are critical in exit strategy. If we do not have these already defined – exit strategy is a good point to specify them.

RB at applicable sites – some agencies do not allow this.

How do we know when we got there. Sampling locations, verification methods and locations, etc.

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Documentation of the Approved Decision Logic

- Exit strategy decision logic elements include
  - Termination of specific remedial activities
  - Basis for change in monitoring programs
  - Contingent actions
- Exit strategy and site decision documents must be consistent
  - e.g., reopen record of decision (ROD), if necessary
- Update of the dynamic exit strategy includes review of clean-up goals relative to updates in site conditions

Exit strategy – what we do when we reach there.

What are the steps to turn the system off.

Record of decision (ROD), Explanation of Significant Differences or Permit Modifications – whatever it takes – need to be done.

Conditions changed that make it in appropriate for the original assumptions – need to go back and look at them.

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Termination of Specific Remediation Activities – When to…

- Cease operation of a component
  - Example: off-gas treatment
- Switch from one technology to another
  - Example: soil vapor extraction to bioventing
- Turn off parts of the system
  - Example: decommission an extraction or monitoring well
- Cease active remediation and decommission the system
  - Example: pump and treat

Exit strategy document is the best place to put details of specific steps we need to take to conclude the operations or specific component of the entire system or system train.

Once we complete the process, removal of the system and associated well network, etc.

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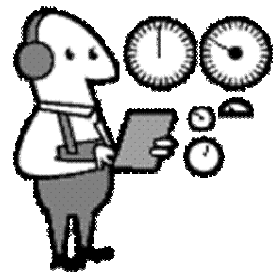
Basis for Changes in Monitoring Programs

- Long-term monitoring
- Remedial system operation monitoring
- Optimize
  - Cease or modify locations
  - Change frequency
  - Add or drop constituents from the analyte list



Monitoring has three variables that can be optimized

When to cease/modify sampling monitoring locations

When to modify monitoring frequency

When to add/drop constituents from the analyte list

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Contingent Actions If…

- Not reaching goals within predicted time
- Non-attainment of expected rate of contaminant mass removal
- Site conditions change, examples
  - Plume migration
  - Additional sources are found
  - New contaminants identified
- Generating more waste than being removed
- Risk of operating the remedial action exceed the risk posed by the site conditions

Plan B? If something does not go as expected, what do we do? Need to be documented properly.

More waste and increased risk due to operation of the system – should be addressed.

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Exit Strategy Based on Clear Problems and Objectives – Examples

- Measurable performance goals established
  - Soils – PCBs, lead, unexploded ordnance, and radiation wastes
- Revised remedial action strategy
  - Achieve cleanup in < 2 years
- Agreement (decision logic) on what is required to demonstrate attainment of cleanup goals
  - Confirmation soil sampling, final radiation status survey, final geophysical unexploded ordnance survey
- Optimize landfill and groundwater long-term monitoring
- National Priorities List (NPL) delisting in progress
  - Completion in FY06

The exit strategy was in place from the beginning for each of the contaminants. Buy-in on performance goals, how we would demonstrate attainment with them, was extremely important.

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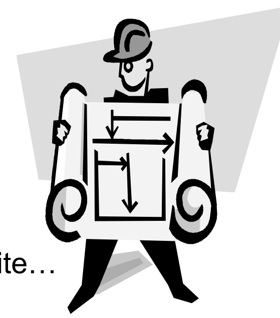
How To Develop the Exit Strategy

- Risk or ARAR from the conceptual site models (CSM) – review each contaminant of concern
  - Associated closure goal concurred by the regulatory body
    - Metrics
      - Concentration at specific locations
    - Duration of measurement
      - Maintain approximate concentration for four events, etc.
    - Method of documentation
  - Remedial action with performance metrics
    - Technology
    - Expected time to closure
    - Goal of the method
    - Measurement points
    - Criteria for change
  - Identify contingencies and uncertainties
- Repeat the process for next site…and next site…
  - Review each contaminant of concern



ARAR – Applicable or Relevant and Appropriate Requirements

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Evaluation of the Exit Strategy Should…

- Update conceptual site model (CSM)
- Re-evaluate clean-up goals based on updated CSM
- Update site decision-logic
- Update the operation of the applied technology
- Select an alternative technology, if needed

Periodically go back and look at the exit strategy and see if we need to make some changes to it – if field observations warrant.

Update as needed.

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Exit Strategy: Summary

- Quality proportional to team effectiveness
- Plan is
  - Dynamic, concise, user-friendly
  - Referenced daily
  - Helps attain prompt, cost effective site closure
- Must document decision logic
- Strategy based on
  - Conceptual site model
  - Resource use
  - Remedial action objectives
  - Cleanup goals
  - Compliance criteria
  - Performance metrics history
  - Defined clean-up schedule

The quality of the exit strategy is directly proportional to the effectiveness of the restoration team.

Should be a dynamic, concise, user-friendly plan that is referenced daily to attain prompt, cost effective site closure.

Strategy is based on the CSM, resource use, remedial action objectives, cleanup goals, compliance criteria, performance metrics history, and a defined clean-up schedule.

Must document its decision logic.

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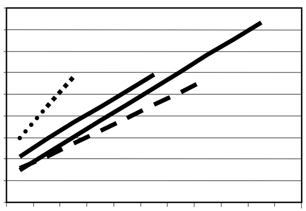
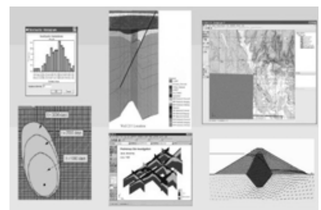
Questions and Answers





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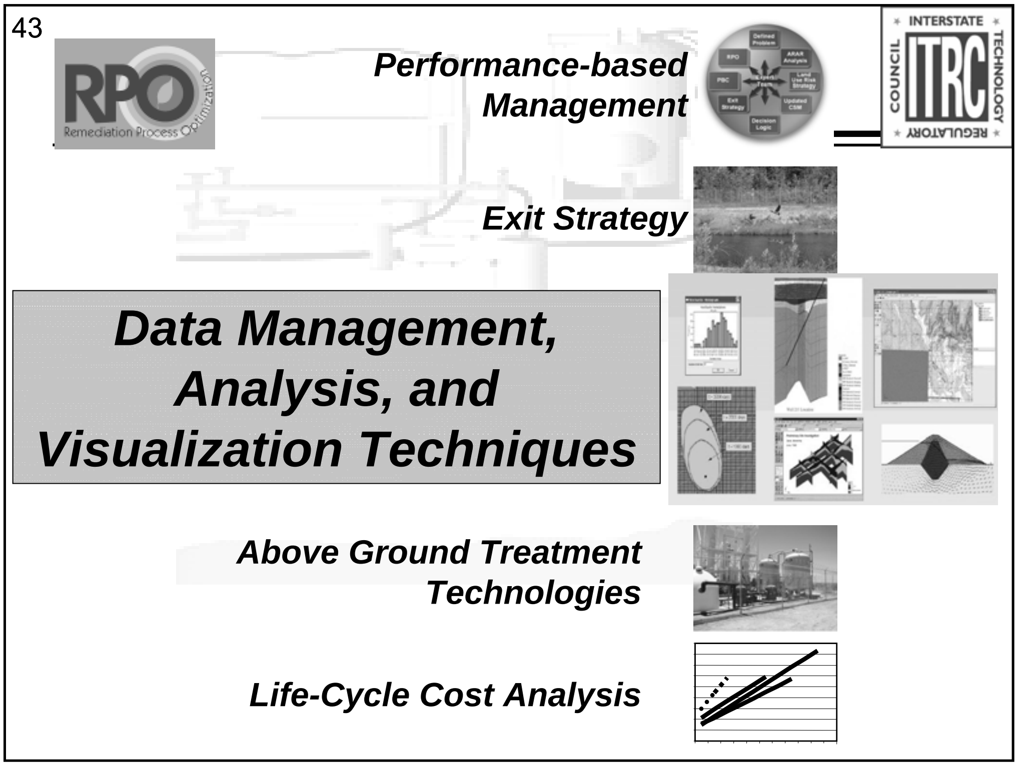

RPO team’s fact sheet on *Data Management, Analysis, and Visualization Techniques* (RPO-5, March 2006) is available at www.itrcweb.org under “Guidance Documents” and “Remediation Process Optimization.”

Richard Hammond

USEPA Electronic Knowledge Management Team Leader

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Data Management, Analysis, Visualization Techniques: Goals of the Fact Sheet

- Data versus information versus knowledge
- Concepts
  - Data management (DM, or Database Manager)
  - Data analysis (TE, or Topic Expert)
  - Data visualization (TE + DM)
- Use in RPO

Although the boundaries are not distinct, in the data management and knowledge management world,

•Data is the commodity that is collected in the field or from a laboratory instrument. It has no intrinsic value until combined with human expertise and experience.

•Information is sorted data, data that has been organized into perhaps spreadsheets. Information is at the level of database managers.

•Knowledge incorporates subjective human experience. At a minimum, knowledge includes the consensus of all stakeholder opinions.

Data management has become a rather mechanical process. Moving bits of data around a system securely is relatively straightforward. Data management is weighted toward database managers (DBAs).

Data analysis is weighted heavily toward technical experts. A common misconception is that database managers have domain or topic expertise. The actual process of calculating results from a model is not nearly as difficult as the development of the algorithms required to run that model. Algorithms fall entirely inside the technical experts arena.

Data visualization brings both technical experts and database experts together. Although visualization can require other expertise as well, the combination of technical expert and the expertise to pull the correct data from the larger dataset creates visualizations. Data and knowledge visualization must take the intended audience into account. Both the psychology and the sociology of the audience will play into how well that audience receives and understands the message being delivered. Another distinction that may be relevant is the difference between data visualization and knowledge visualization. Again, although not clearly demarcated, data visualization graphically represents “hard” data such as chemical analyses, while knowledge visualization graphically represents both hard data and “soft” data such as stakeholder opinion.

The Conceptual Site Model, at least in part, is a living knowledge visualization tool, useful for presenting the status of decisions to all stakeholders. A spreadsheet full of numbers is visualized differently by an experienced toxicologist and a parent living next to a potentially hazardous waste site.

The RPO process provides a good opportunity to review past practices. Often, data management is prioritized over ensuring that the correct data is collected to meet the objectives (closely tied to the exit strategy and proposed land use) and over visualization products. The RPO process provides the project team with the opportunity to assess questions such as:

1. Is the data being managed efficiently and effectively? Metrics associated with data management will measure items such as database quality and database efficiency (data management).

2.Is the correct data being collected? Metrics include comparison of data results to the original hypothesis. Can the original questions be answered via the current data collection activities (data analysis)?

3.Has the “story” been effectively conveyed through the data? Pictures can be very valuable, but they must convey a valid message (data and knowledge visualization).

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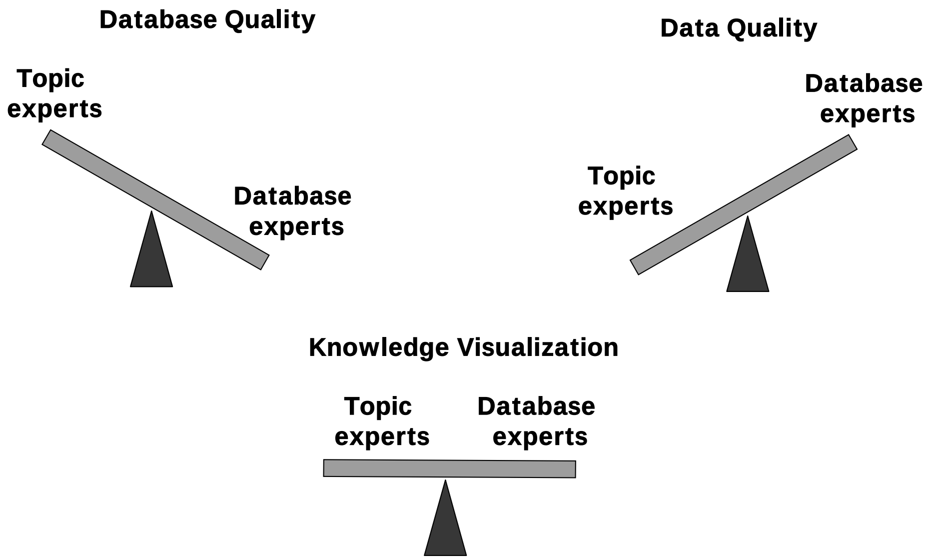
The Big Picture



No associated notes

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Why Use Data Management, Analysis, and Visualization Tools…

- Volumes of data
- Data located in various places
- Currently limited analyses or decisions made based on these data
- Recent advances in computer data storage and retrieval (XML)
- RPO is a good time for a systematic reevaluation

We have enough data! We have much less information and even less knowledge. Data comes in many forms – paper, spreadsheets, hand written, phone conversations, geospatial products, etc. Adding value to that data is still not well understood. The RPO process provides an opportunity to ask the basic question – Why am I collecting this sample? Will this sample help me prove or disprove my hypothesis?

Advances in storage and visualization tools have continued to increase over time. However, in the last five years, the Internet and particularly the WWW has increased the possibility of communication exponentially. It is now quite practical to have remotely scattered teams all working on the same site in real time. Therefore, regardless of the use of electronic data in the past, there is little question that even on very small sites, all structured data should be managed electronically, not only because the management of that dataset will be more efficient but also because the possibilities to communicate with other stakeholders about that dataset are boundless.

The advent of Extensible Markup Language (XML) has been of great benefit for data sharing problems that were mechanical in nature. However, to be used effectively as a communications tool, XML requires a great amount of input from the topic experts as well as open communications among all stakeholders. While this work can seem burdensome, it has the added benefit of building trust among team members and stakeholders.

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Data Management

- Data management is good house-keeping
- Processes and procedures to ensure data are most useful to the organization
  - Strategic data planning (DM + TE)
  - Data element standardization (DM +TE)
  - Data management (DM) data (TE)
  - Data synchronization (TE + DM)
  - Data sharing and database development (TE + DM)

Strategic data planning, data element standardization, information management control, data validation, data synchronization, data sharing, and database development.

"Data management at its simplest level is purely good housekeeping - ensuring the data you want are accessible when you want them, and provided at a cost and quality that meets your needs. … Most importantly, data management is about understanding data - turning data into useful information."

Moving data is equivalent to operating a railroad system. The railroad engineers can build tracks and engines and cars to haul products. They can develop "rules of the road", understand the costs of fuel, etc. What they cannot do is know where to build the tracks or what type of products should go on the train. A railroad engineer knows how to haul a new automobile. That same engineer cannot comment on the quality of that automobile. A database manager can move data all around a system. That same database manager cannot comment on the quality of that data. To extend, the railroad engineer can make statements about how fast the product was delivered, how efficient the shipment was (no autos fell off the train car/ no data was lost in the transmission), but can make no statements about what the data means. If a topic expert provides a set of business rules that tells the database manager to combine certain fields in certain ways, the database manager can ensure that those fields are combined in those ways. The technical expert can determine if those combinations are meaningful, for example to further the remediation of a site.

An important planning component includes data synchronization. When datasets get large (or even not so large), it becomes difficult to impossible to visually see which version of the database is being utilized. The database manager and project team members must coordinate to ensure that the most current (or most appropriate) version of the data is being used. All electronic data can be date and time stamped "automatically" (remember, nothing happens automatically. There must be a business rule established).

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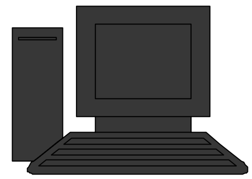
Data Management/Data Analysis



- Electronic data submission
  - Advantages and disadvantages
  - Formatting (DM + TE)
  - Internet access (DM)
  - Security (DM with input from TE on what should be secure)
- Review of software packages
  - Warehouse (DM)
  - Data storage (DM)
  - Decision-assisting tools (TE with input from DM)
- Table comparing several data management packages
  - Provide in *Data Management, Analysis, and Visualization Techniques* Fact Sheet (RPO-5, March 2006)
  - Available at www.itrcweb.org under “Guidance Documents” and “Remedial Process Optimization”

Although computers are very unforgiving, which in turn requires a great deal of upfront effort to ensure that everything is “normalized”, if this effort is undertaken seriously, per Edward Deming – adding quality into every step instead of trying to tack it on at the end of the process, the entire team and stakeholder group will have many opportunities to work through hard issues and develop trust. Because the quality of the dataset is so critical to acceptance of the proposed remedies, the upfront effort required to ensure its viability should be a foregone conclusion. While security can be a concern via electronic delivery, it is interesting to consider that security for paper documents is obtained because of their sheer volume. The cost/benefit of stealing those records would be a pretty interesting business case. If they are not worth stealing, one could ask if they are worth analyzing!!

Based on previous slides, it may be apparent that the project resources should be steered toward decision-assisting tools while data management, storage and transport can be outsourced to database managers. Within the decision-assisting toolkit, again the ease of product production can be a deficit. Producing pretty “geo-art” pictures that do not accurately reflect the situation can be more harmful than helpful. ***No computer makes a decision. People make decisions***. The fact that we can capture a groundwater modeler’s ideas from 20 years ago and continue to generate pictures from that algorithm says nothing about its actual value. To be redundant, the technical expert must have at least a strong idea of the strengths, weaknesses, and constraints that every model carries.

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Data Analysis

- Classical statistical models
  - Often analytical models
    - Solving a single, linear equation – Darcy's flow
- Probabilistic statistical models
  - Often numerical analysis
    - Monte Carlo simulation
- Understanding the strengths and weaknesses of each statistical model is important
- The main responsibility for analysis rests with the Topic Expert, not the Database Manager

In relation to understanding the decision-assisting toolkits, a primary requirement must be to define what types of statistical models will be utilized to validate/disprove the hypothesis. Classical statistical models are linear and therefore solve smooth regression problems rather nicely. Examples might include the decline of a pump performance or the decline of the budget. The underlying principle at play with classical or deterministic statistical models is population normality. Everyone is familiar with the classic "normal" curve.

However, when considering systems such as soil and groundwater, even the least technical amongst us will be able to detect that a normal distribution is not a foregone conclusion. According to deterministic statistics, one should be able to find the proverbial needle in the haystack through sufficient random sampling, owing to the "fact" that the haystack is normally distributed as is the needle. That issue is only multiplied when searching for a single microgram of contaminant amongst 1,000,000 micrograms of soil…over 100 acres of site

During the 20th century and continuing into today, probabilistic statistical models have been developed that deal more effectively with systems that are "non-linear." Environmental systems are the most difficult type to model, being *weakly heterogeneous*. It is fairly clear that patterns exist, but how to measure and map those patterns is a difficult problem.

When one considers that the mathematics of fractal geometry have only seen use since perhaps the 1960s, very little older than the USEPA, and the fact that many of the models are in (seeming) opposition to several centuries of classical statistics, it is easy to understand both the ignorance and resistance to the use of such techniques. While each type of modeling has it place, it is clear that the basic algorithm of the statistical approach that will be taken will certainly impact any further sampling scheme development.

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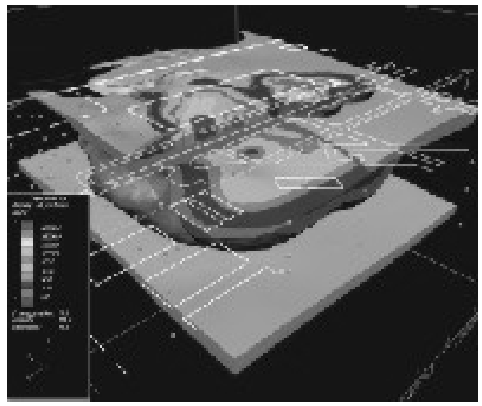
Data Visualization

- Collaborative effort of DM and TE + other stakeholders
- Visualization must convey accurate, precise and representative view of data
- Visualizations are very powerful, but can also be very deceptive
- Include not just maps, but also graphs, text and multimedia displays and even “storytelling”



Data visualization is the most powerful aspect of all electronic tools available. As an easy example, the picture above conveys a nice blue stream, flowing past the yellow foliage of fall, or the intense center of a contaminant plume surrounded by numerous and ominous groundwater monitoring wells.. Because many of us have experience with monitoring wells, we readily accept the monitoring well idea, but the reality is that “The Truth” is not in that graphic. Imagine a family with none of our experience to draw on, a family that has been told they are living next to a *potentially* hazardous waste site. Imagine that image in reds and yellows, the United States version of danger (other countries and cultures use different colors to symbolize these ideas). ***How the story is told is probably the most critical feature of any environmental restoration project.***

Considering the previous slides, hopefully it will not seem so radical to consider that data visualization is an extension of language visualization. The efforts to understand what things will be called via Extensible Markup Language (XML), how they will be analyzed and finally how they will be visualized will bring many issues to the fore. The main outcome of this process is to collectively understand what scale of measurement is possible at any particular site. All of the tools required for that effort must be aligned. As an example, if the site is heterogeneous to the point that it will not yield data to the desired level of accuracy and precision, asking it to produce that data is equivalent to using a US atlas to find Main Street in Anytown, USA. No matter how large a magnifying glass one used, Main Street is just not there.

The philosopher Pierre Bourdieu speaks of “symbolic violence” (http://en.wikipedia.org/wiki/Pierre_Bourdieu), adding quantitative value to qualitative data. In the same way, we could speak of visual violence, making things appear to be The Truth when in fact, they are either weakly or strongly suspected.

This image was obtained from *www.battelle.org/environment/images/modeling_2.jpg.*

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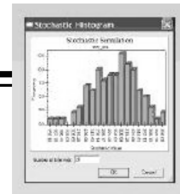
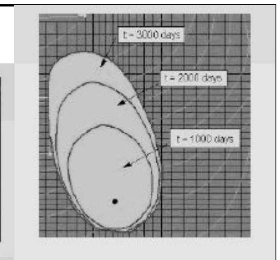
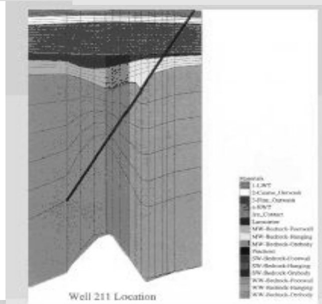
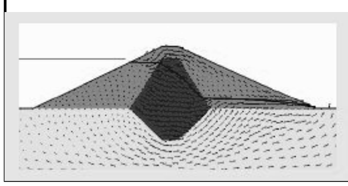
Choosing a Package

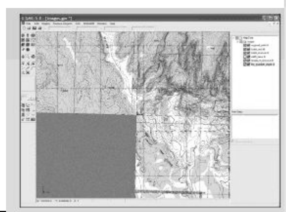
- General considerations
  - Cost, user friendliness, speed
- Operational and maintenance considerations
  - Compatibility with other software and operating systems
  - Documentation and support
  - File type and image size
- Technical considerations
  - 2-D, 3-D, or 4-D
  - GIS capabilities
  - Transmission speeds
- Analytical software lies mainly in the Technical Expert’s area











Hopefully, the previous slides have excited you about the possibilities of electronic knowledge management. There is a lot to deal with but there are also many experts now available to help with these issues. In reality, computers are not doing anything new. However, by being able to do the same old thing many times, they do provide insights to humans that would have been difficult to achieve using manual techniques.

Hardware requirements – For purposes of this overview, it can be noted that even basic desktop computers are now quite powerful. However, as a technical requirement, it is likely better to bring in the experts for this decision if you are uncertain. Hardware is a part of the data management subsystem, not the decision making subsystem.

Software requirements – It is critical that the project manager have a clear understanding of the strengths and weaknesses of various software. Each is useful and each is incomplete.

Operational considerations – Although open source standards are impacting proprietary softwares and formats, it is still critical to assess what types of files, the size of those files and the frequency of transmission that will be required of those files (how many train cars, when should they arrive and how frequently will you be scheduling such a pickup – not so hard, eh?). These decisions are much more likely in the realm of the database managers.

Technical considerations – This is one aspect of the project that requires equal input from both the technical expert and the database managers. Understanding what is desired and what is possible can help adjust project parameters. As well, understanding the statistical models will also set specifications for other technical aspects of the project.

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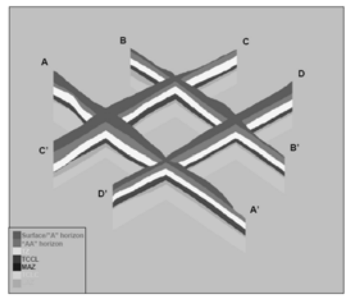
Data Management, Analysis, and Visualization Techniques: Summary

- Use of these tools aid decision-making for better cleanups
- These tools are not used enough
- Additional sources of information are needed for complex situations
- User technical considerations
- The associated ITRC document can be a first source of information on these topics

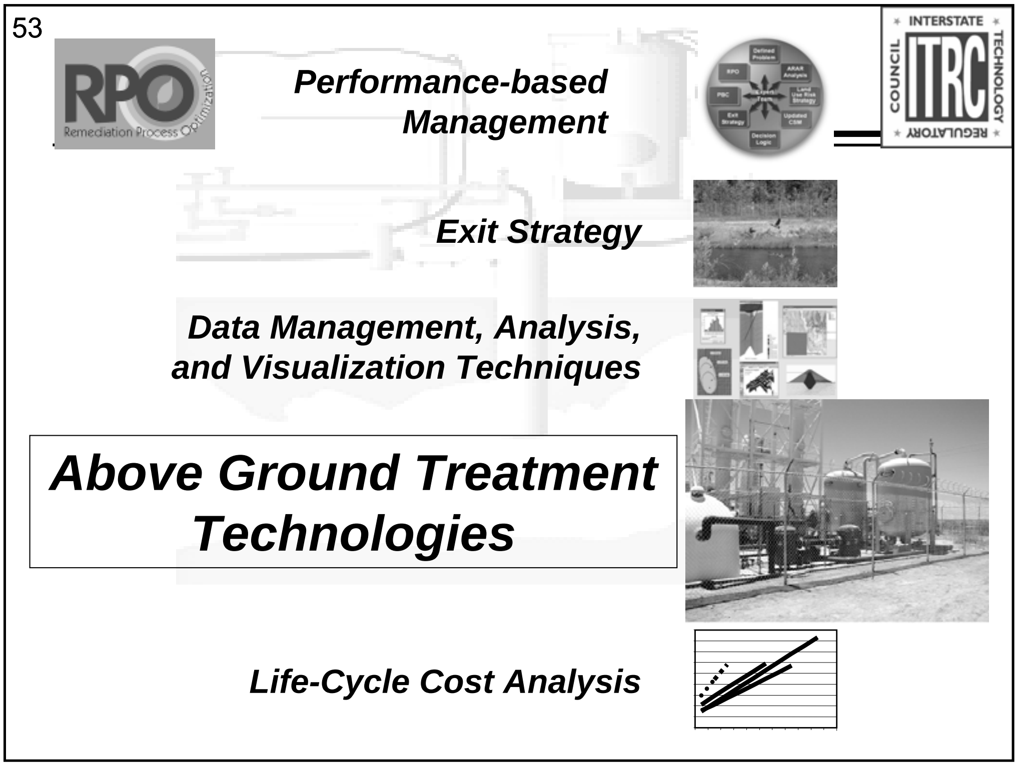


The first bullet is correct – use of these tools ***aids*** in decision-making. The final call is always a human activity.

Using these tools will help project managers understand their strengths and weaknesses. Clearly, these tools provide benefit. Measuring the amount of that benefit and understanding when the power of the tools has been misapplied comes through experience.

The user community is quite large and there's really nothing like getting a computer guru to start talking about a project…talk about producing a lot of data!

Ultimately, electronic data management and knowledge management is still just data management and knowledge management. We have the capacity to understand how to apply these tools effectively even without a strong understanding of the tools themselves. As one gains experience in each arena, the overall product can be more effectively utilized, including the electronic tools. However, tools they are and tools they will remain. Humans are required to make all the decisions. The database managers can run the train, but the technical experts have to fill it with a profitable product.



RPO team's fact sheet on *Above Ground Treatment Technologies* (RPO-4, March 2006) is available at www.itrcweb.org under "Guidance Documents" and "Remediation Process Optimization."

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Optimization of Above Ground Treatment Systems: Goals of the Fact Sheet

- Issue of interest due to large operating costs at many sites
- Provide overview of common optimization opportunities for
  - Extracted groundwater
  - Air sparging/soil vapor extraction (AS/SVE)
  - Multi-phase extraction (MPE)
- Identify information needed to evaluate performance

We will discuss the optimization opportunities associated with the three most common and expensive treatment technologies. Groundwater extraction, air sparging/soil vapor extraction (AS/SVE), and multi-phase extraction (MPE). There are some issues that are common to these technologies and some unique to each. We discuss all of these issues. We will identify the information that would be needed by those performing the optimization activities for these systems.

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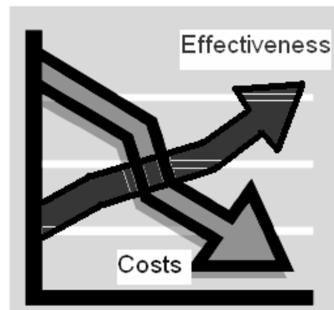
Benefits of the Optimization of Above Ground Treatment Systems

- Enhanced contaminant mass reduction
- Enhanced contaminant capture
- Increased system reliability
- Reduction in operational costs



These systems represent long-term remediation projects that can benefit from optimization in two primary ways – improvement in performance and reduction in costs. Performance is judged by how well the system contains the extent of contamination or removes contaminant mass, or both. Part of this is the amount of time the system is up and running. Optimization may increase the reliability of the system. Cost reductions can be related to utility costs, labor costs, or consumables, among other that we will discuss further.

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Above Ground Treatment System Components

- Liquid and vapor streams
- Integral to many extraction systems
- Often costly to operate and maintain
  - Labor
  - Utilities
  - Consumables
  - Waste disposal
  - Repair
  - System and discharge monitoring and analysis

Above ground treatment is integral to many groundwater and soil vapor extraction systems. Though the fact sheet addresses issues related to the subsurface performance of these systems, most of the costs are incurred in operating the above ground portion of the systems. These above ground treatment systems address treatment of both liquid and vapor streams often through the use of multiple treatment steps in a complex treatment train.

These systems are often costly to operate and maintain. The costs can be categorized for optimization purposes into the following:

Labor

Utilities (electricity, gas, water, phone)

Consumables (e.g., carbon, reagents)

Waste disposal (e.g., sludge, recovered product)

Repair (parts, replacement equipment)

System and discharge monitoring and analysis

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Optimization Begins with Review of Operational Data

- Discharge (permit) limits
- Chemical concentrations
  - Actual versus design
- Water and air flow rates
  - Actual versus design
- Pressures in system
  - Across vessels or equipment
- Residual (e.g., sludge) production rates
- Significant recurring maintenance problems
- Incurred costs
- Subsurface performance information

Any optimization study or RPO should gather a set of data on the system performance and costs. If the operating contractor regularly compiles these data into the period reports, the optimization process is much easier. These data include the requirements the treatment system must achieve under permit or other set goals. These may be reported in an National Pollutant Discharge Elimination System (NPDES) permit or air discharge permit. A copy of the permit(s) would be useful.

Chemical concentrations measured in the influent and effluent are fundamental to evaluating performance, but practically, concentrations are needed at intermediate points between major treatment steps. These data assist in assessing the performance of these components and identifying needed changes. The chemical concentrations measured may include non-contaminant related, such as pH, iron, calcium, etc., as these may affect the performance or maintenance costs.

The data compiled should include the measured liquid and vapor flow rates at various points in the system. Pressure (or vacuum) drops across treatment components should also be measured and reported. These observed flow rates, pressure drops, and chemical concentrations must be compared to the design values. Significant departures from the design parameters are red flags for needed changes in the optimization.

The amount of residual materials generated by the treatment system should be considered. These residuals can include spent resins, carbon, NAPL, and generated sludge. The costs for the disposal or change out of these materials can be significant. The quantities of these residuals are important data points for assessing need for change or for alternative disposal options.

The operators should indicate, either in the reports or via interviews, what represent recurring maintenance problems. These should be considered as key points addressed in the RPO. Solutions to these problems can improve performance and reliability and reduce costs.

The costs, broken out be the categories identified in the previous slide, should be reported. These data may be in the reports, billings, or the negotiated contract.

Water levels, observed vacuums, monitoring well concentrations, and extraction well flow rates represent key data needed for evaluation of subsurface performance. These data should be provided in the recent periodic reports.

General Items to Consider in Optimizing Above Ground Treatment Systems

- Inefficient or unnecessary treatment processes
- Reduction in labor while maintaining performance
- Reductions in energy use
- Modifications to process monitoring program
- Reductions in consumables
- Alternative disposal means
  - For treated water, sludges
- Must coordinate changes in subsurface components and above ground components

There are a number of areas the RPO team should focus on when evaluating these kinds of systems. This slide lists those major areas. We will talk about each.

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Evaluate Treatment Processes and Process Monitoring

- Treatment processes
  - Compare actual to design performance
  - Identify modifications or alternatives to current processes
  - Eliminate unneeded equipment or processes
- Process monitoring
  - Focus analysis on information needed for
    - Discharge
    - Assessing treatment component performance
  - Verify need for
    - Each sample location
    - Current sampling frequency
    - Current analytical suite
  - Add or subtract as appropriate
    - Samples
    - Locations
    - Analyses

First and foremost, the RPO team should evaluate each treatment component. Again, major differences between actual measurements and the design values are good tip-offs to the need for change. In some cases, design values are no longer valid given the progression of remediation (concentration and extent of the plume decrease, hopefully, over time). The RPO team should assess if each treatment step is still needed, if there are less expensive and/or more reliable alternatives, or if there are appropriate changes in the operating parameters for the existing component. For example, vapor treatment may no longer be needed if concentrations in the influent have decreased significantly, or the amount of polymer addition may be reduced if the flow rate and concentrations have declined.

The amount of sampling done within the treatment plant may be ripe for optimization. The key is that the data collection must be consistent with the decisions to be made. No more and no less data should be collected. The application of the data-quality objectives or technical project planning process is valuable for this step. In many cases, more samples are obtained than are needed for site decisions. In fact, some sites may have on-site labs that are no longer cost-effective. In other cases, the amount of data collected are insufficient to assess performance. Sample locations can be added or removed, and samples can be taken more or less frequently. The analytical suite can be increased or decreased. The concepts previously discussed on data management can be very useful here, too.

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Review Energy and Labor

- Energy consumption
  - Evaluate need for all pumps
  - Consider variable-frequency drive motors
  - Identify large pressure drops in system
  - Verify need for any thermal treatment process
- Labor reductions
  - Identify where operators are spending time
  - Engineer improvements to reduce time spent
  - Include: preventive maintenance, automation, elimination of unneeded processes, replacement of processes with others that require less time
  - Consider capital costs for changes relative to labor savings

With the current interest in being more energy efficient, it is appropriate to reconsider the energy use at these treatment plants. Electrical use is typically driven by the number and size of pumps and blowers. A holistic evaluation of the need for pumps in the system can be useful. The need for each pump should be verified and efficient options such as replacement of standard motors with variable-frequency drive motors or ones that are better fit to the application should be considered. Constrictions in the system that increase pressure drop could be addressed to reduce pump back-pressure. In some extreme cases, the system could be run in batch mode to allow the system flow rates to be more consistent with the efficient operating range for the motors.

The other major energy use is for thermal treatment of waste streams, such as thermal oxidizers. The need for such expensive treatment should be verified, especially if the media concentrations have decreased since start up. Other treatment options such as carbon adsorption may now be more cost-effective and just as protective. Lastly, the lighting arrangement may be altered to reduce electrical use or added insulation may reduce heating costs.

The largest costs may be incurred for labor to operate the system. The best approach for the RPO team is to interview the operators and find out where they spend their time in operating and maintaining the system. The optimization should be focused on finding ways to reduce the effort in those areas where the operators spend most of their time. The slide lists some alternatives for reducing labor. Any change in the system that would have a capital cost should be subject to a life-cycle cost analysis, as Bud Johnson will discuss in more detail later. Only those changes where the savings in O&M costs will shortly outweigh the capital investment should be undertaken.

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Consumables and Disposal Practices

- Consumables
  - Carbon or resin use – basis for changeout
  - Adjust reagent dosages in light of actual concentrations
  - Method of procurement (savings in bulk, adequate storage)
- Disposal practices
  - Sludge management, delisting
  - Treated water disposal alternatives
  - Reductions in waste volume

Materials used in the treatment process can represent a significant cost for some systems. These include carbon (liquid- or vapor-phase), ion-exchange resins, polymer, bag filters/filter cartridges, acids, caustics, oxidants, biocides, nutrients, and carbon sources. The RPO team should look at the current usage for opportunities to improve the process. The basis for carbon and resin changes should be evaluated to assure the most cost-efficient use of the materials is made. In some cases, the carbon may not be changed frequently enough, risking undesirable releases. If bag filters are used and represent a large expense for materials and labor, alternatives such as automatic continuous backwashing sand filters may be an alternative.

The dosages of any reagent should be evaluated for consistency with current contaminant concentrations, influent pH, etc. and adjustments may be recommended. In some cases, the reagent addition can be stopped altogether. Again, differences between the actual and design concentrations should be a red flag. The RPO team should evaluate the means of purchasing the materials, considering the potential for purchasing in bulk if storage space is available.

The disposal methods for waste streams from the process should be evaluated. This includes the disposal of sludge that may be produced. The materials should not go to a Subtitle C landfill unless necessary. In some cases, low-toxicity sludges that are considered listed hazardous waste could be delisted resulting in significant savings in disposal costs. The delisting process may be lengthy and the costs for the process must be considered.

The means for disposing of treated water should be evaluated. In some cases, disposal via a publicly owned treatment works (POTW) may reduce costs by allowing less on-site treatment. In other cases, high costs per 1000 gallons for discharge to a POTW may be avoided by surface water discharge or local reuse.

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Common Optimization Issues for Soil Vapor Extraction (SVE)

- Subsurface performance
  - Soil moisture
  - Air flow paths
  - NAPL
- Mass removal rates
  - May be very high initially
  - Decline over time
  - Affect treatment, subsurface operation
- Addition of wells, increase in vacuum or flow
- Condensate production and management
- Need for off-gas treatment

Picture from USEPA Region 9: Charnock MTBE Cleanup Project - Soil Vapor Extraction

Now lets discuss some of the opportunities specific to the individual technologies. For soil vapor extraction systems, the optimization issues often are related to the subsurface performance. In particular, the RPO should assure the current operations and well locations and screen depths are adequate to produce the needed air flow within the target treatment zone. One difficulty is to get air flowing through areas of high moisture content or in the capillary fringe. The high moisture content may shield NAPL from adequate contact with the air flow. Some means to reduce moisture may be necessary, including dewatering, multi-phase extraction, surface covering, or even thermal enhancements. In some cases, additional wells or higher system air flow rates and vacuums may be needed. The goal is to enhance the mass removal rates. Mass removal rates will diminish over time and may approach an asymptote. Pulsing the system, use of lower air flow rates to account for diffusion limitations, or even air injection may be useful to increase net removal rates.

In the cooler times of the year, the handling of condensate may become an issue. At a number of sites I have worked on, this has been a problem, particularly if the condensate occludes SVE piping or carries through to the vapor treatment system. The RPO team may recommend the use of automated transfer pumps, larger condensate separators and storage tanks, or alternative levels switches in such tanks.

Lastly, SVE systems outfitted with thermal treatment often become less cost effective as concentrations drop. Alternatives may include carbon adsorption, or eventually even direct discharge to the atmosphere may be acceptable. In other cases, extracted concentrations may be too high and dilution air may be needed to avoid problems with the treatment system and safety issues.

Picture from http://www.epa.gov/region09/cross_pr/mtbe/charnock/sourceclean.html. “Soil Vapor Extraction System installation on a site at the intersection of Sepulveda and Palms.”

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Common Optimization Issues for Groundwater Treatment

- Evaluate continued need for any metals treatment
  - Metals concentrations were often overestimated
- Redundant treatment components
  - Example: air stripping with carbon
- Lower-than-expected flow rates or concentrations
- Need for off-gas treatment
- Inadequate maintenance, spare parts inventory
- Biofouling
- Adequacy of capture/subsurface performance

Groundwater extraction has a number of common issues. Several of these have been used as examples in the discussion of the previous slides. One particularly fruitful situation for optimization would be treatment systems with a metals precipitation components. There are many systems that are running such components that have never seen the expected levels of metals, often due to overly conservative designs based on monitoring well samples. Systems with metals precipitation units should be carefully assessed as to the need and operating parameters. In some cases, the units can be removed entirely. I know of a number of unused filter presses that have resulted from overly conservative designs.

There are other components that may not be needed as they are redundant. This may include carbon polishing following air stripping, multiple serial air strippers, etc.

Again, the flows and concentrations may be lower than those assumed in design. Batch operations, partial recirculation, and equipment resizing may be necessary and the RPO team should identify such situations. The impacts to the various processes have to be considered. The need for the treatment of off gas from an air stripper should be evaluated, particularly if the concentrations and mass removal rates have dropped significantly. The off gas may be suitable for direct discharge to the atmosphere in accordance with regulation.

Any maintenance issues should be addressed and specific recommendations made by the RPO team. In some cases, excessive downtime may be reduced by having adequate spare parts inventory at the site.

The subsurface performance of the extraction system is unfortunately often degraded by the growth of biomass on the well screens, in the formation, and even in the piping. Less often, chemical precipitates may occlude the well screens and piping. There are a number of chemical treatments, including organic acids and dispersants, oxidizers, and even heat that may be used to treat the wells along with mechanical surging. The piping may need to be mechanically cleaned or “pigged.” This is a very common problem at hazardous waste sites.

Lastly, the performance of the extraction system should be evaluated to assess the adequacy of capture/containment of the plume and the rate of cleanup, if that is an objective. Additional wells or increased extraction rates may be recommended. This is a difficult aspect to assess in an RPO. Modeling, calculations, contouring, all may be necessary to assess capture.

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Common Optimization Issues for Multi-phase Extraction

- Includes two-phase, dual-phase extraction, "bioslurping"
- Inadequate vacuum in drop tube
  - Addressed by proper equipment sizing and air vents in drop tubes
- Inadequate vacuum response in the formation
  - Addressed by proper equipment sizing, drop tube setting
- High downtime for system
  - Proper maintenance and management of condensate and liquids to protect blower

The last technology to discuss is multiphase extraction. This includes the technologies that are called bioslurping and two-phase extraction (these involve the simultaneous removal of vapors and liquids via a single extraction pipe and blower. It also includes dual phase extraction that involves separate movers for the vapors (e.g. a blower) and liquids (e.g. a submersible pump).

One common problem is inadequate vacuum to entrain or lift liquids. This can be solved by changing equipment or operating conditions. In some cases, added vents in the drop tubes may increase air velocities to the level needed to maintain entrainment of liquids. If there is inadequate vacuum response in the formation to enhance lateral movement of water and/or NAPL to the well or to offset the physical drawdown of the water table, different larger equipment or, in the case of slurping, different (higher) drop tube settings may help. Condensate/liquids management may be labor intensive and difficult. Alternative equipment may reduce the labor burden and better protect the blower in slurping. Proper maintenance of the above ground equipment such as the blower, separators, and piping may not be occurring and the RPO team should recommend improvements if downtime is a problem.

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Common Optimization Issues for Multi-phase Extraction (continued)

- Liquid emulsion (water/NAPL) separation
  - Increase detention time
  - Chemical treatment
  - Dissolved air flotation (DAF)
  - Organoclay
- Biofouling of equipment
- Vapor-phase treatment appropriate for influent concentrations

Continuing with multi-phase extraction, one very common problem with slurping systems where NAPL is present is the development of emulsions of NAPL and water. These are often difficult to deal with. Additional detention time in larger influent tanks, use of chemical emulsion breakers, dissolved air flotation, or inexpensive organoclay sorption units can reduce the impact of these problems.

Biofouling can also affect multi-phase extraction systems. The actions previously discussed can apply here as well.

Since the vapor concentrations for multi-phase extraction systems can be high and highly variable depending on the water table and drop tube or pump settings, the vapor treatment can be difficult. The treatment option should be appropriate for the concentrations observed and expected in the near future. Thermal oxidation may no longer be needed if concentrations have dropped or a rental thermal oxidizer may be needed for a period of time if concentrations are higher than economic for carbon.

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Above Ground Treatment Technologies: Summary

- Applies to any above ground treatment system
- Common specific optimization issues for
  - Soil vapor extraction/air sparging
  - Groundwater treatment
  - Multi-phase extraction
- Benefits of optimizing treatment systems
  - Enhanced performance
  - Cost savings
  - Expedited site cleanup

The new fact sheet on above ground optimization discusses these issues in more detail. The ITRC RPO fact sheets are available at www.itrcweb.org under "Guidance Documents" and "Remedial Process Optimization."

General concepts just presented are appropriate for almost any above ground treatment system to some degree.

We have discussed the common specific optimization issues for groundwater treatment, soil vapor extraction/air sparging, and multi-phase extraction

The ultimate payoff for the optimization would be:

Enhanced performance

Cost savings

Expedited site cleanup

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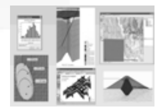
Performance-based Management

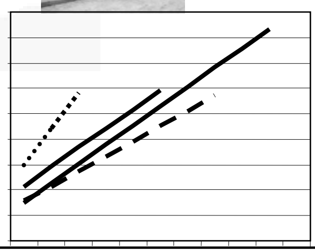
Exit Strategy

Data Management, Analysis, and Visualization Techniques



Above Ground Treatment Technologies

Life-Cycle Cost Analysis



RPO team's fact sheet on *Life-Cycle Cost Analysis* (RPO-2, March 2006) is available at www.itrcweb.org under "Guidance Documents" and "Remediation Process Optimization."

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Life-Cycle Cost Analysis

The term “life-cycle cost” refers to the total project cost across the lifespan of a project, including design, construction, operation and maintenance (O&M), and closeout activities. The cost estimate developed during the RPO is a projection of the life-cycle cost for modifications to an existing remedial action from design through response complete.

Definition

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Life-Cycle Cost Can Be Used for

- Cost comparison of alternatives
- Cost effectiveness evaluation
- Cost/benefit analysis
- Regulatory Compliance - Sarbanes-Oxley Act (SOX)

to

to

Cost Comparison of Alternatives

Present-value of the life-cycle cost allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This single number, referred to as the net present value, is the amount of funding that must be set aside at the beginning of a remedial action to ensure that funds will be available for the entire duration of a remedial action, based on certain economic conditions.

Cost Effectiveness Evaluation

Life-cycle cost and performance data could be used to compare cost on a per pound of contaminants removed or destroyed basis through time for different alternatives. In addition, for cost-reduction recommendations, a payback time, derived from life-cycle cost, of less than five years is preferred. Modifications that require a longer payback time are often disregarded because site conditions may change or innovative technologies may become more appropriate over a five-year time period.

Cost/Benefit Analysis

RPO usually assess the costs—in terms of time, resource consumption, public perception, and dollars—associated with implementing each alternative against the benefits (e.g., enhanced protectiveness, reduced time or cost to achieve remedial action objectives) that would be realized. For example, the O&M costs of the existing remedy can be directly compared to the estimated capital and O&M costs associated with a modified strategy or technology. In such an example case, a cost/benefit analysis can be performed using life-cycle costs and the estimated period of remedial action operation required to achieve remedial action objectives.

Regulatory Compliance Sarbanes-Oxley Act (SOX)

Public companies need to perform life-cycle analysis for long term remediation projects as part of compliance with the Sarbanes-Oxley law. Future liabilities must be accounted for in each company’s balance sheet.

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Life-Cycle Cost for Existing Systems

Sources of cost and performance information

- Actual O&M costs
  - Labor
  - Materials
  - Utilities
  - Monitoring
  - Equipment
  - Off-site disposal fees
  - Administrative costs
- Degree of hydraulic containment and capture attained
- Mass and rate of contaminant removed
- Average monthly run time and downtime

Following a RPO evaluation all costs associated with the current remedial action and proposed remedial actions should be accounted for and compared.

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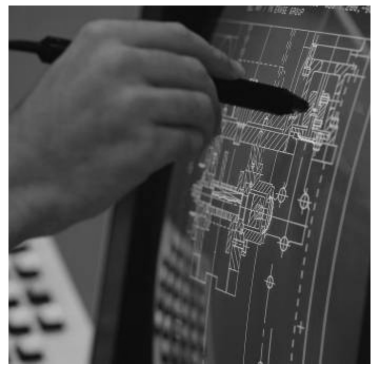
Life-Cycle Cost for Potential Alternatives

- Cost and performance factors to consider in addition to the costs evaluated for the existing system
  - Capital costs for system modifications and upgrades
  - Projected up-time/down-time
  - Engineering and administrative costs



No associated notes.

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Life-Cycle Cost Estimating Should Address the Following Elements

- Both remedial action and O&M activities
- Cost uncertainty
- Either
  - Discount rates for present value
  - Scale-up factors for future inflation costs
- Time
- Periodic capital or O&M costs
- Decommissioning costs
- Methods used for preparing the cost estimate
- Treatability study costs

Key cost components for both remedial action and O&M activities
Major sources of uncertainty in the cost estimate
Either discount rates for present value or scale-up factors for future inflation costs
Time expected to achieve remedial action objectives
Periodic capital or O&M costs anticipated in future years of the project
Decommissioning costs at the project closure
Methods and resources used for preparing the cost estimate
Treatability study costs, when applicable

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Net Present Value (NPV)

- Calculation of NPV is a two step process
  1. Estimating the total costs of remediation considering inflation
  2. Actual calculation of NPV
- Step 1: Estimating the total costs of remediation considering inflation
  - Total costs = Annual cost in year 1
    + Annual cost in year 2 $\times$ (1+i)
    +…
    + Annual cost in year n $\times$ $(1+i)^{n-1}$
  - Where:
    - Annual cost in current dollars, including capital, O&M, replacement, etc.
    - i = annual inflation rate
    - n = total number of years of remediation

The Environmental Protection Agency does not use inflation when calculating a life-cycle cost and performing the comparative analysis of different systems. If the purpose of the life-cycle analysis is to put fund in an escrow account to pay future expenses – capital & operating – then inflation should be included. As an example a remediation system in operation for twenty-five (25) years with an annual operating cost of $100k, a discount rate of 7%, and an inflation rate of 4% has a life-cycle cost of $1,696,073. The same system without inflation has a life-cycle cost of $1,165,358 which is $570,715 less than when an inflation rate is included.

If the purpose of the analysis is to compare different systems then inflation doesn't have to be used unless there are significant capital costs in the future for one of the alternative systems. If there will be future capital costs, and/or an escrow fund or future liabilities need to be quantified then inflation will provide a more accurate number. Remember the accuracy of the number is only as accurate as the projected future costs and the confidence in those projected costs.

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Net Present Value (NPV) – Step 2

- Step 2: Actual calculation of NPV

$$NPV = \sum_{1}^{n} \frac{\text{Annual Cost in Year t with inflation}}{(1+r)^{t-1}}$$

- Where:
  - r = annual discount rate
  - i = annual inflation rate
  - n = total number of years of remediation
  - t = year

No associated notes.

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Life-Cycle Cost Analysis: Underground Storage Tank Case

- Contamination
  - 890 tons of petroleum products contaminated soils
  - Floating NAPL product in groundwater
- 1992-1994
  - Work by New Jersey Department of Environment Protection contractors
  - Conducted remedial remedy selection report and design
  - Installed groundwater collection and treatment system
- Costs
  - $314,000 one-time capital costs
  - $36,000 annual O&M costs

Historic and ongoing remediation steps taken to date:

The work done by the bankruptcy court and the property owner left approximately 890 tons of petroleum products contaminated soils. Groundwater contains floating NAPL product

NJDEP contractors removed these in 1992. A remedial remedy selection report and design were conducted during the first half of 1993.

Installation of a groundwater collection and treatment system began late in 1993 and was completed in early 1994

Total capital costs and one-time costs of $314,000, Annual O&M costs of $36,000

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Life-Cycle Cost Analysis : Underground Storage Tank Case (continued)

Table: Pump and Treat Values

Year	Inflation Value	Present Value	Year 1 Investment
1	$36,000	($36,000)	$36,000
2	$37,440	($35,155)	$71,155
3	$38,938	($34,330)	$105,485
4	$40,495	($33,524)	$139,008
5	$42,115	($32,737)	$171,745
6	$43,800	($31,968)	$203,714
7	$45,551	($31,218)	$234,932
8	$47,374	($30,485)	$265,417
9	$49,268	($29,770)	$295,186
10	$51,239	($29,071)	$324,257
11	$17,763	($9,463)	$333,720
12	$18,473	($9,241)	$342,961
13	$8,005	($3,760)	$346,721
14	$8,325	($3,672)	$350,392
15	$25,975	($10,756)	**$361,148**

Table: In-Situ Electrical Resistance Heating Values

Yr	Inflation Value	Present Value	Year 1 Investment
1	$1,016,000	($1,016,000)	$1,016,000
2	$12,480	($11,718)	$1,027,718
3	$12,979	($11,443)	$1,039,162
4	$5,624	($4,656)	$1,043,818
5	$5,849	($4,547)	$1,048,364
6	$18,250	($13,320)	**$1,061,685**

Please note the sunk costs of ($314k) spent before the RPO are not included in the analysis. If a life-cycle analysis had been performed before the initial actions were taken then the comparative costs of the two systems would have been different. Please remember in-situ electrical resistance heating was not a proven technology in 1992. If the technology was proven then the life-cycle cost analysis for the pump and treat system would have included the original $314k in sunk costs and $652 in operating and closure costs for a life-cycle cost of $966k. The comparison numbers would have been $1,062k versus $966, or a difference of $96K. The pump and treat system would take over 27 years to achieve the end result compared to 6 years for the In-Situ Electrical Resistance Heating system.

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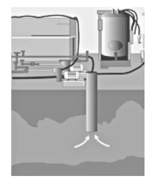
Overall Summary and Conclusions

- Performance-based Management
- Exit Strategy: Seeing the forest beyond the trees
- Data Management, Analysis, and Visualization Techniques
- Above Ground Treatment Technologies
- Life-Cycle Cost Analysis



1. All the information you heard and saw today is available in the Fact Sheets, available from download from the links found at the end of this presentation or at www.itrcweb.org. As noted, the basis for the fact sheet training was the Technical Regulatory Guideline: Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation, http://www.itrcweb.org/Documents/RPO-1.pdf. Many of the concepts discussed today can be found in the RPO document.

2. All of the concepts presented today are "tools in the toolbox," available for all practitioners of site remediation. They are intended as an aide to your work and are to be used and modified, as needed, to suit the needs of your particular projects. While we encourage their use we realize that not all tools or applications are appropriate for all situations.

3. Performance-based management is an upcoming issue. Federal agencies are mandated to implement performance-based management as part of their business practices. State regulators can expect to see some variant of performance-based management and or performance-based contracting proposed for all federal lead cleanup projects.

4. Look for the upcoming technical regulatory guidance document on performance-based management to be published by ITRC. Associated Internet-based training will also be provided.

5. If you have any questions please do not hesitate to contact the instructors or any member of the ITRC RPO Team. Look for our contact information on the “Meet the ITRC Instructors” provided near the beginning of this presentation and www.itrcweb.org.

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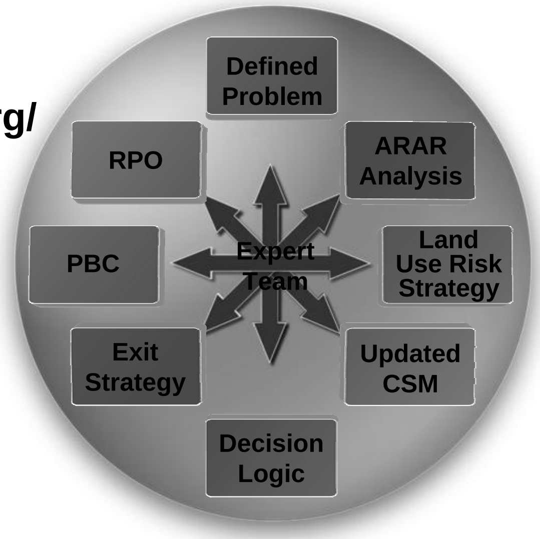
Thank You for Participating

- **Links to additional resources**
  http://www.clu-in.org/conf/itrc/rpofs/resource.cfm
- **2nd question and answer session**



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

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

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