Solving Cleanup Challenges Through Risk Reduction

Green Remediation

Briefing for the Paducah Citizens Advisory Board
October 16, 2008

EM Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

Green Remediation

Green remediation is the practice of considering all environmental effects of remedy implementation and incorporating options to maximize net environmental benefit of cleanup actions.

From "Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites," USEPA, EPA 542-R-08-002

Core Elements of Green Remediation

Six core elements

1. Energy
2. Air
3. Water
4. Land and ecosystems
5. Materials and waste
6. Stewardship

From "Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites," USEPA, EPA 542-R-08-002

Green Remediation Objectives

- Achieve remedial action goals
- Support use and reuse of remediated parcels
- Reduce total pollutant and waste burdens on the environment
- Minimize degradation or enhance ecology of the site
- Minimize impacts to water quality
- Conserve natural resources
- Increase sustainability of site cleanups

From "Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites," USEPA, EPA 542-R-08-002

Examples of Green Remediation

- Bioremediation
- Phytoremediation
- Passive treatments
- Recovery and reuse of contaminants

From "Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites," USEPA, EPA 542-R-08-002

Green Remediation in Paducah

Green Remediation Evaluations at the Paducah Gaseous Diffusion Plant			
Technology	**Technology Description**	**Green Core Elements**	**PGDP Evaluation Results**
Permeable Treatment Zone	Small cuttings of iron are mixed with a carrying agent and injected into the subsurface in a linear pattern to create a "wall" where they interact with TCE and reductively dechlorinate the contaminant and "capture" Tc-99.	Energy - Passive	Performed treatability study for the technology in 2001. Due to injection methods and geologic conditions, the iron and carrying agent did not flow into the subsurface, but came back to the surface by migrating around packer systems and annular space. Systems also tend to plug over time and require remedial maintenance.
Bioremediation Enhancement of PCBs	Utilizes injection of bacteria and nutrients to enhance the natural degradation of the PCBs in the sediments.	Energy – Passive	PGDP supplied nutrients and bacteria to PCB-containing ditch sediments to destroy PCBs (Outfall 011). An area of Outfall 012 also was lined with coconut husks to further enhance the rate of PCB destruction.
Engineered Wetlands	Wetlands are constructed as a flow thru filter to contain metals migrating from source areas.	Passive after placement	USEC and DOE are constructing a wetland in Outfall 013 to filter metals migrating from cylinder yards.
Solvent Recovery	C-400 Project is going to condense TCE vapors and recycle the solvent to the degree possible.	Air, Material and Waste, and Stewardship	The action will utilize recycling of the reclaimed solvent to the degree possible. It will minimize waste generation since the solvent will not require oxidation and scrubbing resulting in the generation of additional waste materials.
Direct Anerobic Reductive Dechlorination (Bioremediation)	A biological reaction in which bacteria replace chlorine atoms with hydrogen atoms on a chlorinated hydrocarbon (e.g., TCE→*cis*-1, 2-DCE→vinyl chloride). Requires an environment with no oxygen.	Energy - Passive and Land and Ecosystems	Evaluated in GWOU FS in 2001. The RGA is an aquifer containing much oxygen, which must be removed to create the proper environment (i.e., anaerobic conditions). This environment must be maintained by providing food (e.g., lactate, vegetable oil, etc.) for the bacteria. The process is fast, but can result in producing degradation compounds that are more toxic than TCE. Also, cannot be used to address DNAPL.

Other Green Remediation Technology

Other Green Remediation Technologies			
Technology (Applicable Site)	**Technology Description**	**Green Core Elements**	**Considerations for Application**
Biobarrier (No Identified User)	Bacteria and nutrients are injected into the subsurface in specific areas. Over time, this creates large quantities of biomass that reduce hydraulic conductivity, thereby slowing or stopping contaminant migration.	Energy - Passive	Considered for a treatability study at PGDP, but was canceled due to inability to control flow and contaminant migration direction. May have limited impact in destroying or reducing contaminant levels.
Phytoremediation (Oak Ridge & Portsmouth)	Utilizes plants to remove, transfer, stabilize, or destroy contaminants in soil, sediment, and groundwater.	Energy – Passive, Land and Ecosystem, and Long-Term Stewardship	May be suitable for some areas of the Soil or Surface Water OUs. Groundwater is generally too deep at PGDP for use near the plant. May have some capability near Little Bayou Creek TCE groundwater seeps, but still will be very limited due to RGA thickness (30 ft). May bioaccumulate some radiological components. Does not operate when plans are not growing, such as in winter.
Passive Vapor Extraction/Baro-Balls/BioVenting (Sandia)	Utilizes borings to allow VOC contaminant vapor extraction through changes in atmospheric pressure. BaroBall valves may be used to prevent high atmospheric pressure from entering the subsurface thru the borings.	Energy - Passive	The vadose zone at PDGP is tight. Vacuum pumps utilized in soil gas testing encountered difficulty in extracting vapor. Remediation time frame would be expected to be similar to that for natural attenuation.

Other Green Remediation Technology

Other Green Remediation Technologies (Continued)			
Technology (Applicable Site)	**Technology Description**	**Green Core Elements**	**Considerations for Application**
Biowall (Multiple DOD Sites)	Biowalls are used to intercept and treat contaminated groundwater. Sections of the aquifer are trenched and replaced with mulch or compost, which provides food to bacteria and creates an anaerobic condition leading to anaerobic degradation. Biowalls also can be created with fluids such as vegetable oil.	Energy – Passive	Special considerations needed for PGDP include the total depth of the RGA (100 ft) and insuring that in-place permeability of mulch meets or exceeds that of native RGA materials.
Nano-Particle Injection (NASA – Cape Canaveral)	Nano-particles (10^{-9} meter) of zero-valent iron emulsions are injected into the aquifer and flow with the groundwater and reductively dechlorinate the TCE.	Energy – Passive	Special considerations needed for PGDP include the groundwater velocity of RGA water for retention time, migration of treatment materials outside of VOC impacted area, potentially negative impacts to land and ecosystems due to the particle size (10^{-9} meter) of treatment elements.
Geo-Siphon (Savannah River)	Utilizes siphon action to accelerate flow of contaminated water through reactive media to a discharge point. A large diameter well containing a treatment media is constructed. The natural head difference between the cell and discharge point to operate siphon.	Energy - Passive	PGDP hydrogeologic conditions provide the best applicable locations near Little Bayou Creek and Ohio River. May be applicable to the RGA seeps. Thickness of the RGA groundwater contaminant zone; minimal elevation differences between the creek, Ohio River, and RGA; and the need to place the siphon in the Ohio River floodplain may be limiting factors.

Other Green Remediation Technology

Other Green Remediation Technologies (Continued)			
Technology (Applicable Site)	**Technology Description**	**Green Core Elements**	**Considerations for Application**
Aerobic Oxidation (Cometabolic) (Savannah River, DOD, & Others)	Biological breakdown of TCE during which TCE is "cometabolized" by an enzyme produced by bacteria in the presence of oxygen. Results in the production of nontoxic degradation products.	Energy - Passive and Land and Ecosystems	Currently being studied by the KRCEE-led TCE Degradation Project Team. Process is slower than anaerobic, but uses the natural RGA conditions. May require enhancements to be effective. DNAPL toxicity may negatively impact the bacteria.

Conclusions and Path Forward

- DOE actions taken under CERCLA are designed to be consistent with green remediation principles
- DOE will incorporate reporting of green remediation aspects of remedial actions as part of the its ongoing pollution prevention reporting

For More Information

More information on bioremediation and other green technologies can be found on these sites:

- http://www.frtr.gov/ (Federal Remediation Technologies Roundtable)
- http://www.itrcweb.org/ (Interstate Technology and Regulatory Council)
- http://cluin.org/greenremediation (EPA Technology Innovation Program)
- www.brownfieldstsc.org (EPA Brownfields Land and Revitalization Technology Support Center)