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Green Remediation Best Management Practices: Sites with Leaking Underground Storage Tanks

A fact sheet about the concepts and tools for using best management practices to reduce the environmental footprint of activities associated with assessing and remediating contaminated sites

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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 involved in cleaning up contaminated sites.[1] Best management practices (BMPs) of green remediation involve specific activities to address the core elements of greener cleanups:

- Reduce total energy use and increase the percentage of energy from renewable resources.
- Reduce air pollutants and greenhouse gas emissions.
- Reduce water use and preserve water quality.
- Conserve material resources and reduce waste.
- Protect land and ecosystem services.

Overview

Approximately 543,800 releases of petroleum or hazardous substances from federally regulated underground storage tank (UST) facilities were confirmed by the U.S. EPA as of September 2018. Of these, approximately 65,450 releases at UST facilities had not yet reached the "cleanup completed" milestone.[2] State agencies maintain responsibility to implement and oversee cleanup of all UST releases except those on tribal lands, where the U.S. EPA has jurisdiction. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) estimated that in 2017, alone, state cleanup funds collectively spent approximately $1.113 billion in cleaning up UST releases.[3] Private insurance policies and other financial responsibility mechanisms, along with a relatively small amount of money from the federal Leaking Underground Storage Tank (LUST) Trust Fund, additionally fund UST cleanups.

Releases from USTs storing petroleum commonly involve contaminants such as benzene, toluene, ethylbenzene and xylenes (BTEX) and sometimes other chemicals of concern such as methyl *tert*-butyl ether (MTBE), ethanol, or lead scavengers (ethylene dibromide and 1,2-dichloroethane). UST releases of petroleum hydrocarbons also may result in petroleum vapor intrusion into overlying or nearby buildings.[4] In contrast, a release from an UST storing chemicals could involve any of the approximate 1,200 substances (excluding radionuclides) currently identified as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act.

In addition to one or more tanks, an UST system typically comprises pipes, fittings, pumps, dispensers and leak detection or containment devices. Common causes of UST releases include corrosion, structural failure, faulty installation or advanced age of equipment as well as operator errors. The federal UST regulation, as revised by the U.S. EPA in 2015, now specifies requirements for secondary containment, operator training, and operation and maintenance.[5] At some sites, removal of one or more LUSTs and associated remediation of contaminated groundwater, soil or surface water are conducted under broad cleanup initiatives such as Superfund, federal facility restoration or brownfields programs.

Use of green remediation BMPs can help minimize the environmental footprints of cleaning up sites where UST releases have occurred. BMP implementation at such sites is intended to complement rather than replace requirements under federal or state-specific UST regulations.[6]

> Most UST releases involve petroleum fuel rather than chemicals containing hazardous substances, and most involve retail fueling stations on relatively small land parcels. Many UST cleanup projects are of relatively short duration.

Project Planning

Environmental footprint reductions throughout the life of an UST cleanup can be gained through BMPs focused on green purchasing and other aspects of sustainable materials and waste management, such as:

- Choose products manufactured through processes involving nontoxic chemical alternatives.
- Select products with recycled and biobased contents such as agricultural or forestry waste.
- Use products, packing material and disposable equipment with reuse or recycling potential.
- Select locally made materials whenever possible.

Other BMPs concerning project administration for an UST cleanup include:

- Contract a laboratory using green practices and environmentally friendly chemicals.
- Prepare, store and distribute documents electronically through an environmental information management system.
- Reduce travel through increased teleconferencing and use of nearby facilities when project meetings or lodging are needed.
- Establish record-keeping procedures for environmental footprint metrics such as fuel consumption and material recycling.

Petroleum product leaking from tanks at the Telles Ranch site on the Colorado River Indian Tribes Reservation resulted in free product up to 3.5 feet thick in groundwater monitoring wells and product seepage into an adjacent irrigation drainage canal. After the seepage was contained, a free-product recovery system began operating. Use of the **ASTM Standard Guide for Greener Cleanups**[7] helped U.S. EPA project managers identify four BMPs to be considered for future implementation, such as purchasing renewable electricity and using solar power packs. Use of the ASTM standard also helped identify 18 other BMPs already in place, such as using a passive/no purge system for groundwater sampling, using a telemetry system to monitor product levels in the tank storing recovered product, and recycling the recovered product.[8]

Site Characterization

Integration of green remediation BMPs during site characterization and other early stages of an UST site cleanup can help reduce the project's cumulative environmental footprint. BMPs concerning sample collection and analysis include:

- Use dynamic, adaptive management strategies to minimize energy and other resources needed for field mobilization.
- Deploy geophysical tools such as ground penetrating radar to define the boundaries of tanks and other buried objects without disturbing land.
- Maximize use of portable meters with photoionization or flame ionization detectors to screen soil cuttings or sample cores for contaminant presence, which minimizes initial need for sample analysis by offsite laboratories.
- Select direct-push (DP) tools to collect subsurface samples rather than conventional auger systems that typically involve more fuel consumption, land disturbance and investigation-derived waste such as drill cuttings.
- Equip DP rigs with real-time, direct-sensing tooling such as membrane interface probes or laser induced fluorescence to minimize separate mobilization of field crews with portable or hand-held sensors.
- Use a multi-port sampling system in groundwater monitoring wells to minimize the number of wells needing to be installed.
- Use low/no-purge technologies such as passive diffusion bags to sample groundwater or saturated sediment, which minimize sampling visits, material consumption and wastewater generation.
- Use field test kits when feasible to minimize needs for offsite analysis of samples and associated sample shipping, and select test kits that generate minimal waste.
- Use a mobile laboratory or portable equipment for chemical analysis in the field, except when fixed laboratory analysis is required for purposes such as confirmatory testing.

Additional BMPs are described in other U.S. EPA fact sheets addressing topics such as site investigation and environmental monitoring, excavation and surface restoration, remediation technologies, or project aspects such as clean fuel and emission technologies.[9]

Other field techniques can help reduce the environmental footprint of site characterization activities as well as later corrective actions, such as:

- Use borehole purge water that is uncontaminated or treated rather than potable water to prepare grout needed for wells and pipes.
- Use biodegradable hydraulic fluids to operate equipment such as hydraulic drill rigs.
- Steam-clean or use phosphate-free detergents instead of organic solvents or acids to decontaminate equipment not used directly for sample collection.
- Contain and properly dispose of decontamination fluids, to prevent their entrance into storm drains or ground surfaces.
- Stockpile segregated drill cuttings for potential onsite distribution of clean soil.

UST System Removal

Removal of an UST system typically involves excavation and transfer of various wastes to offsite facilities. As a result, deployment of heavy non-road machinery and equipment powered by internal combustion engines may account for a significant portion of an UST cleanup's environmental footprint. BMPs aimed to reduce consumption of diesel or other forms of fuel and minimize associated emission of air pollutants during UST removal, as well as subsequent environmental remediation, include:

An UST cleanup that involves excavating 5,000 cubic feet of soil and operating a soil vapor extraction system over three years for deeper soil could emit 190 tons of carbon dioxide equivalent, approximately the same amount emitted through electricity consumption of 21 homes over one year.

- Implement idle reduction techniques such as restricting engine idle to a specific duration and using auxiliary power units to power cab heating and air conditioning when the machinery/equipment is not actively engaged.

- Retrofit aged diesel-powered machinery/equipment with advanced technologies such as diesel oxidation catalysts, diesel particulate matter filters and partial diesel particulate filters.
- Choose waste hauling companies using tractor-trailers equipped with aerodynamic devices, low-rolling resistance tire technology and other verified technologies aimed to increase fuel efficiency and reduce diesel emissions.[10]
- Reduce targeted air emissions or particulate matter through use of fuel additives verified by agencies such as the California Air Resources Board.[11]
- Use solar power packs to operate portable equipment, hand-held devices and temporary electrical fixtures.
- Consolidate deliveries of incoming materials or equipment to avoid deploying partially filled trucks.

Various state programs may include greener cleanup specifications. For example, the Indiana brownfields program administering the state's petroleum orphan sites initiative now requests consultants to include green remediation strategies in project bids.[12]

Green remediation BMPs applying to the process of emptying, excavating and disposing of an UST system include:

- Cover ground surfaces with impermeable, re-useable fabric in areas used for fluid extraction and transfer.
- Control odor and fugitive dust by applying biodegradable foam on equipment and soil surfaces.
- Segregate and stockpile excavated soil and material that is clean or minimally contaminated for beneficial reuse.
- Use surgical excavation techniques that are based on well-defined boundaries of the subsurface objects needing removal, to avoid unnecessary land disturbance.
- Flush system pipes with nitrogen instead of water, to reduce wastewater generation while removing explosive gas.
- Transfer extracted fuel or chemicals to local recyclers that use environmentally sound procedures.
- Minimize the volume of water used for rinsing a tank.
- Reuse available drums to store tank sludge that requires offsite disposal.
- Dispose of tanks, pipes and other metal components of an UST system at a state-approved or -certified tank disposal yard for recycling, to reduce burdens on the local landfill.
- Salvage demolition debris such as metal canopies, tank pad cement and parking area asphalt for transfer to local recyclers rather than the local landfill.
- Remove and preserve healthy shrubs that obstruct machinery access, for re-planting during site restoration.

Restoration of land disturbed by tank system removal may include BMPs such as:

- Choose native species of plants for revegetation, which typically need little or no maintenance such as mowing or irrigation.
- Use a mix of trees, shrubs, grasses and forbs that fosters biodiversity and related ecosystem services.
- Use woody debris reserved during excavation to develop landscaping or create habitat for wildlife and pollinating insects.
- Integrate green infrastructure elements such as rain gardens or bioswales to minimize stormwater runoff in urban settings.[13]
- Replace damaged concrete or asphalt surfaces with pervious materials such as permeable pavers in areas not requiring impervious surface, to increase infiltration and subsurface storage of precipitation .

Remediation of Contaminated Environmental Media

Cleanup remedies for UST sites may involve one or a combination of technologies such as groundwater pump-and-treat systems, soil excavation and offsite disposal, soil vapor extraction, air sparging, bioventing, bioremediation, dual-phase extraction or in situ chemical oxidation. BMPs applying to multiple technologies include:

- Reuse existing wells to inject or extract fluids, and design new wells for future reuse.
- Reuse existing structures to house treatment systems, supplies and field equipment.
- Maximize use of gravity flow rather than active pumping to introduce, withdraw or transfer fluids within a treatment system.
- Install one-way check valves in well casings to promote barometric pumping, which extracts soil vapor through a passive energy process.
- Use onsite renewable energy to power equipment with a low or intermittent energy demand, such as wind power to drive an air compressor or photovoltaic power to operate a chemical injection pump.
- Assure proper sizing of remediation equipment, to maximize energy efficiencies.
- Use centrifugal blowers rather than positive displacement blowers with intake air-line mufflers, to reduce noise generation.
- Soundproof all aboveground equipment housing.

Corrective action was taken at the Rainbow Valley Citrus Maintenance Yard Facility in Goodyear, Arizona, to remediate groundwater contaminated by petroleum hydrocarbons released from two USTs. Renewable energy rather than grid electricity powered equipment that collected off-gas from two vapor extraction wells during air sparging. The energy was generated by a 2.5 watt solar-powered fan assembly on a vent pipe above each well. When compared to use of a 5 horsepower electrical blower, this approach avoided using about 20,000 kilowatt hours of electricity over 10 months, avoided associated emission of about 13.8 metric tons of carbon dioxide equivalent, and saved about $13,000 in cleanup costs.[14]

- Operate all or portions of a remediation system during off-peak hours to reduce demands on the local electricity grid (and cost of electricity purchasing), if the targeted rate of remediation progress can be maintained.
- Operate pumps in pulsed mode when nearing asymptotic conditions or when continuous pumping is not needed to contain a plume or reach cleanup objectives.
- Optimize treatment systems periodically to maintain peak operating performance and identify opportunities for taking any equipment offline as cleanup progresses.
- Switch to a "polishing" technology once effectiveness of an existing treatment system declines, as evidenced by significant decreases in mass recovery rates.
- Use passive sub-slab depressurization system to mitigate vapor intrusion in buildings when practicable.
- Recover and recycle recovered product or separated non-aqueous phase liquid through local fuel or waste recyclers.
- Use automated data logging systems with equipment such as electronic pressure transducers and thermocouples for in situ monitoring, which minimizes sampling visits over extended periods.
- Reuse or reinject treated/uncontaminated groundwater where allowed, instead of discharging it to surface water or publicly-owned treatment works.
- Develop a remediation infrastructure that can be integrated with site reuse, such as designing subsurface pipe networks that can first convey water for treatment and later convey water for onsite irrigation.

Cleanup at the 34-acre former AM General/LTV Aerospace and Defense Facility brownfield site in South Bend, Indiana, involves remediating soil and groundwater contaminated by petroleum fuels, solvents and other materials stored in 39 USTs. About 99% of the materials deconstructed from the site's 665,000-square-foot former manufacturing plant were salvaged for recycling or onsite use such as constructing buildings. The site's multi-phase extraction system is supported by a fuel product recovery process partially powered by two mechanical windmills, each of which pumps up to 1.5 gallons per minute.

Decisions about BMP selection and implementation can be enhanced by assessing the environmental footprint of cleanup activities on a site-specific basis, particularly for a large or complex site. For example, EPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint* can help project teams identify and quantify relevant footprint metrics and select BMPs that best target contributions to the footprint.[15] Implementation of some BMPs at an UST site may be restricted or infeasible due to requirements of a state's LUST program and other state regulations or to factors such as limited availability of preferred products and services.

Organizations managing multiple UST cleanups may save resources by using EPA's methodology, the ASTM *Standard Guide for Greener Cleanups* or other tools to develop a BMP implementation plan tailored to site-specific conditions. Practices established by federal or state programs and business sectors also could be explored. The state of Arizona, for example, recommends certain practices to improve environmental outcomes of site cleanups, including those involving tank excavation or replacement.[16]

This fact sheet provides an update on information compiled in the December 2008 "Best Management Practices for Excavation and Surface Restoration" fact sheet (EPA 542-F-08-012), in collaboration with the Greener Cleanups Subcommittee of the U.S. EPA Technical Support Project's Engineering Forum.

To view BMP fact sheets on other topics, visit CLU-IN Green Remediation Focus: www.clu-in.org/greenremediation.

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