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Green Remediation Best Management Practices: Excavation and Surface Restoration

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

Excavation of soil, sediment or waste material is often undertaken at contaminated sites to:

- Address immediate risk to human health or the environment as part of immediate or long-term removal actions.
- Prepare for implementation of in situ or ex situ remediation technologies and construction of associated infrastructure.
- Address contaminant hot spots in soil or sediment for which other remedies may be infeasible due to extremely high cost, long duration or technical constraints.

Many opportunities exist to reduce the environmental footprint of excavation activities and final restoration of disturbed land, surface water and ecosystems. Excavation as well as subsequent backfilling activities rely on use of heavy earth-moving machinery and often involve managing large volumes of material.

Project Planning

Early and integrated project planning allows excavation approaches to set the stage for sharing natural resources, processes and infrastructures throughout site investigation, remediation and reuse. Planning-related BMPs for excavation projects include:

- Maximize use of available satellite imagery to define the boundaries of excavation areas and operate machinery in the field with high "surgical" precision.
- Incorporate a high-resolution site characterization strategy, which uses high-density data sets rather than repeated field mobilizations to address information gaps as cleanup progresses.
- Establish a dynamic work strategy, which provides flexibility to adjust cleanup activities according to real-time field measurements. For example, screening soil samples at pre-determined decision points through use of laser-induced fluorescence technology might indicate that contaminated subsurface material in some areas could be left in place and covered with clean material instead of excavated.
- Develop advanced schedules for anticipated onsite activities, to minimize traffic between onsite contaminated and clean zones and the days in which work is actively performed in the field.
- Identify onsite or nearby sources of topsoil, to avoid long-distance transport of clean soil. Options may include onsite manufacturing of topsoil through use of locally sourced industrial byproducts such as compost or silica-based spent foundry sands.[2]

Waste coordination assistance is offered by many state and municipal agencies to plan beneficial reuse of excavated materials. For example, the New York City Clean Soil Bank (CSB) matches projects generating surplus clean native soil with projects needing soil for construction. In the first three years of operation, the CSB enabled a 1.2 million-mile reduction in truck transportation, which reduced diesel fuel consumption by approximately 250,000 gallons.[3]

- Identify onsite or nearby sources of backfill material such as shredded tires or crushed concrete.
- Incorporate green requirements into cleanup and supporting service procurements.
- Choose service providers with local offices, to minimize the distance of worker commutes and machinery transport.
- Choose equipment and product vendors with nearby production or distribution centers, to minimize delivery-related fuel use.
- Retrieve native, noninvasive plants for later replanting.
- Rescue and relocate wildlife that rely on habitat in areas to be excavated. Many environmental, academic or community groups offer help in conducting wildlife rescues and compiling wildlife or plant inventories.
- Identify existing or anticipated ecosystem services to be considered in project designs.[4]

Onsite air emissions can be reduced by finding opportunities to use less fuel. Selection of BMPs may be influenced by site conditions, the regional air quality status, local ordinance or the weather anticipated during field work. Related BMPs that may be incorporated into project plans include:

Consumption of fuel and associated emission of air contaminants typically account for a major portion of the environmental footprint of excavation and backfilling activities.

- Use fuel-efficient on-road vehicles such as hybrid electric sport utility vehicles and pickup trucks.
- Use off-road machinery fueled by biodiesel blends that minimize emission of particulate matter.
- Use on-road or off-road utility vehicles fully powered by electricity.
- Use retrofitted diesel-fired machinery or portable equipment with emission control technologies such as diesel oxidation catalysts, diesel particulate filters or approved fuel additives. Information on verified technologies is available from the U.S. EPA[5] or California Air Resources Board.[6]

BMPs to reduce diesel fuel consumption and associated air emissions from trucks or tractor trailers that will transfer excavated soil or other materials to offsite locations for disposal, recycling or reuse include:

- Select the closest qualified waste facility.
- Combine excavated material with comparable waste generated at nearby sites, for consolidated transfer in a single trip or fewer trips to the intended facility or site.
- Choose trucking fleets that use vehicles equipped with fuel efficiency options such as tractor-trailer skirts and air tabs as well as clean diesel technology, which is generally available in newer trucks or through engine and emission system retrofits in older trucks. Details about engine retrofits are available from the Diesel Technology Forum.[7]
- Use alternate shipping methods that may be available, such as rail lines.

Field Activities

The amount of diesel fuel needed to operate heavy machinery such as backhoes or graders may be reduced by BMPs such as:

- Deploy machinery that is suitably sized; use of undersized or oversized equipment can decrease efficiencies considerably.
- Use machine models capable of performing assorted tasks, whenever feasible, to avoid field deployment of multiple types of machines. For instance, a single excavator can be equipped with a bucket for digging, a breaker for demolition or a grapple for land clearing.
- Use an automated coupling system rather than a manual pin-on system for changing excavator attachments, to reduce machine operating time.
- Incorporate electronic intelligence systems to improve productivity within and among field machines. "Smart" systems enable work managers to remotely monitor field operations via machine-to-machine communications and identify changes to be made by machinery operators accordingly.
- Use machines with variable-speed control technology, which automatically reduces engine speed during low workload requirements, or with pump torque control, which allows a machine operator to change a machine's hydraulic pump torque.
- Use machines with repowered or newer engines that are more fuel efficient.
- Implement an engine idle reduction plan to avoid fuel consumption when machinery is not actively engaged. Options include manual shutdown after a specified time such as five minutes, engagement of automatic shutdown devices, or use of auxiliary power units to heat or cool machinery cabs.
- Perform routine, on-time maintenance such as oil changes to assure fuel efficiency.

Characterization and excavation of lead-contaminated soil at the Ross Metals Inc. NPL site in Rossville, Tennessee, were completed simultaneously through high-resolution site characterization and dynamic work strategies deployed in a single field mobilization. Real-time measurements were made with a portable x-ray fluorescence (XRF) spectrometer, which reduced the need for sample analyses by an offsite laboratory and avoided potential overexcavation. Following excavation and offsite disposal of approximately 70,600 cubic yards of material, additional XRF data combined with offsite laboratory analytical results confirmed that the site's targeted standard for lead in residential soils had been met.[8]

- ♦ Deploy direct-push technology (DPT) instead of rotary drilling rigs whenever feasible for additional subsurface sampling or for monitoring well installation. DPT can reduce drilling duration by as much as 50-60% while eliminating generation of drill cuttings or the need to dispose of drilling fluids.

The amount of additional diesel fuel as well as gasoline, propane or non-rechargeable electric batteries needed to operate small or mid-sized auxiliary field equipment can be minimized by using onsite sources of renewable energy. Relevant BMPs include:

By reducing the need to transport liquid fuel or extend the local electricity grid, onsite renewable energy offers the potential to significantly reduce the environmental footprint of excavation at sites in remote areas, such as former mining sites.

- ♦ Use solar power packs to recharge batteries in small electronic devices such as cell phones, laptop computers and sensors.
- ♦ Deploy mobile power systems to operate construction equipment or tools such as electricity generators, chainsaws, wood chippers, refrigeration units, or temporary lighting fixtures. Mobile power systems typically use maneuverable photovoltaic (PV) panels or small wind turbines that can be easily transported via carts, pick-up trucks or trailers.
- ♦ Install a ground-mounted PV array, wind turbine or mechanical windmill to power equipment needed for long-term site monitoring or maintenance. If properly scaled and configured, these renewable energy systems also could power equipment for other remediation activities such as groundwater pumping.

Generation of dust and potential mobilization of airborne contaminants during excavation and backfilling can be reduced through BMPs such as:

- ♦ Limit the speed of trucks and other vehicles traversing the site to 10 miles per hour.
- ♦ Spray water onto surfaces of vulnerable work areas, in conjunction with water conservation and runoff management techniques.
- ♦ Emplace a fabric cover over excavated material that is loaded into open trucks for onsite or offsite hauling.

Green remediation strategies also help reduce consumption of fresh water, reclaim or reuse uncontaminated water, and avoid introduction of toxic processing materials into groundwater or surface water. Related BMPs include:

- ♦ Cover soil in work areas with tarps or heavy mats for dust suppression, instead of periodically spraying water onto exposed surfaces. Use of biodegradable cover fabric will help control erosion and provide a substrate for future plant growth. Alternatively, a synthetic fabric can often be reused for other purposes.
- ♦ Contain and properly dispose of all decontamination fluids to prevent their entrance into storm drains or ground surfaces.
- ♦ Use graywater that may be available from onsite or nearby sources for purposes such as washing or steam-cleaning excavation machinery or irrigation of affected vegetation.

Other BMPs focus on preserving water quality and conserving natural resources during the process of dewatering contaminated sediment after its excavation or dredging:

- ♦ Lay synthetic barriers and fluid collection systems on ground surfaces of staging and work areas, to avoid introducing toxic materials to underlying groundwater.
- ♦ Avoid use of dewatering coagulants or flocculants containing chemicals that are potentially toxic to aquatic life.
- ♦ Use a passive rather than active mechanical process to dewater sediment when possible. A passive process relies on natural gravity flow and evaporation of the water rather than equipment such as filter presses powered by slurry pumps.
- ♦ Implement a dewatering process that maximizes recycling of slurry and other process water.
- ♦ Use geotextile bags or nets when possible to assure containment of excavated sediment during dewatering and to increase efficiency when handling and transporting the dewatered sediment.
- ♦ Transfer treated slurry water to other onsite areas or nearby sites for beneficial use in remedial or non-remedial applications such as wetlands enhancement or plant irrigation.

Designs for backfilling, grading and stabilizing a 3-acre basin affected by mining waste at the Elizabeth Mine NPL site in South Strafford, Vermont, included intent to mirror the site's natural contours and drainage patterns. The fully graded surfaces were seeded with native plant species that target Vermont state conservation and wildlife goals.

Other BMPs used at this 250-acre site included using biodiesel to operate heavy machinery; choosing machinery equipped with clean diesel technologies for excavation, waste consolidation and construction of a 45-acre capping system; using onsite resources to manufacture needed topsoil rather than importing raw materials; and choosing construction products verified as environmentally friendly or preferable. Use of biodiesel (B-20), alone, over six months of remedy construction was estimated to reduce emission of hydrocarbons and sulfur dioxide by 20%, carbon dioxide by 16% and particulate matter and carbon monoxide each by 12%.[9]

Countless and diverse manufactured products are purchased for use during excavation and surface restoration, such as personal protective equipment, synthetic sheeting and routine business materials. Green purchasing considers product lifecycles and gives preference to products with recycled and bio-based instead of petroleum-based contents; products, packing material and disposable equipment with reuse or recycling potential; and contents and manufacturing processes involving nontoxic materials. BMPs relating to environmentally sound purchasing include:

- Choose geotextile fabrics/tarps made of recycled material.
- Use hydraulic fluids that are biodegradable for operating equipment such as drill rigs.[10]
- Use phosphate-free detergents instead of organic solvents or acids to decontaminate equipment not used directly for sample collection.
- Substitute temporary silt fences with biodegradable erosion controls such as tubular devices filled with organic materials. Such devices capture sediment transported by stormwater runoff from or to adjoining slopes while building substrates for future vegetation.[11]

Selection of BMPs concerning excavation and surface restoration activities at a specific site can be facilitated through use of the ASTM Standard Guide for Greener Cleanups.[12] Use of the U.S. EPA *Methodology for Understanding and Reducing a Project's Environmental Footprint* and associated spreadsheets can additionally help project managers make informed decisions by quantifying the anticipated environmental footprint and adjusting project activities accordingly.[13]

BMPs focused on maximizing reuse or recycling of excavated material and minimizing generation of waste during the process of excavating contaminated material include:

- Segregate and stockpile drill cuttings generated by drilling, to facilitate onsite reuse of the material.
- Reclaim and stockpile uncontaminated soil for use as infill or other purposes such as habitat creation.
- Salvage organic debris that is uncontaminated and free of pests or disease, for use as supplemental infill, mulch or compost.
- Salvage uncontaminated objects with potential recycle, resale, donation or onsite infrastructure value, such as steel, concrete and granite.
- Designate collection points for recycling single-use items such as metal, plastic and glass containers; paper and cardboard; and other consumable items.

Cleanup at the 113-acre Curtis Bay Coast Guard Yard NPL site in Baltimore, Maryland, involved soil excavation, sediment dredging and extensive building demolition. Use of BMPs aimed at sustainable materials and waste management resulted in recycling of approximately 2,620 tons of concrete, 20 tons of steel, 110 tons of timber and 2,050 tons of petroleum-contaminated soil. The project's greener cleanup strategy also created approximately 60,000 square feet of greenspace and introduced drainage controls such as permeable pavement that allow infiltration of precipitation.[14]

Safeguarding Land & Ecosystems

Additional BMPs can be integrated in work plans to specifically address the potentially significant environmental footprint an excavation project may pose on land and ecosystems. Relevant BMPs include:

- Restrict machinery, vehicle and worker traffic to well-defined corridors that are minimally obtrusive.
- Place metal grates over thick mulch in onsite traffic corridors, which minimizes soil compaction while fostering subsurface infiltration of precipitation.
- Emplace geotextile surface material and quick-growth grass seeds in staging areas, to stabilize the underlying sod.
- Employ rumble grates with a closed-loop graywater washing system or an advanced, self-contained wheel washing system to minimize vehicle tracking of soil and sediment across non-work areas or offsite.
- Inspect equipment left onsite before renewing field activities, to avoid harming animals potentially nesting in the equipment. Operation of equipment with nest debris also could cause equipment inefficiency or breakdown.
- Limit use of artificial lighting that may disturb sensitive animal species.
- Avoid removing trees in staging areas or uncontaminated zones.
- Retain and use downed trees as habitat snags in onsite streams or forests.
- Replicate the site's original contours during soil grading.

Other BMPs focus on minimizing potential soil erosion due to stormwater runoff. For optimal efficiency, stormwater controls at excavation sites can be designed to meet needs of the site's future use. Examples include:

- Convert a portion of the excavation pit to a basin that can capture and store stormwater, instead of fully backfilling the pit.
- Construct permanent earthen berms or dikes to prevent erosion in low-lying onsite or adjacent areas that might remain vulnerable to stormwater flows.
- Incorporate bioswales, tree canopies or other green infrastructure elements that can filter stormwater as well as capture rainwater or snowmelt.[15]

Green infrastructure can significantly decrease the amount of stormwater runoff and pollutants reaching local waters. For example:

- The urban forest in Charlotte, North Carolina, was found to annually intercept about 209 million gallons of rainfall (as of 2006), which saves the city approximately $2,077,400 in annual stormwater management costs.[16]
- In Cincinnati, Ohio, the U.S. EPA and federal partners constructed and studied a rain garden network bordered by berms and populated by drought- and flood-tolerant perennials and grasses. Over four years, the network retained about 90% of all rainfall and achieved an overall stormwater volume retention capacity exceeding 50%.[17]

Use of the National Stormwater Calculator can help estimate frequency of runoff from a specific site based on its soil conditions, land cover and historical rainfall.[18]

- ♦ Minimize use of impermeable materials such as concrete to re-surface areas, and maximize retention or creation of permeable surfaces in areas that are contiguous.
- ♦ Allocate greenspace as a buffer in sensitive natural areas such as steep hillsides, riparian zones or wetlands that are prone to generating or receiving runoff.
- ♦ Establish plans for long-term maintenance and inspections of onsite wet ponds created for stormwater management. Routine maintenance typically includes removing debris after major storms, repairing damaged embankments, and harvesting vegetation when a 50% reduction in water surface occurs.[19]

BMPs applying to the process of revegetating excavated/backfilled areas, particularly those with anticipated ecological reuse, include:

- ♦ Revegetate backfilled areas as quickly as possible through use of a diverse mix of grasses, shrubs, forbs and trees supporting many habitat types.
- ♦ Include plant species that promote colonization of bees and other pollinators.
- ♦ Seed or install native rather than non-native species, which typically increases the rate of plant survival and minimizes the need for irrigation and soil or plant inputs.
- ♦ Choose grass species requiring little or no mowing.
- ♦ Substitute chemical fertilizers, herbicides or pesticides with non-synthetic inputs, integrated pest management methods, and soil solarizing techniques during vegetation planting, transplanting or ongoing maintenance.

Excavation and backfilling activities also may affect land and ecosystems gradually over time. Potential effects include subsidence, soil chemistry imbalance, reduced subsurface microbial populations or failing wildlife habitat restoration. Selection and prioritization of BMPs to avoid such impacts can be facilitated by compiling a pre-excavation inventory of site characteristics such as land contours, drainage patterns, plant species and densities, and resident and migratory animal species. The availability of a baseline inventory also will facilitate final restoration that best recreates a site's pre-development conditions.

Over 33,000 tons of contaminated soil, debris and sediment were removed at the 10-acre Raleigh Street Dump NPL site in Tampa, Florida. In addition, 40 tons of illegally dumped tires were removed and recycled. After placing clean soil, planting grass and restoring wetlands, the potentially responsible parties worked with the Wildlife Habitat Council to further restore the site's ecological systems. Full restoration included doubling the wetlands acreage, creating a 4-acre upland meadow, installing bird and bat boxes, and planting milkweed gardens for Monarch butterfly habitat. The National Oceanic and Atmospheric Administration provided technical expertise to protect aquatic life and coastal habitats throughout site investigation and cleanup.[20]

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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For more information, contact: Carlos Pachon, OLEM/OSRTI (pachon.carlos@epa.gov), U.S. Environmental Protection Agency