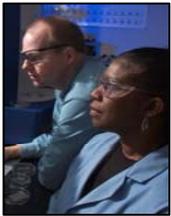


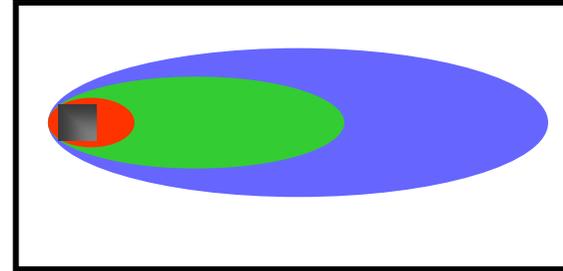
Environmental Science and Biotechnology Overview



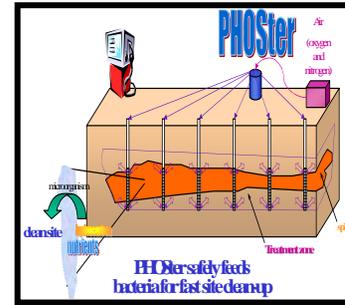
Deborah Moore Shedrow
Director, Environmental Science & Biotechnology

Technical Solutions to Environmental Issues

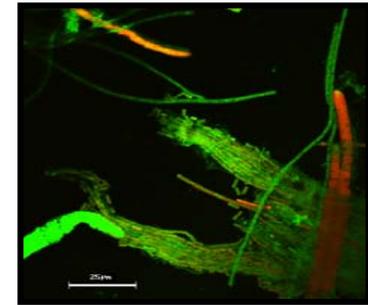
Novel Regulatory Approaches



Remediation and Assessment



Biotechnology



Environmental Core Competencies



Dr. Brian Looney has developed environmental characterization and remediation technologies for organic contaminants, metals and radionuclides. He has received two R&D 100 Awards.

- Optimized groundwater remediation systems
- Field screening and technology deployments
- Special sensors
- Barrier monitoring and containment
- Waste disposal forms
- Ecological remediation, wetlands
- Environmental biotechnology
- Fate and transport modeling
- Environmental dosimetry

Biotechnology Core Competencies



Dr. Christopher Bagwell conducts molecular biology research in our state-of-the art laboratories.

- Microbial Characterization
- Immunodetection
- Biocollection/Biodetection
- Molecular Biology
- Environmental Genomics
- Biofilms/Biofouling/Biocorrosion
- Bioanalytical Chemistry

- ❖ Bioremediation
- ❖ Bioforensics
- ❖ Biodefense
- ❖ Bioenergy

Dependent Capabilities



Dr. Anna Knox integrates mineralogy, geochemistry, agronomy, soil science, and ecology in her interdisciplinary studies.

- Understanding of science and environmental systems
 - Hydrogeology, geochemistry, ecology, microbiology
 - Modeling, risk analysis, performance assessment
- Integrated, multidisciplinary approach to problem solving
- Data synthesis and scaling

Science Based Approaches to Regulatory Compliance

Understanding environmental systems to identify most effective approach



Constructed Wetland

- Novel Compliance Strategies
 - Alternative Toxicity Test Species adapted to soft waters
 - Water Effects Ratio for natural toxicity reducing substances
 - Biotic Ligand Model for full water chemistry interactions and toxicity
 - Mercury Total Maximum Daily Load increase by understanding and correcting human exposure pathway
- Low Environmental Impact, Low Cost Treatment Technologies
 - Constructed Wetlands (Outfalls A-01, H-02) and Dissolved Organic Carbon Addition (Outfall H-12) for metals removal from wastewater
 - Stabilizing soil amendments for stormwater management
 - Aqueous mercury treatment (Outfall A-11)

NPDES Outfall Compliance

First EPA approved alternative species for aquatic toxicity



Daphnia ambigua

- Several outfalls failing NPDES toxicity testing where no toxicant found due to soft waters
- Identified and validated alternative species
- “Problem” outfalls consistently passed toxicity testing with alternative test organism
- Effluent toxicity testing eliminated at these outfalls

Mercury Total Maximum Daily Load (TMDL)

Proved majority of mercury in Savannah River from atmospheric deposition, not SRS



Atmospheric Deposition Station

- Significantly influenced EPA's TMDL approach
- Installed mercury atmospheric deposition station
- Developed and deployed aqueous mercury treatment technology
 - Stannous chloride for chemical reduction and volatilization
 - <1/5 the cost of traditional mercury treatment methods (<\$0.50/1000 gal)

Potential cost avoidance of \$104-563 M for construction of treatment systems

Outfall Water Quality

First permitted wetland treatment system in SC
First system for mercury in nation

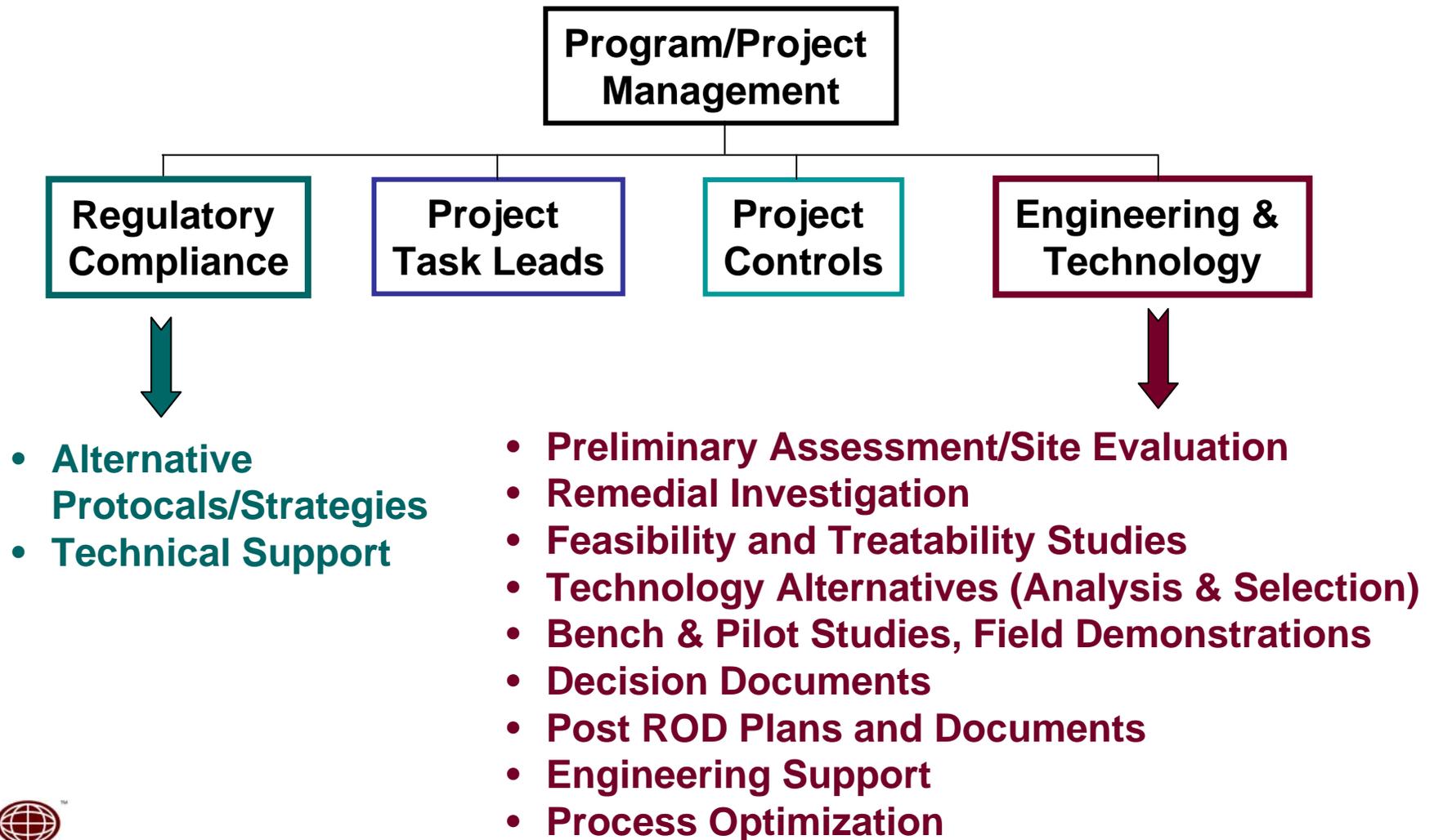


A-01 Outfall Constructed Wetland

- Optimized system functioning to design specifications
- Copper concentrations reduced below compliance limits
- Mercury concentrations reduced to <10 ng/L

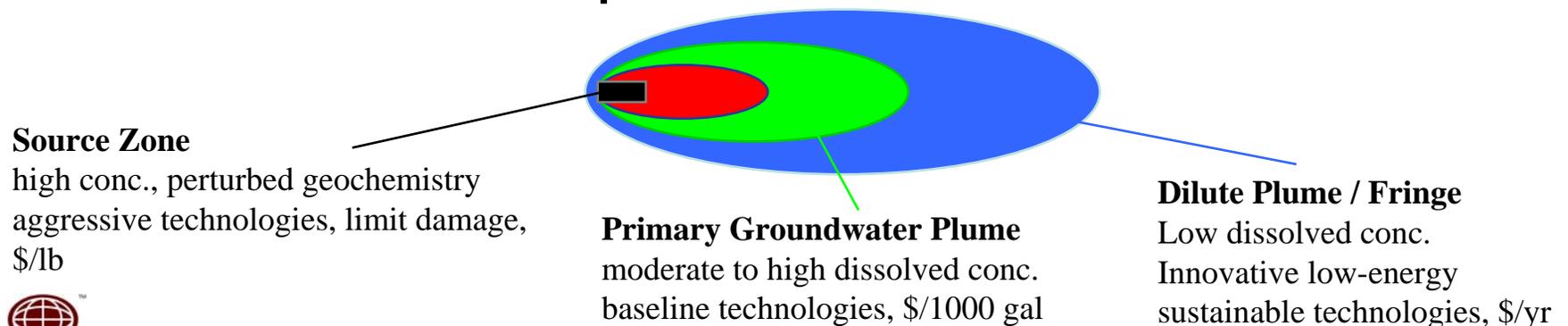
\$2M less than next best alternative

Remediation Program/Project Management: SRNL Roles



Matching Solutions to Risk

- Develop sustainable solutions for contaminated soil and groundwater
 - Chlorinated volatile organic compounds
 - Metals
 - Radionuclides
 - Optimization
- Match solutions to specific site conditions



Characterization

- CVOC, DNAPL - dilute
 - FLUTe
 - Gas chromatography
 - Photoacoustic
- Metal speciation
- Hydrogeologic
- Stable isotopes



Cone penetrometer truck – platform for innovative characterization and sampling



Paducah

DNAPL Characterization and Remediation

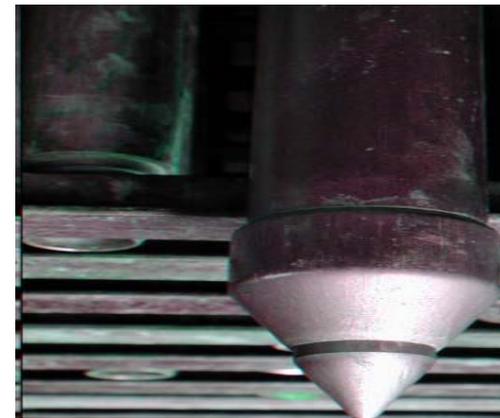
Innovative solutions developed, applied, and/or provided for a multi-million dollar national problem

- Locate and measure DNAPL (dense non-aqueous phase liquids) in-situ using cone penetrometer
- DOE and DOD deployments
- National DNAPL workshops



Ribbon NAPL Sampler

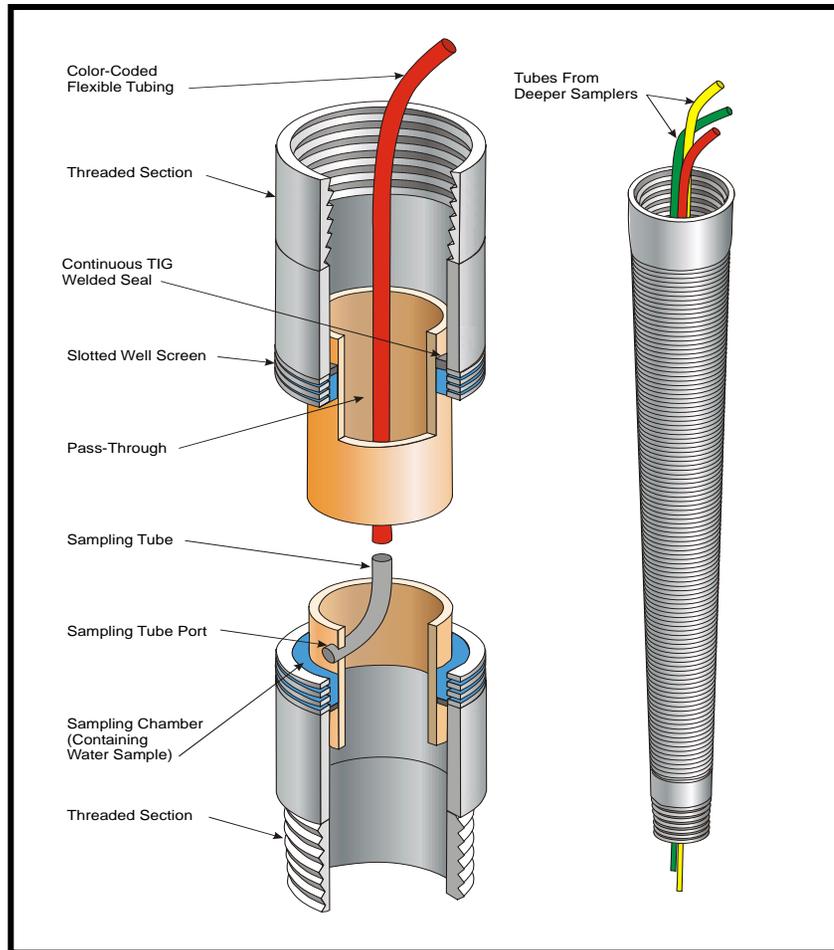
- Immediate field results
- Minimal waste generated



Membrane Interface Probe

- Rapid assessment of source
- No cuttings
- 100 samples/day at selected depths

StrataSampler™

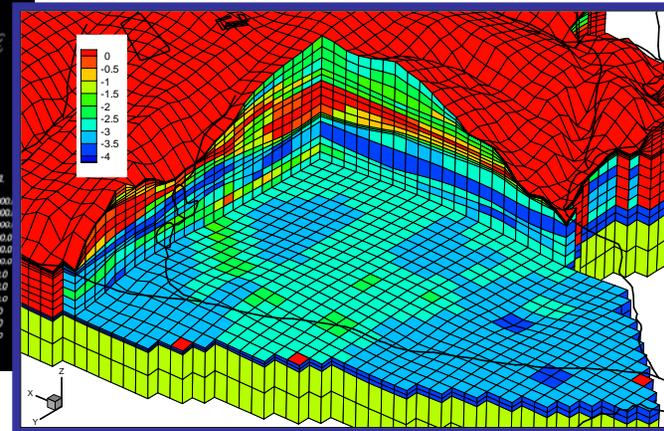
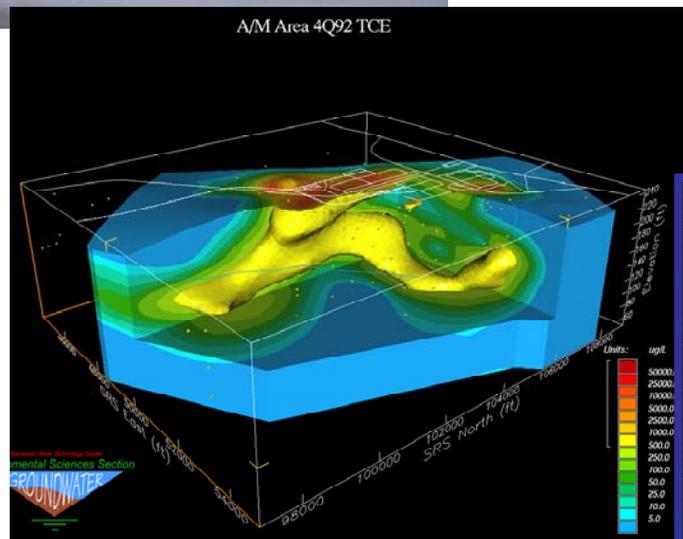


- Allows installation of multiple samplers in a single well
- No packers required to isolate zone
- Eliminates potential for vertical migration of contamination between sample intervals

Conceptual Models



- Develop 3-dimensional conceptual models
 - Large data sets
 - Measurements from multiple scales
 - geophysical logs, core samples, pump tests
 - 0.1 ft – acres



Remediation

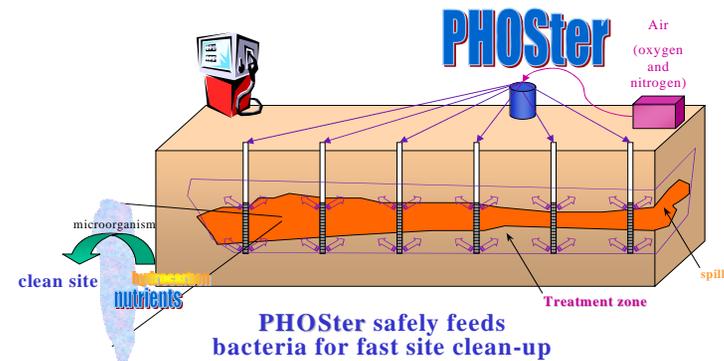


Pantex Soil Vapor Extraction

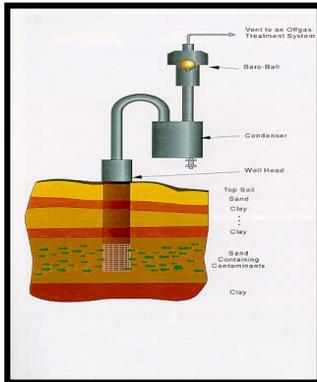
- Match appropriate remedies to site specific solutions
- Immobilize metals and radionuclide
- Sequester and breakdown organics
- Minimize footprint
- Develop energy efficient and cost-effective processes

PHOSter

Stimulate biodegradation through nutrient addition



Renewable Energy Baro Ball™

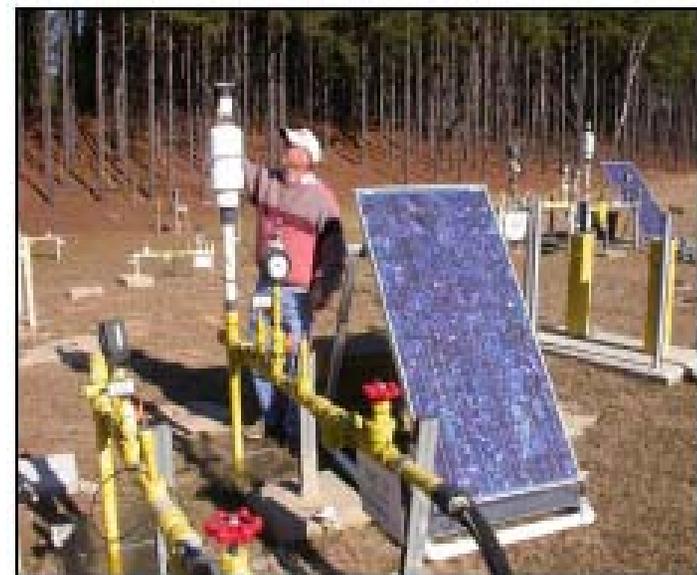


- Removes volatile contaminants from soil
- Low maintenance and no power requirements
- Pressure differential between surface and subsurface induces flow in and out of vadose zone
 - Low pressure check valve
 - Increases contaminant removal at least 2X
 - Can be modified for gas extraction or air injection
 - Reduces sampling times
 - No hidden or on-going life cycle costs
 - Commercially available



MicroBlower Deployment

Regulatory approval for transition to passive system after active SVE



Four MicroBlowers deployed at C-Area Burning/Rubble Pit

- **Used for Soil Vapor Extraction or Bio Injection**
- **Low capital cost (<\$1500 per installation)**
- **Low power (40-Watt solar panel); low O&M cost**
- **Can develop higher vacuum/pressure than barometric pumping**

Microbial Mediated Metals Immobilization

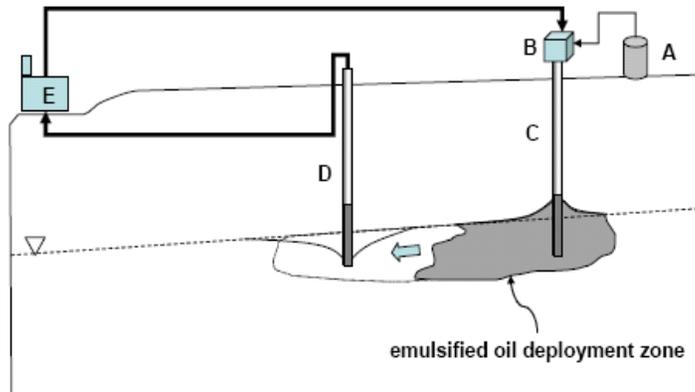
Geochemical response to microbially induced sulfate reduction of insoluble forms of metals and radionuclides



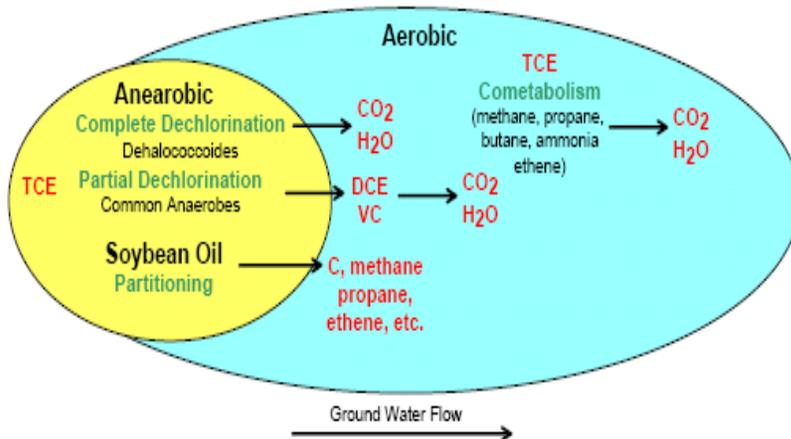
D-Area Coal Pile Runoff Basin

- D-Area Coal Pile Runoff Basin acidic/metals/sulfate plume
- Estimated savings of \$4,500K over baseline technology
- Sulfate-Reduction Remediation
 - Low cost, technically adequate treatment media
 - Organic injection stimulates sulfate reducing bacteria resulting in the *in situ* precipitation of metal sulfides
 - Field scale injection utilized an existing injection system (permeable reactive wall)

Edible Oils



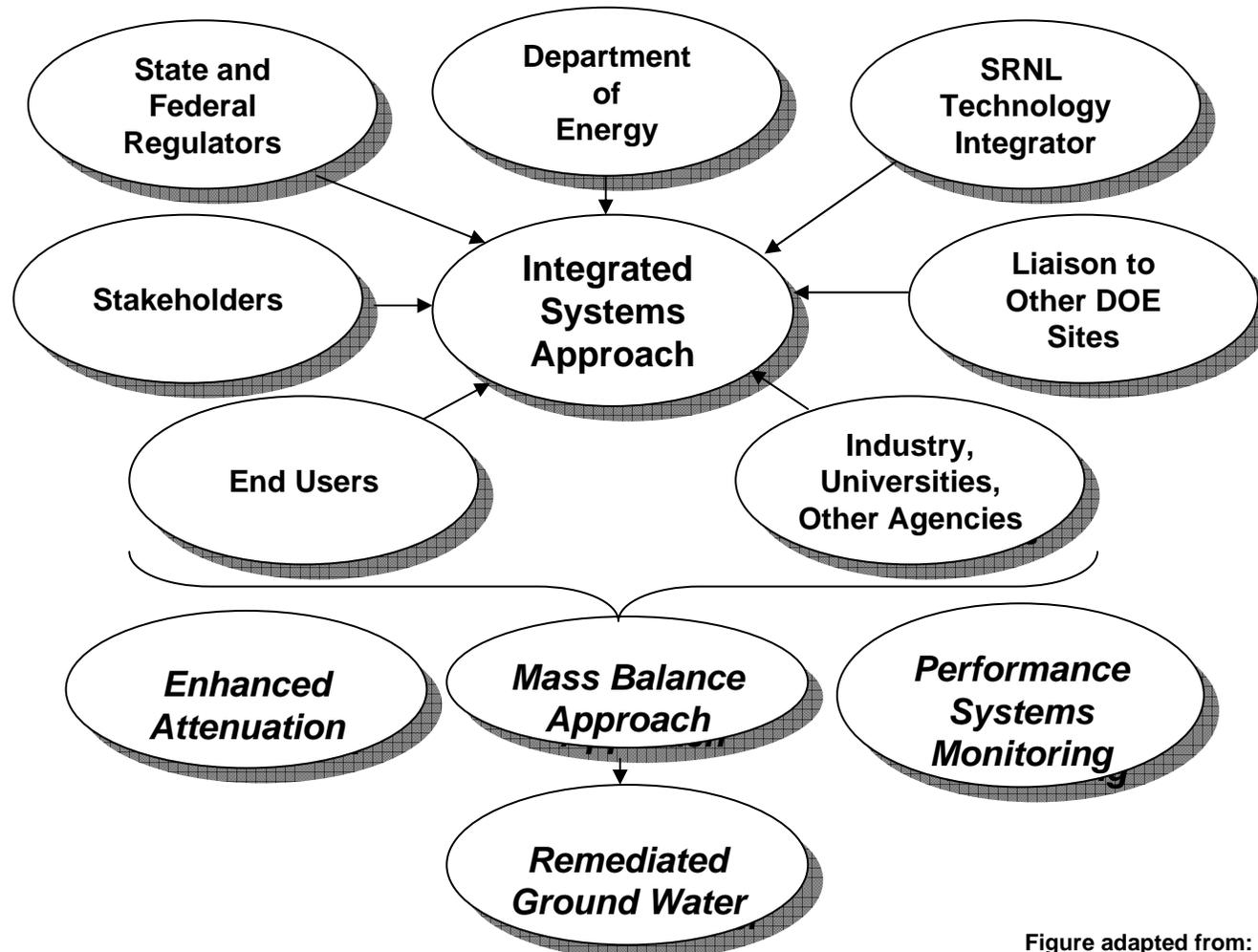
- Edible oils for dechlorination
- Requires defensible studies
 - Hydrogeology
 - Chemistry
 - Geochemistry
 - Microbiology



Monitored Natural Attenuation/Enhanced Attenuation for Chlorinated Solvents Project

- National Lead
- \$6M / 3 yr
- Developed concepts and tools that facilitate integration of sustainable treatments into the remediation process for contaminated sites
 - Use a **mass balance approach** to evaluate the waste site as a whole system
 - **Enhanced attenuation** provides a “bridge” between active treatments and MNA
- Sponsored 14 MNA/EA research projects in attenuation mechanisms, key microbiological controls/indicators of attenuation, and practical tools to estimate viability, longevity and identify key monitoring opportunities

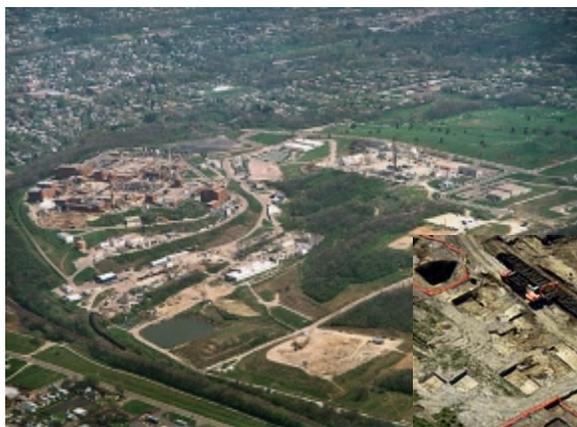
MNA/EA Project Structure



Project integrates diverse components to assemble essential tools for groundwater remediation

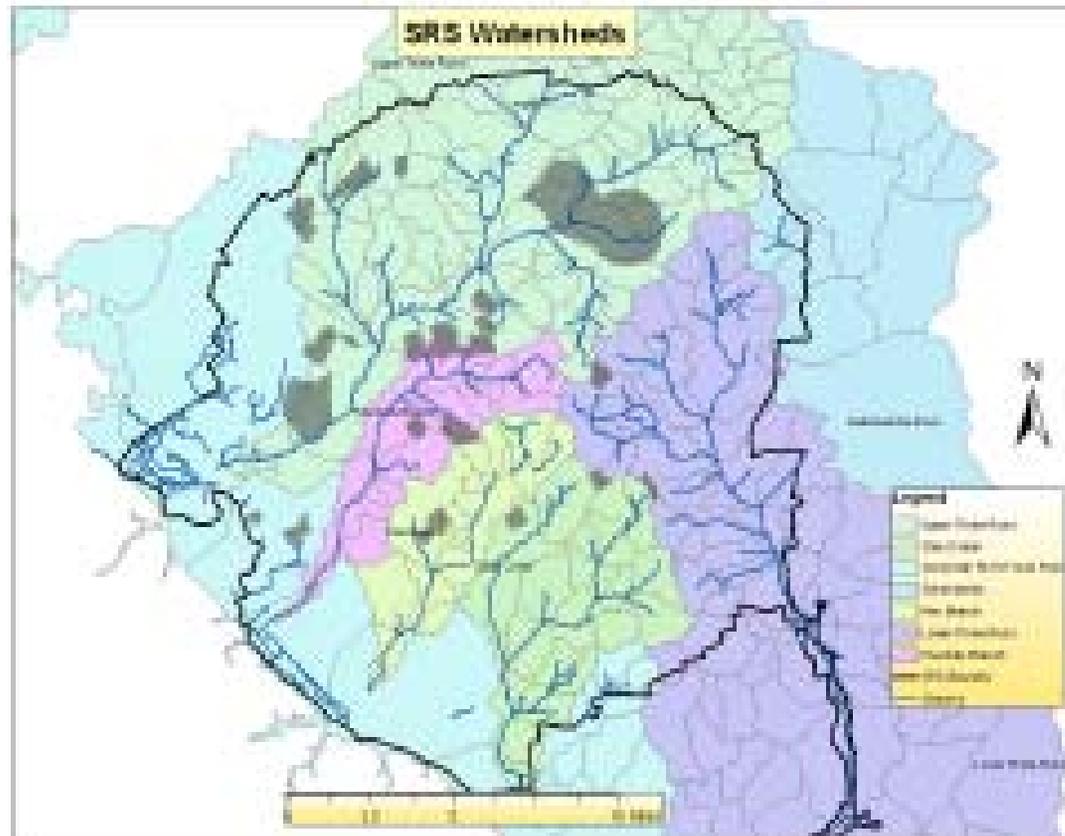
Figure adapted from: Third-Generation R & D: Managing the Link to Corporate Strategy, Phillip A. Roussel et.al., 1991, p.4

National Technical Assistance



- DOE Ohio Closure Sites
 - Developed comprehensive strategy to optimize remediation of groundwater contaminated with TCE and other volatile organic compounds at the Mound Closure Site
 - Provided technical review of Groundwater Exit Strategy for Ashtabula Closure Project
- Coordinated independent peer review of Hanford technology projects to address key issues associated with contaminants that currently enter the Columbia River

SRS Integrated Operable Units



SRS Soil and Groundwater Closure Projects



- Design, fabrication, installation and monitoring support for remediation projects and lab/pilot scale testing of enhanced remedies (e.g., Soil Fracturing, Edible Oil Partitioning, Mercury Treatment)
- Remedial investigation of the characterizing nature and extent of contamination (e.g., P-Area Operable Unit)

International Projects



- Joint Cooperative Committee on Environmental Restoration and Waste Management
- U. S. Department of Energy
 - Savannah River National Laboratory
- Russian Ministry of Atomic Energy
 - MAYAK Production Association
- Hydrospezgeologia

Poland Initiative



BioTiger™

- Proprietary formulation of 12 best cultures
- Deployed for rapid cleanup of oily soils, surfaces
- Rapid, complete degradation of aliphatics and aromatics
- Copious biosurfactant production
- Tolerant of chemical and metal toxicity
- Good activity at temperature and pH extremes

BioTiger™ - Enhanced Oil Recovery

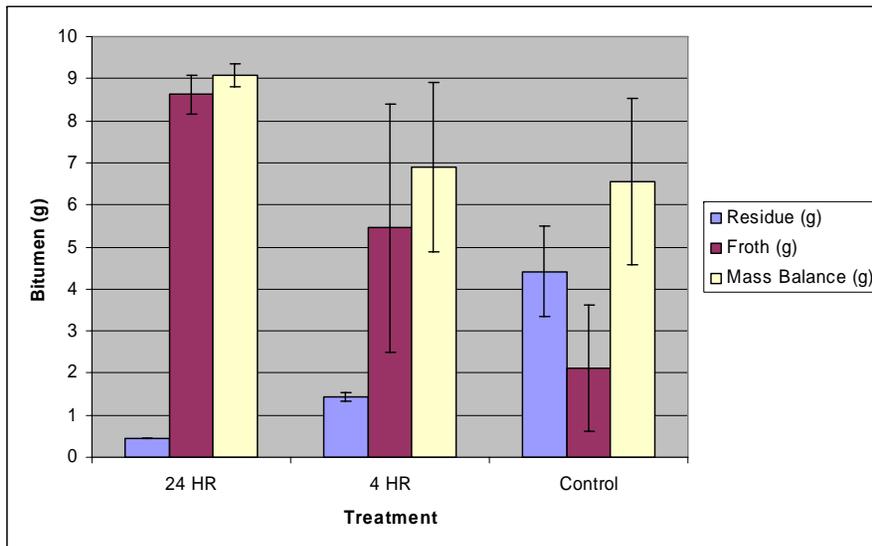
BioTiger™ has shown enhanced recovery of bitumen from Canadian Tar Sands



Canadian tar sands



Bitumen separation assays



BioTiger™ enhanced separation of bitumen from residue

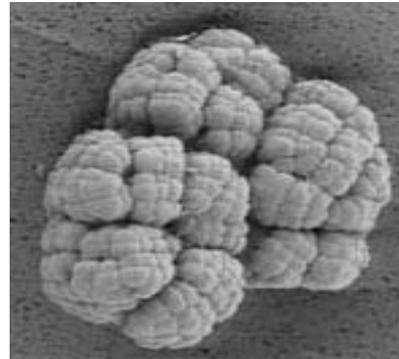
- Tar Sands obtained from Athlabasca Mining Site
- International oil company provided test methodology
- Laboratory tests evaluated BioTiger™
- Four-fold improvement in hydrocarbon separation
- Process patents filed



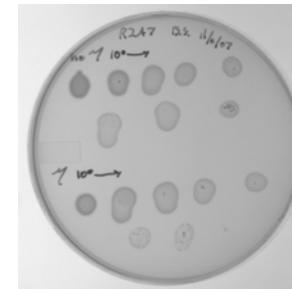
Extreme Resistant Bacteria

Novel Environmental Bacteria

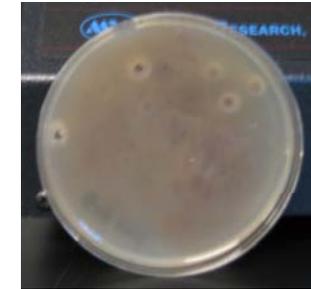
- Unique microbial diversity
- Ultimate survivors
- Bacterial solutions for practical applications



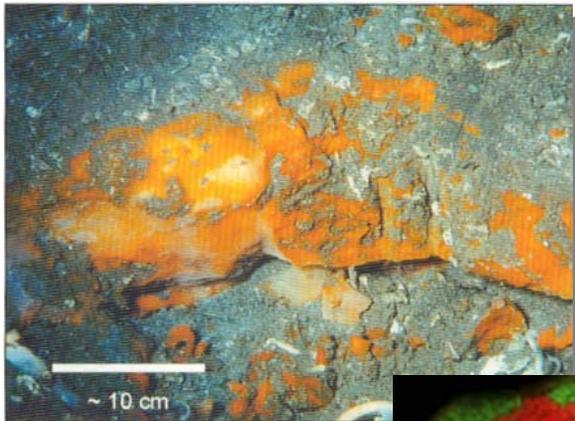
Kineococcus radiotolerans
High Level Waste



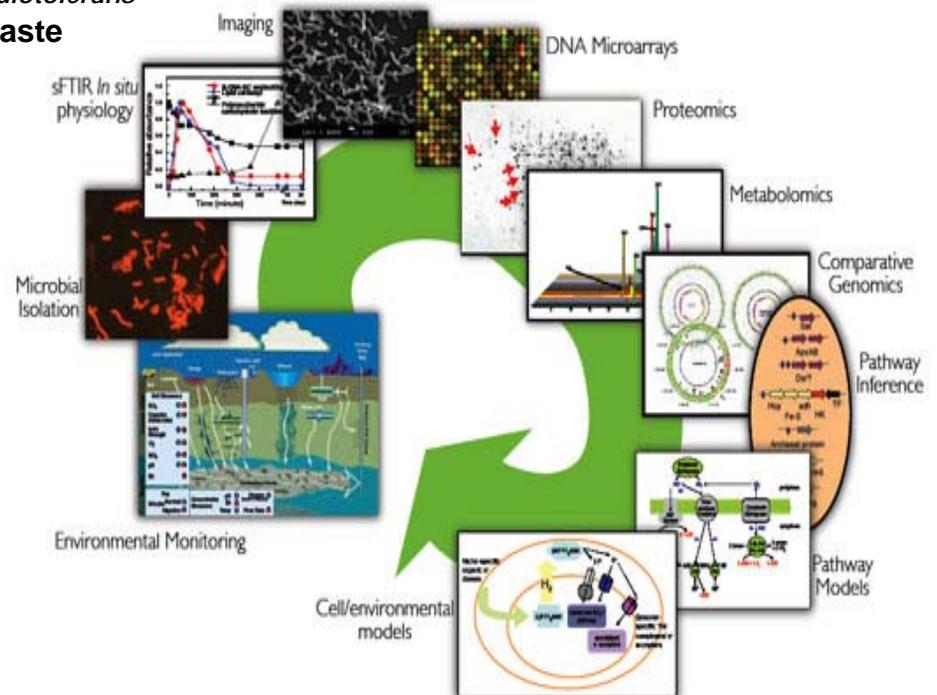
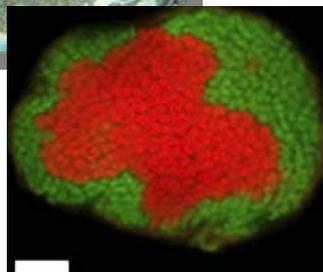
Deep Subsurface



High Metals, pH 1.0



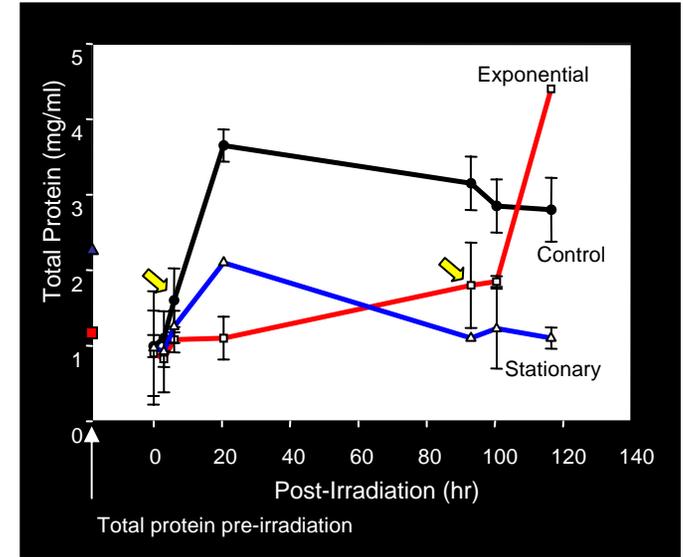
Deep Sea



Radiation Resistant Bacteria

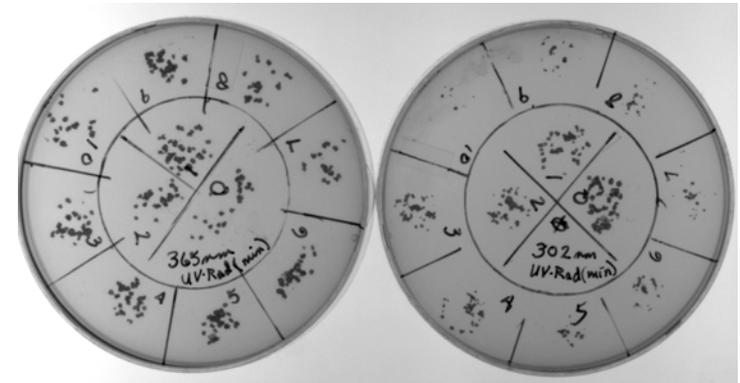
Kineococcus radiotolerans

- Isolated from a high-level radioactive waste environment
- Extreme resistance to a multitude of environmental stresses and DNA damage
- High capacity for metal chelation and sequestration
- Cellular growth can be enhanced during chronic irradiation
- Genome sequence is available for data mining, genome expression, and bio-molecular discovery



Post-irradiation (17 kGy) recovery of *Kineococcus*.

Potential for new biomolecular products and enzymes, potent anti-oxidants, and novel mechanisms for radiation resistance



UV resistance in *Kineococcus*.



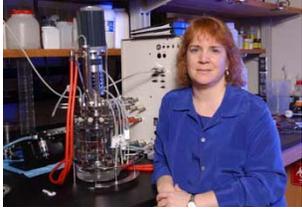
Biocollection/Biodetection/Biomonitoring



ALPES

- Pathogen monitoring
- Toxic mold and fungi
 - Developed and deployed spore sealants
- Immunodetection
 - > 120 monoclonals for specific bacteria
- Aerosol-to-Liquid Particle Extraction System (ALPES)
 - Top performer in deliberate release tests at Nevada Test Site
 - Currently optimizing for collection of viable *Fancisella*
 - Deploy in parallel with Biowatch Units in Houston
 - Partners: USAMRIID, LANL, CDC-Ft. Collins, City of Houston

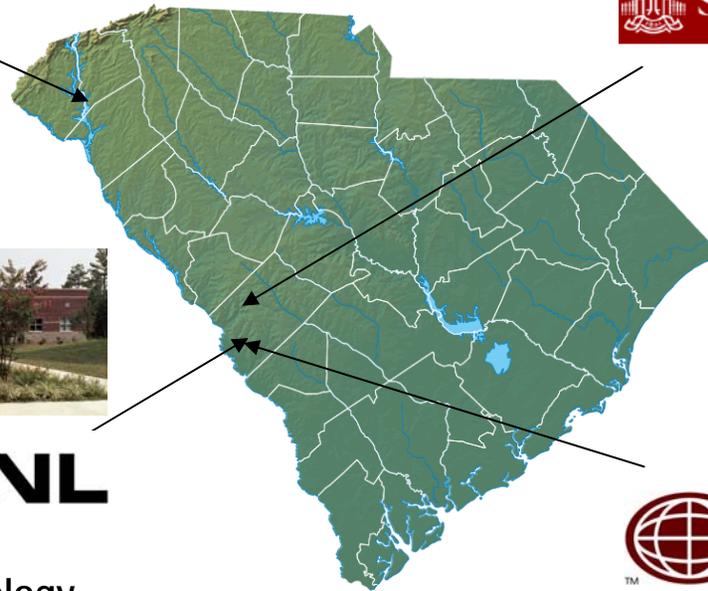
Biohydrogen/Bioproducts Team



Bioengineering
Aquaculture



Microbial Ecology
Microbial Physiology



Microbial Ecology
Molecular Biology
Microbial Physiology



Hydrogen Detection
Hydrogen Separation
Hydrogen Storage

