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# Landfill Reclamation

This fact sheet describes new and innovative technologies and products that meet the performance standards of the Criteria for Municipal Solid Waste Landfills (40 CFR Part 258).

Landfill reclamation is a relatively new approach used to expand municipal solid waste (MSW) landfill capacity and avoid the high cost of acquiring additional land. Reclamation costs are often offset by the sale or use of recovered materials, such as recyclables, soil, and waste, which can be burned as fuel. Other important benefits may include avoided liability through site remediation, reductions in closure costs, and reclamation of land for other uses.

Despite its many benefits, some potential drawbacks exist to landfill reclamation. This technology may release methane and other gases, for example, that result from decomposing wastes. It may also unearth hazardous materials, which can be costly to manage. In addition, the excavation work involved in reclamation may cause adjacent landfill areas to sink or collapse. Finally, the dense, abrasive nature of reclaimed waste may shorten the life of excavation equipment. To identify potential problems, landfill operators considering reclamation activities should conduct a site characterization study.

Landfill reclamation projects have been successfully implemented at MSW facilities across the country since the 1980s. This fact sheet provides information on this technology and presents case studies of successful reclamation projects.

## The Reclamation Process

Landfill reclamation is conducted in a number of ways, with the specific approach based on project goals and objectives and site-specific characteristics. The equipment used for reclamation projects is adapted primarily from technologies already in use in the mining industry, as well as in construction and other solid waste management operations. In general, landfill reclamation follows these steps:

### Excavation

An excavator removes the contents of the landfill cell. A front-end loader then organizes the excavated materials into manageable stockpiles and separates out bulky material, such as appliances and lengths of steel cable.

### Soil Separation (Screening)

A trommel (i.e., a revolving cylindrical sieve) or vibrating screens separate soil (including the cover material) from solid waste in the excavated material. The size and type of screen used depends on the end use of the recovered material. For example, if the reclaimed soil typically is used as landfill cover, a 2.5-inch screen is used for separation. If, however, the reclaimed soil is sold as construction fill, or for another end use requiring fill material with a high fraction of soil content, a smaller mesh screen is used to remove small pieces of metal, plastic, glass, and paper.

Trommel screens are more effective than vibrating screens for basic landfill reclamation. Vibrating screens, however, are smaller, easier to set up, and more mobile.

Printed on paper that contains at least 20 percent postconsumer fiber.

### Processing for Reclamation of Recyclable Material or Disposal

Depending on local conditions, either the soil or the waste may be reclaimed. The separated soil can be used as fill material or as daily cover in a sanitary landfill. The excavated waste can be processed at a materials recovery facility to remove valuable components (e.g., steel and aluminum) or burned in a municipal waste combustor (MWC) to produce energy.

## Steps in Project Planning

Before initiating a landfill reclamation project, facility operators should carefully assess all aspects of such an effort.

The following is a recommended approach:

1. Conduct a site characterization study.
2. Assess potential economic benefits.
3. Investigate regulatory requirements.
4. Establish a preliminary worker health and safety plan.
5. Assess project costs.

## Benefits and Drawbacks

Facility operators considering the establishment of a landfill reclamation program must weigh several benefits and drawbacks associated with this waste management approach.

### *Potential Benefits*

**Extending landfill capacity at the current site**
Landfill reclamation extends the life of the current facility by removing recoverable materials and reducing waste volume through combustion and compaction.

**Generating revenues from the sale of recyclable materials**
Recovered materials, such as ferrous metals, aluminum, plastic, and glass, can be sold if markets exist for these materials.

**Lowering operating costs or generating revenues from the sale of reclaimed soil**
Reclaimed soil can be used on site as daily cover material on other landfill cells, thus avoiding the cost of importing cover soil. Also, a market might exist for reclaimed soil used in other applications, such as construction fill.

**Producing energy at MWCs**
Combustible reclaimed waste can be mixed with fresh waste and burned to produce energy at MWCs.

**Reducing landfill closure costs and reclaiming land for other uses**
By reducing the size of the landfill "footprint" through cell reclamation, the facility operator may be able to either lower the cost of closing the landfill or make land available for other uses.

**Retrofitting liners and removing hazardous materials**
Liners and leachate collection systems can be installed at older landfills. These systems can be inspected and repaired if they are already installed. Also, hazardous waste can be removed and managed in a more secure fashion.

### *Potential Drawbacks*

**Managing hazardous materials**
Hazardous wastes that may be uncovered during reclamation operations, especially at older landfills, are subject to special handling and disposal requirements. Management costs for hazardous waste can be relatively high, but may reduce future liability.

**Controlling releases of landfill gases and odors**
Cell excavation raises a number of potential problems related to the release of gases. Methane and other gases, generated by decomposing wastes, can cause explosions and fires. Hydrogen sulfide gas, a highly flammable and odorous gas, can be fatal when inhaled at sufficient concentrations.

**Controlling subsidence or collapse**
Excavation of one landfill area can undermine the integrity of adjacent cells, which can sink or collapse into the excavated area.

**Increasing wear on excavation and MWC equipment**
Reclamation activities shorten the useful life of equipment, such as excavators and loaders, because of the high density of waste being handled. Also, the high particulate content and abrasive nature of reclaimed waste can increase wear on MWC equipment (e.g., grates and air pollution control systems).

This planning sequence assumes that project planners will make an interim assessment of the project's feasibility after each planning step. After completion of all five steps, planners should conclude the feasibility assessment by weighing costs against benefits. A thorough final assessment should include a review of project goals and objectives and consideration of alternative approaches for achieving those ends.

## Conduct a Site Characterization Study

The first step in a landfill reclamation project calls for a thorough site assessment to establish the portion of the landfill that will undergo reclamation and estimate a material processing rate.

The site characterization should assess facility aspects, such as geological features, stability of the surrounding area, and proximity of ground water, and should determine the fractions of usable soil, recyclable material, combustible waste, and hazardous waste at the site.

## Assess Potential Economic Benefits

Information collected in the site characterization provides project planners with a basis for assessing the potential economic benefits of a reclamation project. If the planners identify likely financial benefits for the undertaking, then the assessment will provide support for further investing in project planning. Although economics are likely to serve as the principal incentive for a reclamation project, other considerations may also come into play, such as a communitywide commitment to recycling and environmental management.

Most potential economic benefits associated with landfill reclamation are indirect; however, a project can generate revenues if markets exist for recovered materials. Although the economic benefits from reclamation projects are facility-specific, they may include any or all of the following:

- Increased disposal capacity.
- Avoided or reduced costs of:
  - —Landfill closure.
  - —Postclosure care and monitoring.
  - —Purchase of additional capacity or sophisticated systems.
  - —Liability for remediation of surrounding areas.
- Revenues from:
  - —Recyclable and reusable materials (e.g., ferrous metals, aluminum, plastic, and glass).
  - —Combustible waste sold as fuel.
  - —Reclaimed soil used as cover material, sold as construction fill, or sold for other uses.
- Land value of sites reclaimed for other uses.

Thus, this step in project planning calls for investigating the following areas:

- Current landfill capacity and projected demand.
- Projected costs for landfill closure or expansion of the site.
- Current and projected costs of future liabilities.
- Projected markets for recycled and recovered materials.
- Projected value of land reclaimed for other uses.

## Investigate Regulatory Requirements

Landfill reclamation operations are not restricted under current federal regulations. Before undertaking a reclamation project, however, state and local authorities should be consulted regarding any special requirements. Although some states have enacted general provisions concerning the beneficial use of recovered materials, as of 1996, only New York State had established specific landfill reclamation rules. In most states, officials offer assistance in project development, and they review work plans on a case-by-case basis. A few states, such as New York and New Jersey, encourage landfill reclamation by making grant money available.

## Establish a Preliminary Worker Health and Safety Plan

After project planners establish a general framework for the landfill reclamation effort, they must account for the health and safety risks the project will pose for facility workers. Once potential risks are identified from the site characterization study and historical information about facility operations, methods to mitigate or eliminate them should be developed. This information then becomes part of a comprehensive health and safety program. Before the reclamation operation begins, all workers who will be involved in the project need to be well versed in the safety plan and receive training in emergency response procedures.

Drawing up a safety and health plan can be particularly challenging given the difficulty of accurately characterizing the nature of material buried in a landfill. Project workers are likely to encounter some hazardous materials; therefore, the health and safety program should account for a variety of materials handling and response scenarios.

Although the health and safety program should be based on site-specific conditions and waste types, as well as project goals and objectives, a typical health and safety program might call for the following:

- Hazard communication (i.e., a "Right to Know" component) to inform personnel of potential risks.
- Respiratory protection measures, including hazardous material identification and assessment; engineering controls; written standard operating procedures; training in equipment use, respirator selection, and fit testing; proper storage of materials; and periodic reevaluation of safeguards.
- Confined workspace safety procedures, including air quality testing for explosive concentrations, oxygen deficiency, and hydrogen sulfide levels, before any worker enters a confined space (e.g., an excavation vault or a ditch deeper than 3 feet).
- Dust and noise control.
- Medical surveillance stipulations that are mandatory in certain circumstances and optional in others.
- Safety training that includes accident prevention and response procedures regarding hazardous materials.
- Recordkeeping.

The program should also cover the protective equipment workers will be required to wear, especially if hazardous wastes may be unearthed. The three categories of safety equipment used in landfill reclamation projects are:

- Standard safety equipment (e.g., hard hats, steel-toed shoes, safety glasses and/or face shields, protective gloves, and hearing protection).
- Specialized safety equipment (e.g., chemically protective overalls, respiratory protection, and self-contained breathing apparatus).
- Monitoring equipment (e.g., a combustible gas meter, a hydrogen sulfide chemical reagent diffusion tube indicator, and an oxygen analyzer).

## Assess Project Costs

Planners can use information collected from the preceding steps to analyze the estimated capital and operational costs of a landfill reclamation operation. Along with the expenses incurred in project planning, project costs may also include the following:

- Capital costs:
  - — Site preparation.
  - — Rental or purchase of reclamation equipment.
  - — Rental or purchase of personnel safety equipment.
  - — Construction or expansion of materials handling facilities.
  - — Rental or purchase of hauling equipment.
- Operational costs:
  - — Labor (e.g., equipment operation and materials handling).
  - — Equipment fuel and maintenance.
  - — Landfilling nonreclaimed waste or noncombustible fly and bottom ash if waste material is sent off site for final disposal.
  - — Administrative and regulatory compliance expenses (e.g., recordkeeping).
  - — Worker training in safety procedures.
  - — Hauling costs.

Part of the cost analysis involves determining whether the various aspects of the reclamation effort will result in reasonable costs relative to the anticipated economic benefits. If the combustible portion of the reclaimed waste will be sent to an offsite MWC, for example, planners should assess whether transportation costs will be offset by the energy recovery benefits. Planners also need to consider whether capital costs can be minimized by renting or borrowing heavy equipment, such as excavating and trommel machinery, from other departments of municipal or county governments. Long-term reclamation projects may benefit from equipment purchases.

# Case Studies

**Table 1. Landfill Reclamation Project Summaries**

| Project | Operation Start | Mined Area | Use of Recovered Material | Main Objectives |
|---|---|---|---|---|
| Naples Landfill (Collier County, Florida) | April 1986 (ongoing). | 10 acres | Cover material. | Decrease liability. Recover soil. |
| Edinburg Landfill (Edinburg, New York) | Dec. 1990 and June 1991 (both completed). | 1 acre | | Alternative to landfill closure. |
| | Aug. - Sept. 1992 (completed). | 1.6 acre | Construction fill. | Reduce landfill footprint. |
| Frey Farm Landfill (Lancaster County, Pennsylvania) | Jan. 1991 - July 1996 (completed). | 300,000 to 400,000 cubic yards | Waste-to-energy fuel. Cover material. | Recover fuel. Reuse of landfill capacity. |

**Source Based on: Dickinson, 1995.**

## Naples Landfill Collier County, Florida

In 1986, the Collier County Solid Waste Management Department at the Naples Landfill conducted one of the earliest landfill reclamation projects in the country. At that time, the Naples facility, a 33-acre unlined landfill, contained MSW buried for up to 15 years.

In an evaluation performed by the University of Florida on 38 of the state's unlined landfills, investigators discovered that the Naples Landfill (along with 27 others) posed a threat to ground water. Moreover, the high cost of complying with the state's capping regulations for unlined landfills concerned many county officials. Florida's capping regulations required the installation of a relatively impermeable cover or cap and postclosure monitoring.

Naples officials developed a reclamation plan with the following objectives: decreasing site closure costs, reducing the risk of groundwater contamination, recovering and burning combustible waste in a proposed waste-to-energy facility, recovering soil for use as landfill cover material, and recovering recyclable materials. Collier County never built the waste-to-energy plant. The project did prove successful, however, in recovering landfill cover material. The project proved less successful at recycling recovered materials (e.g., ferrous metals, plastics, and aluminum). These materials required substantial processing to upgrade their quality for sale, something the county chose not to pursue.

In 1991, the U.S. Environmental Protection Agency selected the Naples Landfill reclamation project as a demonstration project for the Municipal Solid Waste Innovative Technology Evaluation (MITE) program. The MITE program assessed the excavation and mechanical processing techniques used in the project for reclaiming cover material to be used in ongoing landfill operations. It also assessed the capacity and performance of equipment, the environmental aspects of the project, the characteristics of recovered materials, the market acceptability of recovered materials, and the probable costs and economics of the overall project. The MITE assessment found the processing techniques used in the Naples project effective and efficient for recovering soil but not for recovering recyclables of marketable quality.

During the MITE demonstration project, Collier County effectively and efficiently recovered a soil fraction deemed environmentally safe under Florida's MSW compost regulations. The 50,000 tons of reclaimed soil were suitable for use as a landfill cover material and as a soil medium for supporting plant growth.

Air quality monitoring indicated that landfill gas was not an issue at the reclamation site, apparently due to the high degree of waste decomposition that had already occurred. As a result of this finding, typical personnel protective gear worn during the project consisted of standard construction apparel.

Ongoing reclamation activities at the Naples facility focus exclusively on recovering soil for use as landfill cover material. All excavated materials other than the reclaimed soil and small amounts of recyclables are redisposed of in lined landfill cells. Reclamation activities are only performed on an as-needed basis. A 3-inch trommel screen is used to reclaim the soil cover material. The weight ratio of reclaimed soil to overs (i.e., materials caught by the screen), after white goods and tires are separated, is 60 to 40. This indicates that the Collier County landfill reclamation project is efficient given that 60 percent of the reclaimed material is reused as landfill cover material.

Based on 1995 prices, landfill cover material costs Collier County $3.25 per ton. According to Collier County's director of solid waste, the reclamation of cover material on an as-needed basis costs the county $2.25 per ton, a savings of $1 per ton.

According to county officials, the reclamation project yielded the following benefits: lower operating costs through reuse of cover materials, extended landfill life, reduced potential for ground-water contamination from unlined cells, and possible avoidance of future remediation costs.

## Edinburg Landfill Edinburg, New York

The New York State Energy Research and Development Authority (NYSERDA) and the New York State Department of Environmental Conservation sponsored projects to assess the feasibility and cost-effectiveness of undertaking landfill reclamation efforts to avoid closures and reduce the footprint of state landfills. NYSERDA established these projects in anticipation of the closure of numerous landfills in New York State, and based, in part, on the success of the Naples Landfill reclamation project.

NYSERDA's first demonstration project was conducted at a 5-acre MSW landfill in Edinburg, New York, which received waste from 1969 to 1991. NYSERDA chose the Edinburg Landfill because of its small size and lack of buried industrial waste. After NYSERDA chose to sponsor the reclamation of 1 acre of the 5-acre landfill, Edinburg town officials expanded the project to reclaim 1.6 additional acres.

NYSERDA divided the Edinburg demonstration project into three phases. The first phase, started in December 1990, included the excavation of 5,000 cubic yards of waste from a 12-year-old section of the landfill at an average depth of 20 feet. The second phase, initiated in June 1991, included the excavation of 10,000 cubic yards of waste from a 20-year-old section of the landfill at an average depth of 8 feet. The first two phases of the demonstration project cost an estimated $5 per cubic yard for excavation and processing. This cost included the inspection and supervision of a fully contracted operation and was based on an average excavation rate of 1,000 to 1,200 cubic yards per day.

The third phase of the Edinburg project occurred from August to September 1992. NYSERDA provided the majority of the project funding, with the remaining funding (primarily for phase three) provided by the town of Edinburg. This third and final phase reclaimed an additional 1.6 acres (31,000 cubic yards) in 28 days. Because the town supplied required equipment and labor, the contracted cost for this phase decreased from $5 per cubic yard excavated to $3 per cubic yard. Subsequently, the town looked into reclaiming the remaining 2.4 acres of the landfill and completely eliminating the footprint. The proposed fourth stage proved unviable, so the remaining portion of the landfill will be capped.

The Edinburg Landfill is located in a soil-rich area that provides ample amounts of landfill cover material. For this reason, officials tested and approved the reclaimed soil (75 percent of the reclaimed material) for off-site use as construction fill in nonsurface applications. A test burn performed on the reclaimed waste found the British thermal unit (Btu) value to be lower than desired because of the high degree of waste decomposition and stones remaining in the screened material.

The recovered nonsoil materials, representing 25 percent of the reclaimed waste, were hand-sorted for potential recyclables. Although 50 percent of the nonsoil material was considered recyclable, cleaning the materials to market standards was not feasible. Some tires, white goods, and ferrous metals, however, were separated and recycled. The remaining materials were sent to a nearby landfill.

NYSERDA officials developed a worker health and safety plan for the Edinburg project that established work zones, personnel protection requirements, and other operating procedures. The inspectors, as well as all personnel working at the site, were required to wear respirators, goggles, helmets, and protective suits. Excavation equipment was used to separate suspicious drums and other potentially hazardous material for evaluation by the safety inspector using appropriate monitoring equipment. In the event that hazardous materials were encountered, the health and safety plan provided for a project contingency plan, a segregated disposal area, and special waste handling procedures. No significant quantities of hazardous materials, however, were unearthed.

The Edinburg Landfill Reclamation Project was successful both in securing offsite uses for the reclaimed soil and in reducing the landfill footprint to decrease closure costs. The economic benefits would be enhanced further if the avoided costs for postclosure maintenance and monitoring, as well as potential remediation and the value of recovered landfill space, are also considered.

## Frey Farm Landfill Lancaster County, Pennsylvania

In 1990, the Lancaster County Solid Waste Management Authority constructed an MWC to use in reducing the volume of waste deposited in the Frey Farm Landfill, a lined site (double layers of 60-mil high density polyethylene sheeting on a 6-inch clay sub-base) containing MSW deposited for up to 5 years. After building the MWC, the quantity of waste received at the facility declined, leaving a significant portion of the MWC capacity unused. In an effort to increase the energy production and efficiency of the MWC, officials initiated a landfill reclamation project to augment the facility's supply of fresh waste with reclaimed waste.

The reclaimed waste had a high Btu value (about 3,080 Btu per pound). To achieve a more efficient, higher heating value of 5,060 Btu per pound of waste, four parts of fresh waste, which included tires and woodchips, were mixed with one part reclaimed waste.

Between 1991 and 1993, approximately 287,000 cubic yards of MSW were excavated from the landfill. These reclamation activities processed 2,645 tons of screened refuse per week for the MWC. As a result, Lancaster County converted 56 percent of the reclaimed waste into fuel. The county also recovered 41 percent of the reclaimed material as soil during trommeling operations. The remaining 3 percent proved noncombustible and was reburied in the landfill. By the end of the project in 1996, landfill operators had reclaimed 300,000 to 400,000 cubic yards of material.

Before the reclamation work began, officials prepared a safety plan for work at the site and assigned a full-time compliance officer to oversee the operations. During reclamation, workers took precautions to avoid damaging the site's synthetic liner, since it would be reused following the reclamation operations. An initial layer of protective material surrounded the synthetic liner system, aiding worker precautions by acting as a buffer between the liner and the excavation tools. Continuous air monitoring for methane, both in the cabs of vehicles and in the reclamation area, enhanced the operation's safety operations.

Benefits of the project at Frey Farm Landfill include: reclaimed landfill space, supplemented energy production, and recovered soil and ferrous metals. Drawbacks include: increased generation of ash caused by the high soil content found in reclaimed waste, increased odor and air emissions, increased traffic on roads between the MWC and the landfill, and increased wear on both the landfill operation and MWC equipment (i.e., due to the abrasive properties of the reclaimed waste).

Costs for the resource recovery portion of the project were relatively low for the following reasons:

- The distance for transporting both the reclaimed waste and the ash was only 18 miles each way.
- The management authority avoided commercial hauling prices by using its own trucks and employees to transport the reclaimed waste and the ash.
- The landfill and MWC were operated by the same management authority, thus no tipping fees were required. (Generally, a higher tipping fee can be charged at an MWC for reclaimed waste because of its abrasiveness and higher density, which increases the wear and tear on equipment.)

By 1996, MWC facility operators no longer needed supplemental feed materials from Frey Farm Landfill to run at full capacity. Thus, landfill officials concluded the reclamation project in July of that year.

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