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Green Remediation Best Management Practices: Site Investigation

Office of Superfund Remediation and Technology Innovation

Quick Reference Fact Sheet

The U.S. Environmental Protection Agency (EPA) *Principles for Greener Cleanups* outline the Agency's policy for evaluating and minimizing the environmental "footprint" of activities undertaken when cleaning up a contaminated site.[1] Use of the best management practices (BMPs) recommended in EPA's series of green remediation fact sheets can help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome.[2]

Overview

The need for site investigation is common to cleanups under any regulatory program. An investigation can occur at all points in the cleanup process, from initial site assessment through waste site closeout. A site investigation generally is undertaken to:

- Confirm the presence or absence of specific contaminants
- Delineate the nature and extent of environmental contamination
- Identify contaminant sources
- Provide the data necessary to assess potential risk to human health and/or the environment
- Gather the data needed to determine if a remedial action should be taken
- Understand site characteristics impacting the remedy design, construction, or operation and closeout, and
- Evaluate performance of a remedial action.

Site investigations typically involve sampling of soil and groundwater using various drilling and well installation technologies and analysis of samples at offsite laboratories. Investigations also may include sampling of sediment, surface water, soil gas, or indoor air; searching for underground storage tanks (USTs) or other buried objects; or evaluating demolition material containing asbestos, lead-based paint, or other toxic products.

Planning for Site Investigation

Consideration of green remediation options early during the project design phase will help reduce cumulative environmental footprints of a cleanup. Effective planning will include identification of investigative decision points in context of a site's unique contamination scenario and logistics, while accounting for potential remedies and anticipated site reuse.

At each decision point, strategies and methods can be evaluated to determine which are likely to best address the core elements of a green cleanup:

- Reducing total energy use and increasing renewable energy use
- Reducing air pollutants and greenhouse gas (GHG) emissions
- Reducing water use and negative impacts on water resources
- Improving materials management and waste reduction efforts, and
- Enhancing land management and ecosystems protection.

A green site investigation relies on information gained from a thorough preliminary assessment that identifies target areas and site conditions through minimally intrusive techniques. Use of innovative field analytics and direct sensing tools can reduce the environmental footprint of follow-on characterization or cleanup activities, particularly by limiting mobilizations in the field and increasing the density of analytical data. More targeted remedial actions and "surgical" removal actions also can be achieved through use of high resolution sampling tools during site investigations.

Initial BMPs for a site investigation include:

- Evaluating feasibility of using a mobile laboratory, field analytical methods, or direct sensing tools
- Scheduling activities for appropriate seasons to reduce delays caused by weather conditions and fuel needed for heating or cooling
- Identifying local sources of energy efficient machinery and vehicles and alternative fuels
- Establishing electronic networks for data transfers and deliverables, team decisions, and document preparation, and selecting electronic products on the basis of comparisons available in the Electronic Product Environmental Assessment Tool (EPEAT®)
- Selecting facilities with green policies, for worker accommodations and periodic meetings
- Reducing travel through increased teleconferencing, compressed work hours, and flexible work locations, and
- Identifying options for integrating renewable energy resources, including those extending throughout cleanup activities.

Portable electricity generators equipped with photovoltaic panels and batteries can be used to power investigative equipment such as chilling or heating units.

Procurement of goods and services offers other opportunities for conserving natural resources:

- Incorporate green specifications into solicitations and contracts, with respect to environmentally preferred purchasing of materials, awards to contractors with green policies and procedures (such as routine use of water efficient and Energy Star® equipment) and periodic reporting of resource reductions
- Select service providers, product suppliers, and analytical laboratories from the local area and coordinate service and delivery schedules, to reduce fuel consumption and associated air emissions, and
- Specify laboratory analytical methods generating less waste and solvents, such as solid phase micro extraction (SPME), pressurized fluid extraction, microwave extraction, and supercritical fluid extraction, if comparable accuracies can be achieved; for example, SPME provides a single-step process that can reduce sample preparation time by as much as 70% while using little or no solvents.

Collection of representative data during the first round of field activities reduces the need for subsequent sampling. Development of a well conceived site sampling plan can help assure that collected data truly represent a site. Systematic planning, a critical component of optimized strategies for investigating hazardous waste sites, involves identifying key decisions to be made, developing a conceptual site model (CSM) to support decision making, and evaluating decision uncertainty along with approaches for actively managing that uncertainty. The CSM combines analytical data with historical information to identify data gaps and allows for refinement as additional data become available.

Collecting information dynamically and in real time and adjusting the work according to the field findings will minimize mobilizations. Dynamic work strategies that employ data visualization, dynamic sampling programs, and quality controls to minimize uncertainties reduce the need for repeated mobilizations and additional sampling. Use of the Triad approach can help project managers integrate systematic planning, dynamic working strategies, and deployment of these real-time measurement tools. [3]

Energy Use & Renewable Energy

Fewer field mobilizations can result in significant savings of fossil fuel and minimized emission of GHG and other air pollutants. Real-time field measurements can immediately provide data to help determine the next course of action during a single sampling event. Real-time data collection technologies include:

- Direct sensing technology such as the membrane interface probe, laser-induced fluorescence (LIF) sensor, and cone penetrometer testing (CPT)
- X-ray fluorescence analyzers for metals
- Soil gas surveys for volatile organic compounds (VOCs)
- Portable gas chromatography/mass spectrometry for fuel-related compounds and VOCs in soil and groundwater
- Field test kits for analyzing soil and groundwater contaminants such as petroleum, metals, polychlorinated biphenyls, pesticides, explosives, and inorganics, and
- Geophysical surveys for locating USTs, buried steel drums, and boundaries of disposal areas.

Profile: McGuire Air Force Base, C-17 Hangar Site, New Hanover, NJ

- *Used a Triad decision making approach to complete characterization of VOC contamination of soil and groundwater ahead of schedule, consequently reducing the fuel consumption, land disturbance, and dust generation associated with additional sampling days*
- *Used investigative tools such as CPT and fuel fluorescence detectors to generate over 4,500 analytical results in real time, which expedited decision making in the field and avoided fuel use associated with transporting samples to an offsite laboratory*
- *Determined through real-time measurements that natural attenuation of halogenated VOCs was occurring, and avoided excess land disturbance and fuel consumption by incorporating monitored natural attenuation into the remedy*
- *Precisely identified a smear zone of Stoddard solvent, allowing it to be surgically excavated with minimal land disturbance and fuel consumption*

Recommended BMPs for selecting other equipment and processes that minimize fuel and energy consumption include:

- Limiting the number of vehicles deployed onsite, and renting electric, hybrid, or hydrogen fuel cell vehicles
- Instituting idle reduction plans, such as machinery shutdown after three minutes of non-use
- Compressing shipments to offsite laboratories whenever feasible
- Using in situ data loggers wherever appropriate to monitor water levels and water quality parameters

- Using solar-powered telemetry systems to remotely transmit logging data directly to project offices
- Using rechargeable batteries for handheld data loggers and other field instruments
- Using direct-push technology (DPT) for well drilling, which is 50-60% more time efficient than rotary drill rigs and avoids drill cuttings that require assessment and disposal of investigation-derived waste (IDW)
- Segregating soil and groundwater collected from different areas; in many states, media analytically determined to be clean can be deposited onsite rather than transported for offsite disposal, and
- Disposing IDW at the nearest permitted facility.

Air Pollutants & GHG Emissions

Air emissions from mobile sources can be reduced through use of various new technologies. Diesel emission control filters, for example, can reduce particulate matter emissions by as much as 89% and nitrogen oxide emissions by as much as 80%. Switching from low-sulfur to ultralow-sulfur fuels will reduce emissions of sulfur dioxide (an acid rain-causing air pollutant) and also allows use of emission control systems that would be damaged by fuels with a higher sulfur content. Ultralow-sulfur diesel has become the standard in most states; it contains no more than 15 ppm sulfur (S), in comparison to the 500 ppm S in low-sulfur diesel.

Any technology that reduces duration of drilling and groundwater pumping or purging helps reduce the cumulative amounts of pollutants released to the air. Examples include sonic drilling and passive (diffusion-based) sampling devices.

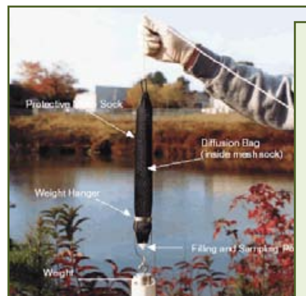
Deployment of diesel-powered machinery, vehicles, and equipment over six months of investigations could emit nearly 32,000 pounds of CO_2, based on a consumption of more than 1,400 gallons of diesel.[4]

Relative Diesel Consumption of Common Investigative Activities over Six Months (gallons)	
Transportation, operation, and support for a rotary drilling rig for four weeks	293
Groundwater sampling with a submersible pump driven by a 2.5-hp gasoline-powered generator	45
Deployment of a truck-mounted DPT rig for subsurface sampling	400
Operation of utility trucks for equipment maintenance, groundwater and soil sampling, and oversight	300
Periodic truck delivery of small equipment and supplies and disposal of nonhazardous waste	260
IDW transfer to a disposal facility by way of tractor trailer	125
Total diesel consumed: 1,423 gallons	

Water Use & Impacts on Water Resources

Green remediation strategies help reduce consumption of fresh water, reclaim or reuse uncontaminated water, minimize potential for waterborne contamination, and minimize introduction of toxic processing materials during a site investigation. Recommended best practices include:

- Using waterless drilling techniques such as DPT
- Exploring options for reusing operational graywater and capturing rainwater for tasks such as irrigation or dust control
- Returning unused clean water to surface water bodies rather than discharging it to a public sewer system
- Using low-flow sampling equipment wherever possible during monitoring, to minimize purge volumes and energy consumption while producing little IDW



Use of passive diffusion bag samplers reduces or eliminates purge water associated with well sampling; multiple vertically-placed samplers can provide a vertical profile of groundwater samples at one-foot intervals.

- Steam-cleaning or using phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment
- Containing decontamination fluids and preventing their entrance into storm drains or the ground surface
- Treating potentially contaminated purge water through use of appropriate treatment techniques such as activated carbon filtration prior to discharge to storm drains or waterways
- Using closed-loop cleaning systems relying on graywater to wash non-sampling related machinery and equipment
- Using biodegradable hydraulic fluids on hydraulic equipment such as drill rigs
- Selecting groundwater monitoring equipment made of noncorrosive material, to avoid potential cross-contamination and equipment replacement, and
- Quickly restoring any vegetated areas disrupted by equipment or vehicles, to control stormwater runoff and avoid soil transport to surface water bodies.

Integrating the needs of remedial and monitoring phases during design of sampling wells will help reduce subsurface drilling throughout the life of a cleanup. Well designs also can accommodate a site's potential cleanup remedy(s) and reuse goals, in ways that meet the site's future demand for water while preserving any portions of the property targeted for specific use.

Materials Management & Waste Reduction

Site investigation procedures typically involve use of an assortment of manufactured products such as personal protective equipment (PPE), sample containers, and routine business materials. Green purchasing considers product lifecycles and gives preference to:

- Products with recycled and biobased contents such as agricultural or forestry waste instead of petroleum-based ingredients
- Products, packing material, and disposable equipment with reuse or recycling potential, and
- Products manufactured through processes involving nontoxic chemical alternatives.

IDW generation and management account for a significant portion of the environmental footprints of site investigation. IDW includes drill cuttings, well purge water, spent carbon from filtration equipment, reagents used with environmental field test kits, contaminated PPE, and solutions for decontaminating non-disposable PPE and equipment.

Reducing the volume of generated IDW will decrease the need for related containers such as plastic disposal bags and 55-gallon storage drums, and for treatment or disposal of IDW in an appropriate hazardous or nonhazardous waste facility. Recommended BMPs to reduce the volume of routine waste or IDW and decrease materials consumption include:

- Recycling cardboard boxes and beverage bottles
- Reducing use of single-use plastic bags
- Reducing the number of sampling days
- Using onsite analysis and other real-time measurement technologies to reduce needs for sample packing materials
- Selecting test kits that generate less waste, such as soil samplers with reusable handles for coring syringes, and
- Segregating drill cuttings by appropriately stockpiling next to a borehole and awaiting analytical results; under many cleanup programs, clean soil may be distributed near boreholes or backfilled into a boring.

Explore Web-based calculators, software models, and other *Footprint Assessment* tools accessible on Green Remediation Focus (http://www.cluin.org/greenremediation), such as the:

- CICA Compliance Summary Tool, to evaluate construction impacts on land, ecosystems, and water
- Energy & Materials Flow & Cost Tracker (EMFACT™), to track materials, energy use, wastes, and costs
- Greenhouse Gas Protocol, to quantify and manage GHG emissions
- MotorMaster+, to select energy efficient motors, and
- Water Evaluation and Planning System (WEAP), to conduct integrated water resource planning

Land Management & Ecosystem Protection

Site investigation activities can disturb a significant amount of land in order to gather the necessary data. Project managers should consider technologies resulting in limited subsurface intrusion and minimal land impacts:

- Ground penetrating radar or other geophysical methods can identify subsurface anomalies such as USTs and buried drums without disturbing land.
- DPT for soil and groundwater sampling do not result in drill cuttings or excess soil waste and related IDW.
- A wide range of direct sensing tools such as the LIF sensor are now available to develop a nearly continuous vertical profile of some volatile and semi-volatile contaminants in the subsurface, both above and below the water table.
- Soil gas surveys are minimally invasive and can provide relatively rapid and cost-effective information about the presence, composition, and distribution of contaminants in the vadose zone and water table.

A Sampling of Success Measures for Site Investigation

- *Reduced fuel consumption and GHG emissions through integrated planning of field activities*
- *Increased use of solar energy-driven auxiliary equipment and small devices*
- *Reduced generation of wastewater from well drilling and sampling*
- *Reduced subsurface and ecosystem disturbance through more use of advanced sampling technologies and visualizing techniques*
- *Fewer soil and groundwater samples needing offsite laboratory analysis*

References [Web accessed: 2009, November 30]

[1] U.S. EPA; *Principles for Greener Cleanups;* August 27, 2009; http://www.epa.gov/oswer/greencleanups

[2] U.S. EPA; *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*; EPA 542-R-08-002, April 2008; http://www.cluin.org/greenremediation

[3] Interstate Technology & Regulatory Council; *Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management*; December 2003; http://www.triadcentral.org/

[4] U.S. EPA; *Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel*; EPA420-F-05-001

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