Oak Ridge SSAB Meeting

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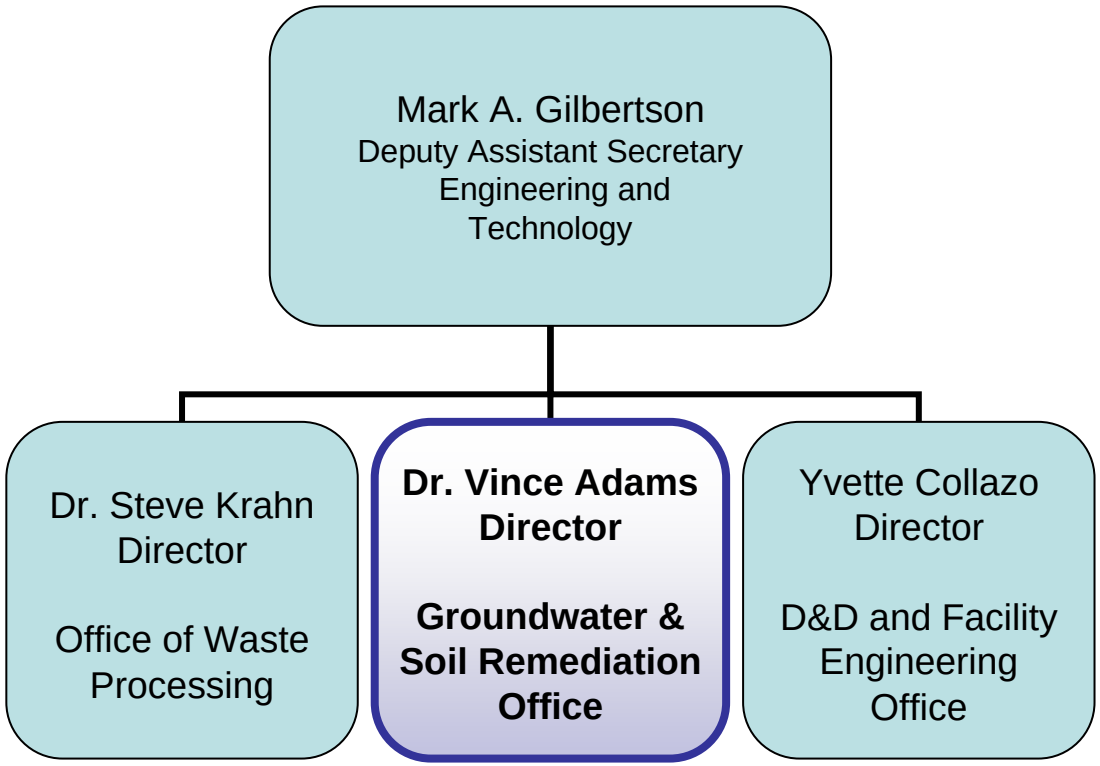
Office of Groundwater and Soil Remediation
(EM-22)

November 12, 2008

Environmental Management
Office of Engineering and Technology



Functions

- Develop policy and guidance
- Assess projects and programs through technical reviews and oversight
- Provide technical assistance and support to the field and other Headquarters offices
- Manage the EM Technology, Development and Deployment Program

Solving Groundwater & Soil Problems

- **Vision**
  - Build **Stronger Collaboration** with Science Community
  - Become a Program Based upon **Stronger Science**
  - Become Recognized as **"Best-in-Class"** and **"Technical Authority"**

- **Mission**
  - Provide **Technical Oversight** for Engineering & Technology **"Best Practices"** Implementation at Sites
  - Apply State-of-the-Art, Safe, Cost-Effective, and Environmentally Sound Technical Solutions
    - **Reduce Project Risks and Uncertainties**
    - Acceptable to Indian Tribes, Regulators, and Stakeholders
    - Implemented by Technical End-Users - FPDs

The Challenge

- Scale of Problem Unprecedented
- 60 Sites in 22 States
- 200 Contaminated Plumes
- Contaminated Soils
- 300 Remedies in Place
- Current Tool Partially Effective
- Technical Impracticability (TI) Waivers
- Monitored Natural Attenuation (MNA)
- Road Map and MYPP
- Develop State-of-the-Art Tools
  - Sampling/Characterization
  - New Remedial Approaches
  - Advance Predictive Models
  - Long-Term Monitoring

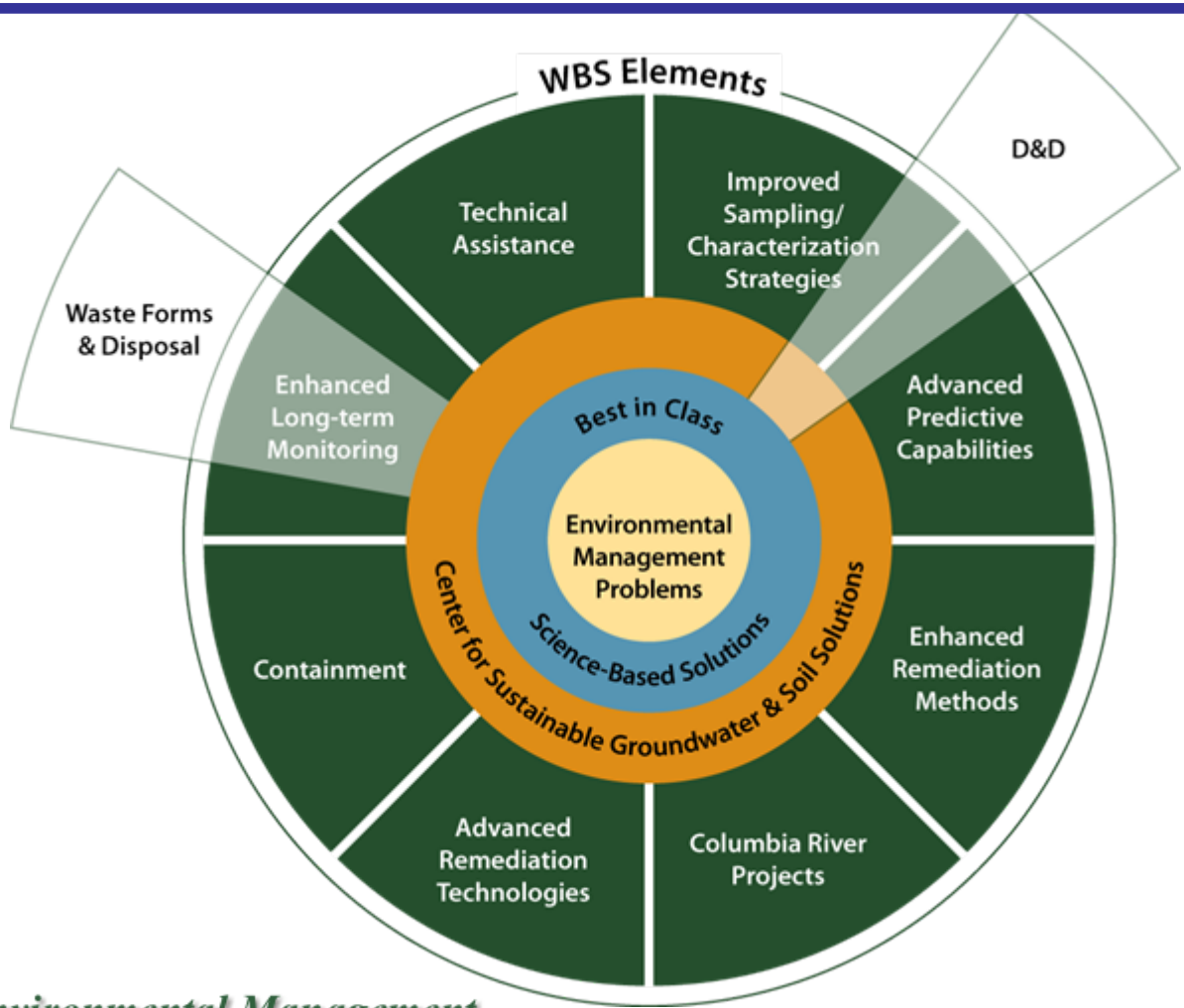
Roadmap - Groundwater and Soil Remediation

Needs Common Technical Challenges

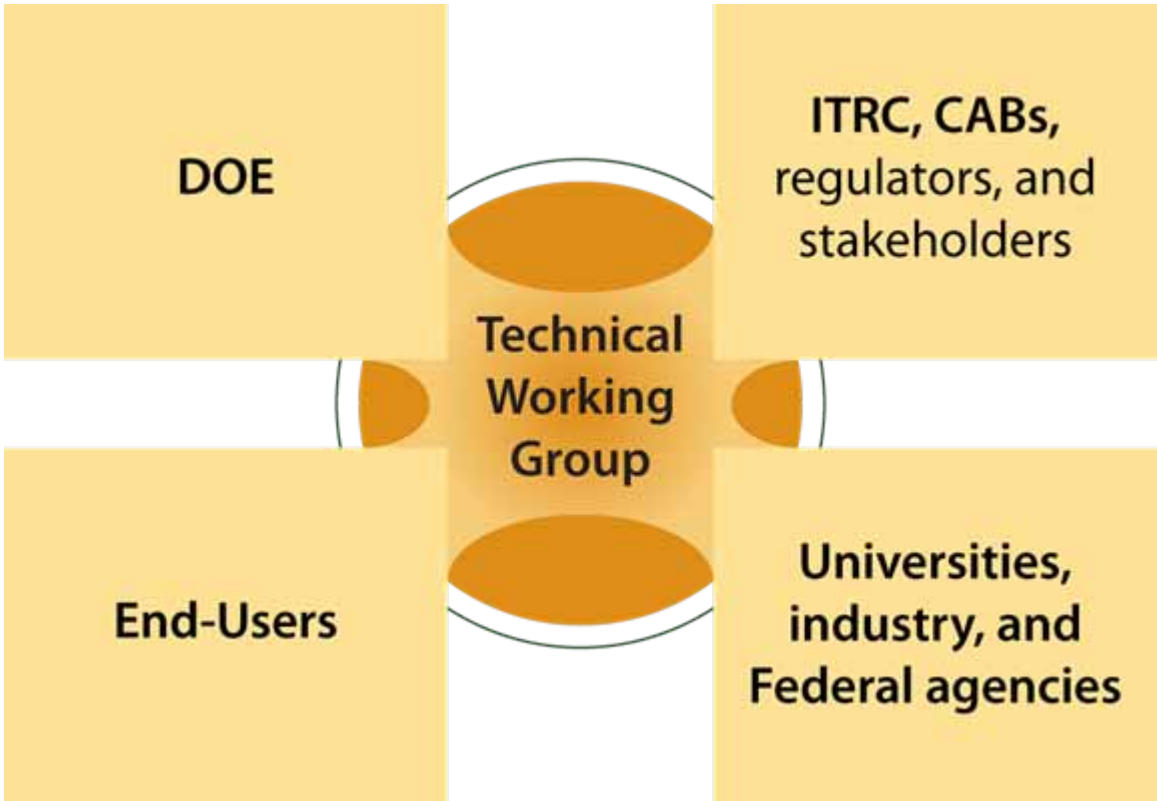
Need Categories	Common Needs Across Complex	Strategic Initiatives
Sampling & Characterization Technology	➢Low-cost field characterization & monitoring techniques acceptable to regulators ➢Characterization in and around piping/storm drains	**Improve Sampling & Characterization Strategies**
Modeling	➢Improved conceptual models and incorporation of science into modeling ➢Fate & transport models that account for unique subsurface characteristics and reactive processes	**Advanced Predictive Capabilities**
In Situ Technology	➢Costs-effective techniques during remedial action and post-closure ➢Monitored natural attenuation (MNA)	**Enhanced Remediation Methods**
Long-Term Monitoring	➢Low-cost monitoring tools to reduce lifecycle costs ➢Long-term monitoring for MNA and barrier performance	**Enhanced Long-Term Monitoring Strategies**

Technical Strategy

Groundwater and Soil Remediation Program



Integration Strategy
Groundwater and Soil Remediation Program

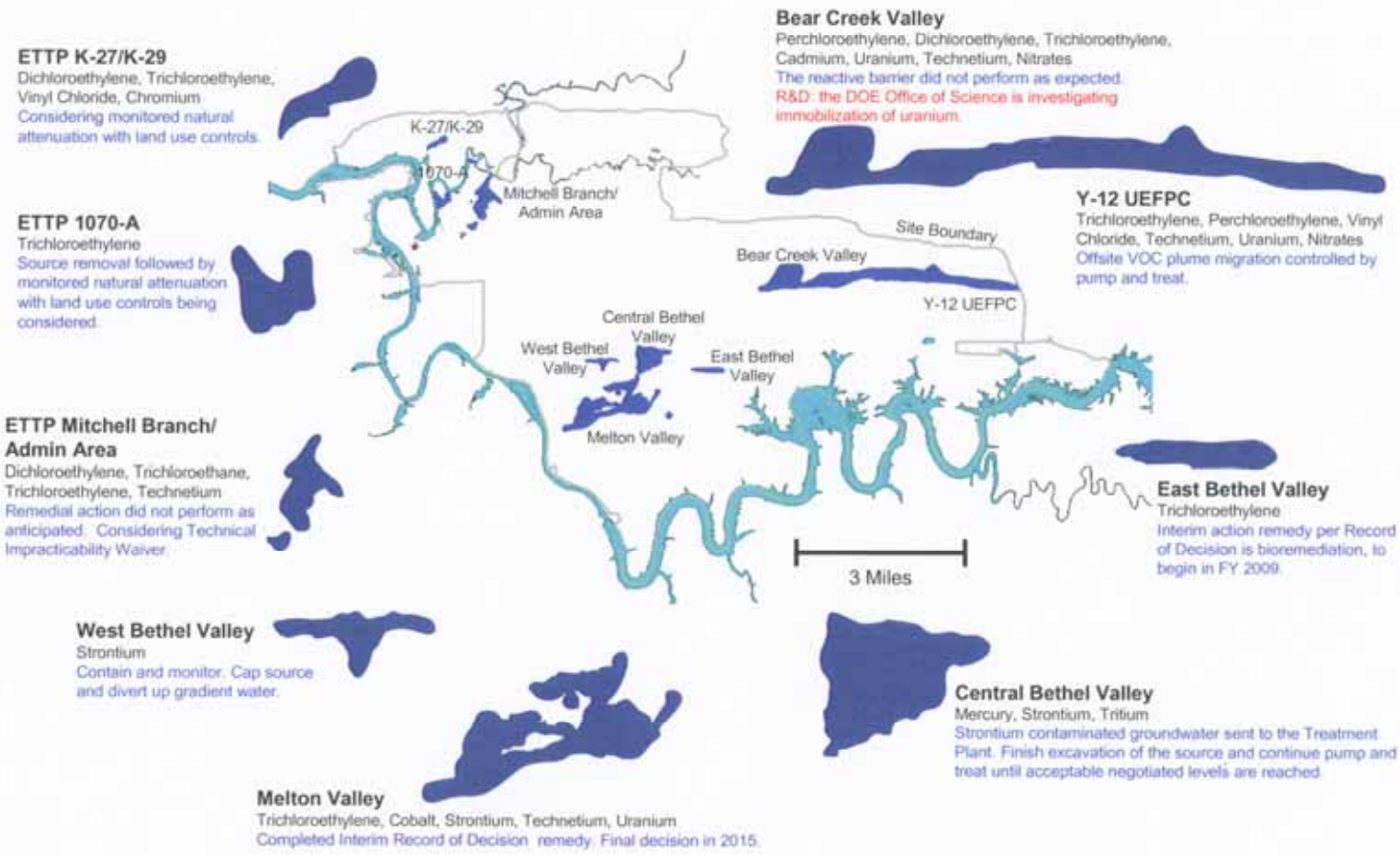


Communication Tools

Groundwater and Soil Remediation

- Individual Project Fact Sheets
- Groundwater Data Base
- Plume Map/Assessment/Score Card Booklet
- Land-Fill Configuration and Assessment Booklet
- Bi-Annual Program News Letter
- EM-22 Program Portal Under Development
- State of the Knowledge Documents Under Development
  - Sr-90, Tc-99, I-129
- Annual Program Planning Meeting
- Guidance Documents/Protocol
  - Monitored Natural Attenuation
  - Conceptual Modeling and Numerical Codes
- External Program Reviews
- Technical Forums
- Communication/Training - Short Courses

Oak Ridge Site: Plume Map (9 plumes)



(Note: Plume details not to scale.)

Oak Ridge Site: Plume Assessments

Site	Contractor	Plume/Area	PBS#	Major Contaminants	Current Plume Size	Source	Plume Status	Regulatory Status	Treatment Status	Comments
Oak Ridge Reservation	Bechtel Jacobs	Bear Creek Valley	OR-0041	PCE,DCE, TCE, Cd, U, Tc, Nit.	○	◒	Yellow	○	Red	The reactive barrier did not perform as expected. R&D: the DOE Office of Science is investigating iodization of the U.
Oak Ridge Reservation	Bechtel Jacobs	Central Bethel Valley	OR-0042	Hg, Sr, Tritium	◒	◒	Yellow	○	Green	Sr contaminated GW sent to the Central Treatment Plant. Finish excavation of the source and continue P&T until acceptable negotiated levels are reached.
Oak Ridge Reservation	Bechtel Jacobs	East Bethel Valley	OR-0042	TCE	●	●	Yellow	◒	NA	Remedy is bioremediation per ROD for interim actions. Interim actions to begin in FY 2009.
Oak Ridge Reservation	Bechtel Jacobs	ETTP 1070-A	OR-0040	TCE	●	◒	Yellow	○	Green	Source removal. Considering MNA. No risks.
Oak Ridge Reservation	Bechtel Jacobs	ETTP K-27/K-29	OR-0040	DCE, TCE, VC, Cr	●	◒	Yellow	○	NA	Considering MNA. No current or future risks identified.
Oak Ridge Reservation	Bechtel Jacobs	ETTP Mitchell Branch/Admin Area	OR-0040	DCE, TCA, TCE, Tc	◒	○	Yellow	○	Yellow	Remedial action did not perform as anticipated. No actions have been identified that can succeed. Considering TI Waiver for DNAPLs in the fractured bedrock. Conditions did not deteriorate upon cessation of the remedial action.
Oak Ridge Reservation	Bechtel Jacobs	Melton Valley	OR-0042	TCE, Co, Sr, Tc, U	○	◒	Yellow	○	Green	Performance of hydraulic containment and seepage capture and containment exceed ROD requirements. Final decision in 2015.
Oak Ridge Reservation	Bechtel Jacobs	West Bethel Valley	OR-0042	Sr	◒	◒	Yellow	○	NA	Contain and monitor. Cap and divert up gradient water.
Oak Ridge Reservation	Bechtel Jacobs	Y-12 UEFPC	OR-0041	TCE, PCE, VC, Tc, U, Nitrates	○	○	Green	○	Green	Offsite VOC plume migration is controlled by P&T.

Major Contaminants: Contaminants in plume that required, currently require, or may require remediation.

Plume size: ○ = Greater than 320 acres, ◒ = 40 to 320 acres, ● = Less than 40 acres

Source: ○ = Active, ◒ = Controlled, ● = Not Present

Plume Status: Red—Contaminants above MCLs/ACLs are currently offsite or projected to migrate offsite, Yellow—Plume is expanding but is not expected to migrate offsite above MCLs/ACLs, Green—Plume is static or shrinking in size. MCL=maximum concentrations level (levels are promulgated standards). ACL=alternate concentration limit (levels are negotiated).

Regulatory Status: ○ = Assessment ongoing, ◒ = Remedial approach proposed (i.e., Proposed Plan), ● = Decision Document in place. Decision Documents are defined as legally binding agreements (i.e., RCRA or CERCLA Interim or Final Records of Decision, Permits, Closure Plans, Corrective Actions, Interim Actions).

Treatment Status: Red—Remedial approaches are not performing as identified in Decision Documents, Yellow—Remedial approaches are not performing optimally (as identified in Decision Documents), Green—Remedial approaches are performing as identified in Decision Documents.

Tool Example: Groundwater Contamination Database

Contaminant (major)	Site	Plume(s) Status	Pump and Treat (29)	MNA and Monitoring (21)	Bio-remediation (10)	Barrier Wall (9)	Source controls (8)	Bio-sparging (6)	Reactive Barrier (5)	Cap (3)	SVE (3)	ISCO (2)	Steam (2)	ERH (2)	Status/ Comments
Ammonia	Moab	red	x												pump and treat
Beryllium	Savannah	yellow		x	x										MNA; bioremediation
Cadmium	Oak Ridge	yellow				x									reactive barrier
	Savannah	yellow													barrier wall
Carbon Tectrachloride	Hanford	yellow	x				x								pump and treat; source zone technologies being investigated
	Idaho	green									x				Active vapor extraction system in place. Monitoring is ongoing.
	Savannah	green		x											MNA
Cesium	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	West Valley	yellow	x												pump and treat
Chromium	Hanford	red, green	x			x									pump and treat; in situ barrier;
	Idaho	green													
	Los Alamos	NA													
	Oak Ridge	yellow		x											considering MNA
Cobalt	Oak Ridge	yellow													
Dichloroethene	Hanford														
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Oak Ridge	yellow	x						x						reactive barrier; pump and treat
	Savannah	yellow, green	x	x				x							recirculating wells; MNA; cap; biosparging
Diesel	Hanford	red													
Iodine	Hanford														
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Savannah	yellow, green				x	x								source controls; barrier wall; under investigation
Lead	check on														
Mercury	Oak Ridge	yellow													
	Savannah	yellow				x									barrier wall
Nitrate	Hanford														
	Idaho	green													
	Los Alamos	NA													
	Oak Ridge	yellow, green	x						x						reactive barrier; pump and treat
Perchlorate	Los Alamos	NA													
RDX (high explosives)	Los Alamos	NA													
Strontium	Hanford	red, green													
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Oak Ridge	yellow	x				x			x					pump and treat; containment; cap
	West Valley	yellow	x												pump and treat
	Savannah	yellow, green		x		x									barrier wall; MNA
Sulfate	Hanford														
Technetium	Hanford	yellow, green													
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Oak Ridge	yellow, green	x	x											reactive barrier; containment; pump and treat
	Paducah	red, yellow	x	x											pump and treat; MNA
	Portsmouth	red, yellow	x			x	x					x			pump and treat; source removal; ISCO; barrier wall
	Savannah	yellow, green				x	x								source controls; barrier wall
Tetrachloroethene	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Oak Ridge	yellow, green	x						x						pump and treat; reactive barrier
	Savannah	yellow, green	x	x				x			x		x	x	recirculating wells; MNA; SVE; pump and treat; steam stripping; ERH; biosparging
Trichloroethene	Hanford	green													
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion
	Oak Ridge	red, yellow	x					x	x						reactive barrier; Pump and Treat; bioremediation;
	Paducah	red, yellow	x	x											pump and treat; MNA
	Portsmouth	red, yellow	x			x	x					x			pump and treat; source removal; ISCO; barrier wall
	Savannah	yellow, green	x	x				x		x	x		x	x	recirculating wells; MNA; SVE; pump and treat; steam stripping; ERH; biosparging; cap
Tritium	Hanford	red													
	Los Alamos	NA													
	Oak Ridge	yellow													
	Savannah	yellow, green		x	x	x	x	x		x					MNA; bioremediation; source controls; barrier wall; cap; biosparging
	West Valley	yellow													
Uranium	Hanford	red, yellow, green	x	x											
	Los Alamos	NA													
	Moab	red, green	x												
	Oak Ridge	yellow, green	x				x		x						groundwater extraction creating a hydraulic barrier
	Savannah	yellow		x	x										reactive barrier, containment, pump and treat MNA; bioremediation
Vinyl Chloride	Oak Ridge	yellow, green	x												considering MNA; pump and treat
	Savannah	yellow, green		x				x							MNA; biosparging

Tool Example: Groundwater Contamination Database

Contaminant (major)	Site	Plume(s) Status	Pump and Treat	MNA	Bio-remedation	Barrier Wall	Source controls	Biosparging	Reactive Barrier	Cap	SVE	ISCO	Steam	ERH	Status/ Comments	Complex Wide Strategic Approach
Strontium	Hanford	red, green														
	Idaho	green	x	x	x										In situ bioremediation for "hot spots", pump and treat for medial zone, MNA for distal portion	
	Oak Ridge	yellow	x				x			x					pump and treat; containment; cap	
	West Valley	yellow	x												pump and treat	
	Savannah	yellow, green		x		x									barrier wall; MNA	
Uranium	Hanford	red, yellow, green	x	x											pump and treat; MNA	
	Los Alamos	NA														
	Moab	red, green	x												groundwater extraction creating a hydraulic barrier	
	Oak Ridge	yellow, green	x				x		x						reactive barrier, containment, pump and treat	
	Savannah	yellow		x	x										MNA; bioremediation	

Groundwater & Soil Remediation Approaches and Solutions

Integrated Approach to Reduce Project Risk & Uncertainty

Monitored Natural Attenuation/Enhanced Attenuation for Chlorinated Solvents

Challenge

Address fundamental challenges in reaching final closure for many DOE sites with contaminated soils and groundwater: transitioning costly source treatments and developing regulatory support.

Solution

Technical guidance, tools, and collaboration with state regulators to promote acceptance of natural attenuation/enhanced attenuation.

Accomplishments

New technologies and tools were developed and demonstrated to promote acceptance of attenuation-based remedies for chlorinated solvents.

Developed guidance with state and federal regulators for implementing technical products within regulatory frameworks and implemented web-based training on technical advances.

Impact

Technical developments enable transition from active, energy-intensive treatments to "green" treatments, minimizing our energy footprint on a national scale, while also saving money.

Publicly available training is resulting in technical advancements in the public/private sectors.

Retrieval of Passive Flux Monitor

Push-Pull Test

Electrical Resistance Heating (ERH)

Challenge

The slow release of industrial solvents trapped in clay layers can extend the timeframe for cleanup by 10s or even 100s of years

Solution

The DOE Environmental Management program funded development of electrical resistance heating (ERH) to speed up the release and removal of solvent contamination from clay layers

Technology developers included researchers from Pacific Northwest National Laboratory and scientists with backgrounds in enhanced oil recovery

Accomplishments

Electrical resistance heating first field demonstrated at the Savannah River Site

Electrical resistance heating patented and commercialized and now being applied by multiple vendors

Applications are now supported by regulatory guidance documents, multiple case studies, and support of multiple federal agencies

Impact

The DOE-developed technology is seeing widespread application within the private sector and for government projects, saving money and significantly accelerating cleanup schedules

The DOE Paducah Gaseous Diffusion Plant (KY) will accelerate cleanup of the soil and shallow groundwater near the C-400 Building by implementing one of the largest ERH projects

Paducah Gaseous Diffusion Plant (KY) electrical resistance heating being designed to treat subsurface

Enhanced Anaerobic Reductive Precipitation/Dechlorination

Challenge

No technologies are currently available to treat technetium-99 (Tc-99) contaminated groundwater *in situ*, yet Tc-99 is a high risk because it is long-lived and mobile in the environment.

Solution

Identify and optimize commercially available in-situ remediation treatment technology to treat metals, radionuclides, and organics in groundwater.

Accomplishments

Enhanced Reductive Precipitation/Dechlorination (EARP/D) has been used at 190 sites, including 21 federal government sites; lab- and pilot-scale tests have shown that Enhanced Reductive Precipitation/Dechlorination can be applied to technetium-99 and other key radionuclides.

ART Phase II will demonstrate an in situ field-scale application at Hanford or Savannah River at an area where technetium-99 is present in the groundwater.

Potential Impact

Enhanced Reductive Precipitation/Dechlorination may provide a solution for *in situ* treatment of radionuclides in groundwater where no current solution exists, thus significantly reducing risk to human health and the environment.

Mobile Batch Injection Trailer

Attenuation-based Remedies for Metals and Radionuclides

Challenge
Environmental clean-up strategies at sites with metals and radionuclides often leave the contaminants in place, but they can pose a risk for 1000s of years.

Solution
Attenuation-based remedies can be implemented to demonstrate reduced risk through development of technical guidance and tools.

Accomplishments
Research to further understand natural attenuation processes in the subsurface is being conducted collaboratively by Savannah River and Lawrence Berkeley National Laboratories with extensive communications with the Environmental Protection Agency and state regulators.

Impact
Sustainable, low-energy approaches to cleaning up metals and rad-contaminated sites will minimize risk receptors.

Training in new technical developments and approaches will be made available first to DOE and to the broad stakeholder community.

Lawrence Berkeley researcher viewing soil samples from site

Savannah River scientist collecting water samples from wetlands

Columbia River Projects: Treatment of Uranium in Groundwater

Challenge
The Natural Attenuation remedy for uranium in groundwater specified in the Record of Decision is not effective; an alternative groundwater treatment system should be deployed.

Solution
A reactive barrier created by injection of polyphosphate solutions into wells to stabilize uranium.

Both the groundwater and the soils above the water table where uranium exists as a continuing source to the aquifer must be treated.

Accomplishments
A pilot-scale field test demonstrated proof-of-principle for creating a barrier, but high groundwater flow rate was problematic.

Laboratory tests to treat uranium source material above the water table are ongoing.

Impact
Passive barrier technology has the potential to save millions in life-cycle costs as compared to an active pump and treat system, which would be the primary alternative considered.

Polyphosphate Injection Pilot Test

Columbia River Projects: Treatment of Groundwater Containing Strontium-90

Challenge

Pump and treat remedy for strontium-90 in groundwater in 100-N Area adjacent to the Columbia River specified in the Record of Decision is not effective in preventing migration of the radionuclide into the river.

Solution

A reactive barrier created by injecting phosphate solutions into wells can stabilize the strontium-90.

Both groundwater and the source zone above the water table must be treated.

Accomplishments

A 300-ft barrier was installed to treat groundwater, but a continuing source of radionuclides in the soils above the water table remained.

Columbia River Project funded lab tests to treat the source zone above the water table and excellent results were obtained; field testing is needed.

Impact

This passive barrier technology could potentially replace the pump and treat system, significantly reducing annual operating costs, saving millions in life-cycle costs and preventing strontium-90 from entering the river.

100-N Area Location for Reactive Barrier

Columbia River Projects: Remediation of Hexavalent Chromium in Groundwater

Challenge
Migration of groundwater contaminated with hexavalent chromium entering the Columbia River at the Hanford Site; high environmental risk.

Solution
Understand where chromium is present as a source and how it moves through soils above the water table; test a variety of technologies to treat groundwater using a systems approach.

Accomplishments
Lab and field studies improve understanding of fate and transport of chromium in soils above the water table and where chromium may be present as a continuing source to the aquifer.

Lab test and modeling ongoing to mend the In Situ Redox Manipulation Barrier; 2008 field demo planned. A 50-gpm test of Electrocoagulation technology was completed. Further pilot-scale tests and monitoring of *in situ* bioremediation show promise, with additional tests in 2008.

Impact
A systems approach using innovative technologies potentially can significantly reduce human health and environmental risks adjacent to the Columbia River, while expediting cleanup with lower life-cycle cost than current baseline technologies.

Electrocoagulation Unit

Enzyme Activity Probes (EAP)

Challenge

Paducah Kentucky Uranium enrichment facility has soil, groundwater, and surface water contaminated with trichloroethylene (TCE), a toxic chlorinated solvent.

Solution

Biochemical assay for detecting expression of microbial oxygenase enzymes involved in aerobic biodegradation of TCE via co-metabolism.

Accomplishments

Results are promising and suggests that aerobic co-metabolism may be a significant contributor to TCE attenuation. Collaborative research effort being conducted by Savannah River, North Wind, and Paducah Site Personnel.

Potential Impact

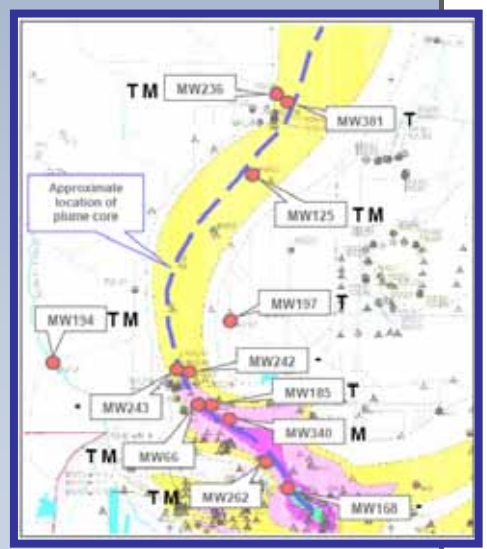
New approach to cleaning up chlorinated organic solvents that will minimize risk receptors

Development of a Standard Application and Interpretation of Enzyme Activity Probes

Paducah NW plume wells with significant enzyme activity

M = soluble methane monooxygenase

T = toluene oxygenases



TCE: 100-1000 µg/L.

Geosiphon™

Challenge

Paducah Kentucky Uranium enrichment facility has soil, groundwater, and surface water contaminated with trichloroethylene (TCE), a toxic chlorinated solvent.

Solution

Implement a large-diameter well is packed with permeable reactive media and allow the natural head difference between well and discharge point drives siphon.

Accomplishments

Geosiphon technology has been implemented at Savannah River. The technology is planned for implementation at the Paducah Site. Technology develop by Research at Savannah River Site.

Potential Impact

Clean-up approach that achieves sustainable contaminant destruction and/or sorption in a low-energy, low-maintenance system.

Siphon accelerates contaminated groundwater flow toward and through reactive media.

Pictures of the installation of a GeoSiphon at Savannah River Site.

Carbon Tetrachloride Conceptual Model

Geophysical Characterization Methods

Challenge

Remediation of carbon tetrachloride present in groundwater over an area of 11 square kilometers In the 200 Area at Hanford must address contaminant sources above the water table.

Solution

A conceptual model of carbon tetrachloride sources was developed and tested to provide an improved understanding of the location and extent of the source material.

Accomplishments

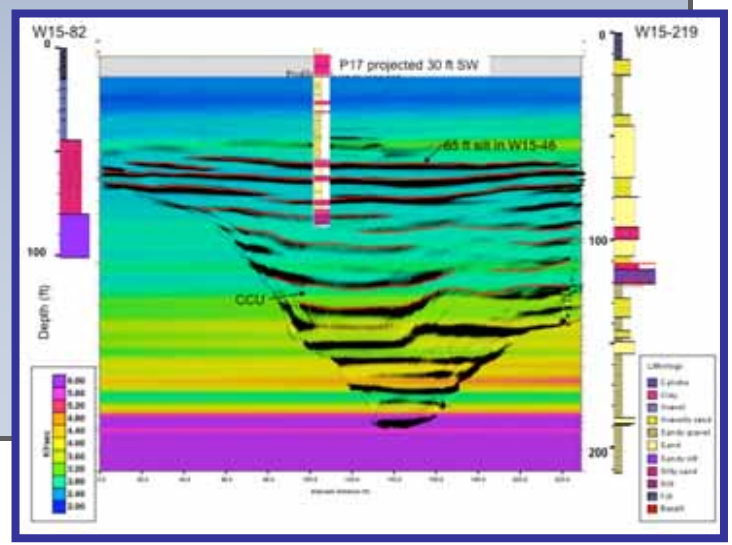
A prompt evaporation model provided key insight into disposal practices.

The lateral extent of the source region was confirmed using Geophysical (Seismic) Methods.

Updated source inventory calculations, based upon field vapor-phase measurements, reduced the unaccounted for inventory to between 21 and 40%.

Potential Impact

Refinements to the understanding of the quantity of source material present in the unsaturated zone near the Z-9 Trench at Hanford may enable a more effective and efficient remedial approach, thus accelerating cleanup schedules and reducing costs.



EM-22 Mercury Stabilization Project

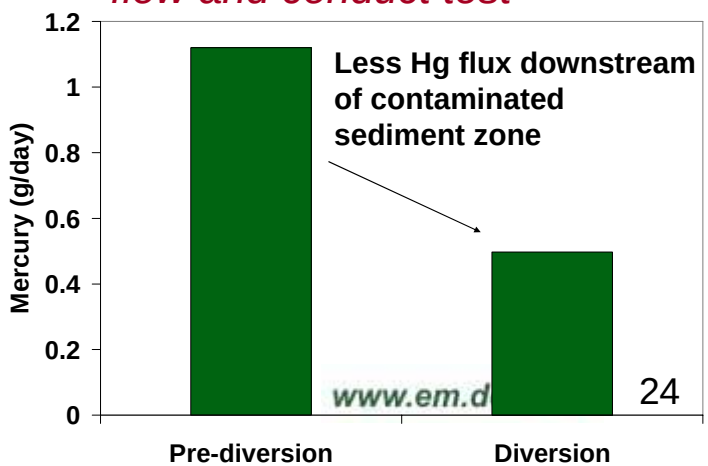
- **Prioritized implementation of new technologies and strategies**
  - Source reduction and soil amendments
  - Water Chemistry Controls
  - Modifications of Stream Characteristics

East Fork Poplar Creek at Y-12

- **Focused on two "quick win" ideas for testing in 2008**
  - Diverted flow away from contaminated sediment (July-Aug)
  - Reduction and volatilization of Hg using $SnCl_2$ (Oct)

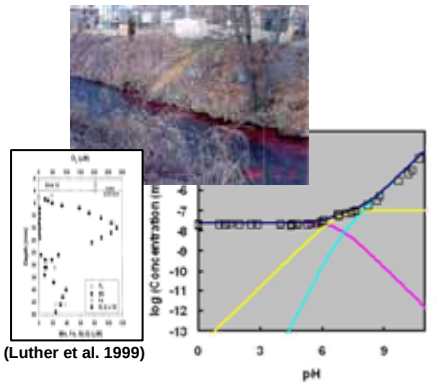
Successful field effort

Overcame substantial organizational, logistical, and regulatory challenges to divert flow and conduct test

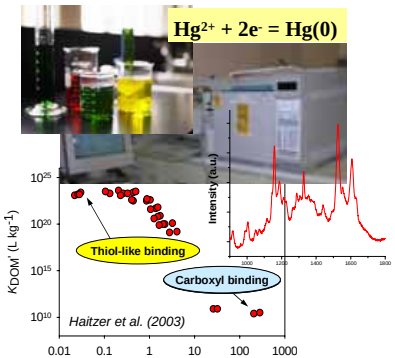


Integrated approach to fundamental understanding of Hg transformation

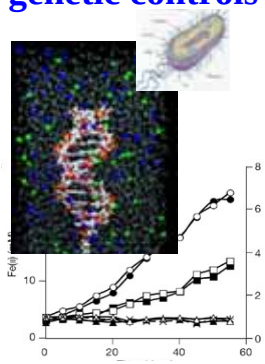
Field biogeochemistry



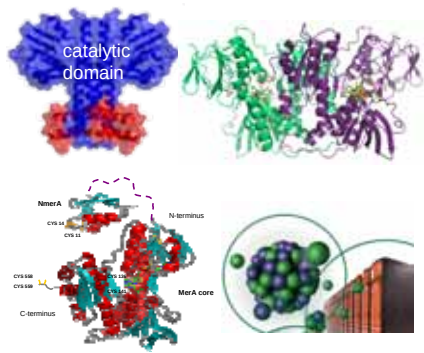
Fundamental rates and mechanisms



Microbial and genetic controls



Molecular structure and simulations



Transformation in field → Speciation & mechanisms → Molecular dynamics

Sediment-water interface
Species/ abundance
Microbial communities

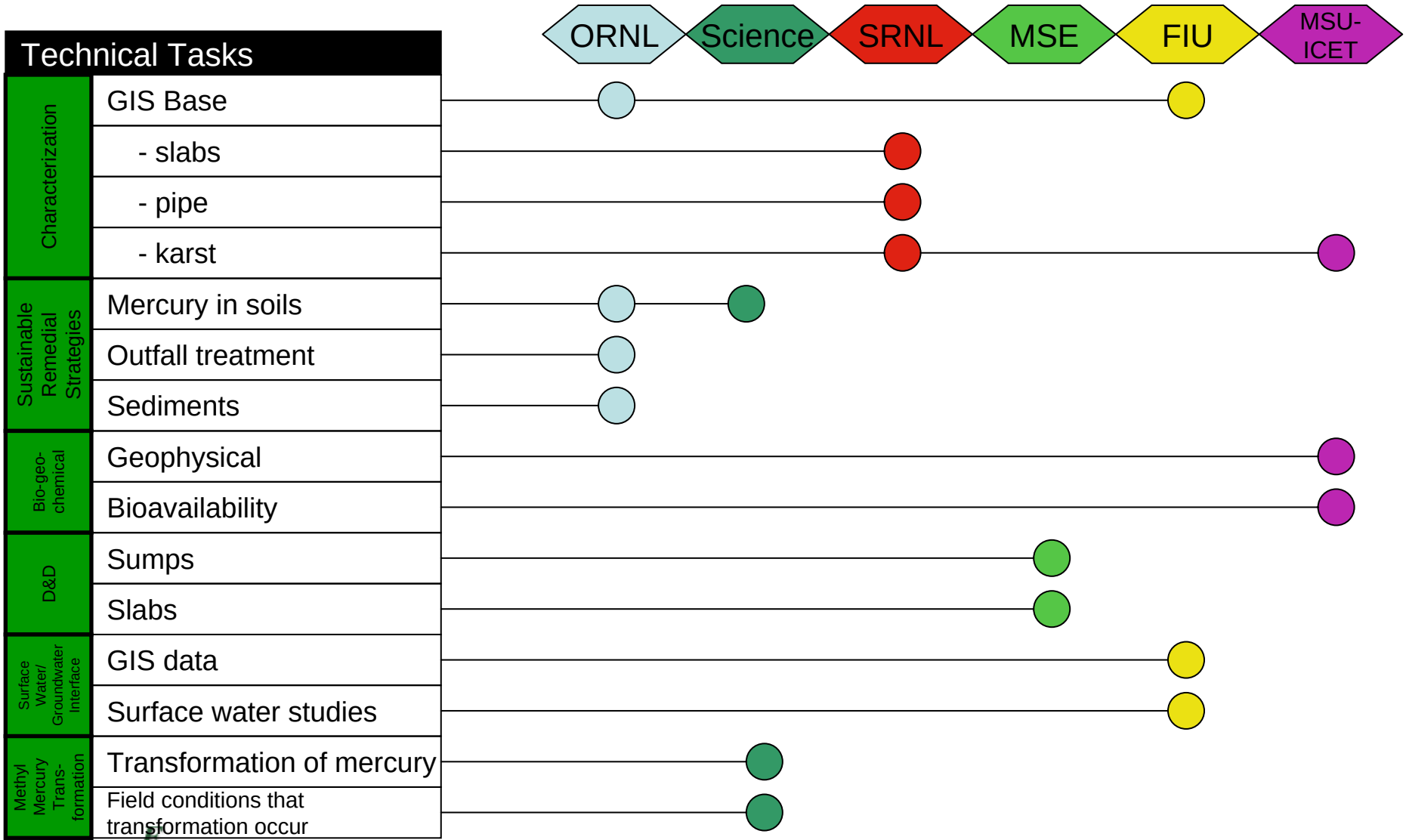
Coupled microbial and geochemical reactions

Molecular level understanding of contaminant association and reaction

Reaction mechanisms and kinetics of mercury methylation and demethylation

Path Forward: Addressing Hg remediation challenges: inhibit methylation and enhance demethylation

Oak Ridge Integrated Facilities Disposition Project
EM-22 & 23 Program Investment



Landfills/Disposal Facilities

- Independent Review and Evaluation
- Improve Capacity Estimates and Optimize Waste Logistics
- Use of Automation to Decrease Error, Exposure, and Problems
- Collect Performance Data to Demonstrate Competence
- Better Understand the Effect of Settlement on Performance
- Estimates of Liner Effectiveness **Too** Conservative
- Organize Historical Data from Past DOE Projects
- Share Experiences Across DOE Complex
- Landfill/Disposal Facility Technical Forum (Oct. 7–9)

Long-Term Stewardship

- Established to Meet Post-Closure Obligations
  - Future Site Mission Transfer to Other Agency
    - SC, NNSA, or NE
  - DOE Sites Without Future Mission Transfer to LM
- Transition Process Primary DOE Orders
  - 430.1B Real Property and Asset Management
- LM – High Performing Organization

Plutonium nanoclusters

- Press release by multiple sources on April 2008 based on 2008 journal article
- Stakeholder concerns with a new Pu transport mechanism
- DOE investigates issue
- Separate independent analysis reports created by DOE Headquarters and National Laboratories
- Lab Data May Not Be Applicable to Field Conditions
  - Proposed Scenario Unlikely

Questions?