Soil Erosion and Sediment Control: A Case History - Laurel Park Landfill

Aerial view of erosion control measures on Laurel Park Landfill.

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Introduction

LANDFILL closure projects are among the most challenging of all civil and environmental engineering works. While admittedly not as glamorous, well-designed landfill closures rival buildings, infrastructure, and other civil and environmental projects in their value to society and in their complexity. In addition to the challenges of waste containment, leachate collection and treatment, and gas collection and venting, closures are required to remain stable and functional for an extraordinary long period of time. The design life for critical system elements of a landfill closure typically spans a hundred years or more - far in excess of the expected life spans of many other engineering works.

Due to their direct exposures to the elements, there is perhaps no greater challenge for the engineering community than stabilizing the soil cover of landfill closures. Large, highly-exposed landfill caps with long, steep slopes create substantial stability challenges, both geotechnical and soil erosion. The long-term solution to these challenges typically lies in the use of self-sustainable vegetation, usually grasses, that serve to hold the cover in place. Quick and certain establishment of the vegetation, as soon as the earthwork is completed, is critical to the short- and long-term success of the project. Erosion from wind, rain, and runoff relentlessly act to wash away seed, amendments, and soil beginning the very moment they are placed, and can wreck the best of plans related to other aspects of the project.

This paper details the closure activities of the Laurel Park Landfill in Naugatuck, Connecticut, and pays special attention to the erosion and sediment control concerns addressed during project design and construction. The size, location, topography and visibility of the site make this project a noteworthy closure.

Description of Site

The site consists of a municipal/industrial landfill located on Huntington Hill in the Borough of Naugatuck, Connecticut, about 1 mile west of the Naugatuck River and about 1 mile southwest of downtown Naugatuck.

The Laurel Park Landfill (landfill) occupies approximately 9 hectares of the 14 hectare site. Prior to remedial construction, the landfill extended to a maximum height of approximately 41 meters above original ground surface [215 to 220 meters above mean sea level (AMSL) at the toe of the landfill slope to 256 meters AMSL at the landfill peak], with some surface slopes in excess of 3:1 (horizontal: vertical). The landfill was covered with a soil cover and sparse vegetation, primarily grasses, shrubs, and bushes. Most of the property immediately bordering the site is forested.

To the north of the site the land surface slopes downwards along a ridge which slopes to the northeast and to the northwest. To the east of the site, the land surface slopes downwards towards the northeast. To the south of the site a topographic high on the adjacent property slopes downwards to the north, east, south, and west.

Bedrock is at ground surface along the east and north sides of the landfill, but dips down steeply in a westerly direction, with bedrock at approximately 15 meters below ground surface on the west side of the landfill.

The landfill was essentially constructed on top of a steep hill which also has slopes in excess of 3:1.

Stormwater Management and Soil Erosion and Sediment Control

The objective of stormwater management was to minimize adverse impact, if any, to adjacent properties as a result of the remedial construction at the site. The objectives of soil erosion and sediment controls were to minimize the potential for soil erosion and sediment migration during the remedial construction activities, and to minimize the potential for soil erosion from the completed remedial activities. To address these objectives, surface water runoff from the landfill, other site areas, and the adjacent borrow area was managed and controlled to minimize changes to the drainage patterns which previously existed in the area of the site. To the extent feasible and practical, surface water runoff was also managed to minimize changes to the drainage patterns which existed in the area of the site prior to development of the landfill. Surface water runoff onto or from area disturbed during the remedial construction activities was managed to minimize the potential for soil erosion and sediment migration, and to facilitate the containment of generated sediment. Following completion of the construction activities, surface water runoff from the constructed landfill cap, which was constructed at relatively steep grades, was managed to minimize the potential for soil erosion and sediment migration.

The stormwater management and soil erosion and sediment controls were designed in accordance with USDPA guidance documents, the Connecticut Soil Erosion and Sediment Control Guidelines, and with USEPA, CT DEP, and Borough of Naugatuck concurrence.

Topsoil and Vegetative Cover Design

The site generally has a moderate climate. The average temperatures are around -1°C during winter months, with a typical low of -8°C and a typical high of 5°C. The average temperatures are around 21°C during summer months, with a typical low of 13°C and a typical high of 29°C. The annual precipitation in the area of the site typically ranges from 94 to 155 centimeters/year, with an average of 117 centimeters.

The key objectives of the revegetation plan for the landfill cap were as follows:

- stabilize the exposed soil as quickly as possible;
- expedite seed germination and seeding establishment; and
- minimize soil and seed loss in bare soil conditions.

Topsoil was obtained and processed from the adjacent borrow area. Testing revealed that the topsoil would need to be enhanced with compost, lime, and fertilizer to provide the best possible conditions conducive for grass growth. In order to establish a good vegetative cover (i.e., to minimize potential erosion), an erosion control seed mixture was applied at an application rate of 404 kilograms of live seed per hectare. Seeding was designed to be completed using hydroseeding methods.

Following application of the soil stabilization and erosion control seed mixture, a wildlife seed supplement was randomly spread by hand broadcasting at an application rate of 5 kilograms of live seed per 1,000 square meters over approximately 20 percent of the landfill cap surface.

The wildlife seed supplement was intended to provide a variety in appearance, as well as provide a plant supplement which favors beneficial insects and song birds and compliments indigenous plant species in the area of the site. Random broadcasting of the seed also lends a natural appearance to the site consistent with the local environment.

An 18-34-12 (Nitrogen-Phosphorous-Potassium) fertilizer then was applied to the seeded topsoil at a rate of approximately 2,800 kilograms per hectare. An erosion control blanket then was installed to provide temporary erosion protection until grass growth was sufficient to provide permanent erosion protection.

Erosion Control Design

To assist in minimizing soil erosion until the grass cover is permanently established on the landfill cap, the design called for a temporary erosion control blanket (ECB) to be utilized over essentially the entire landfill cap, and to be installed as soon as possible after seeding of the topsoil cover. The temporary ECB was specified in the design to be manufactured from straw and/or coconut fiber, and to biodegrade over the course of 2 to 3 years after landfill cap construction completion, at which time the permanent vegetative cover will have been established to minimize potential soil erosion. Temporary ECBs were planned ungradient of the upper and lower benches and adjacent to the chutes to a minimum width of 1.8 meters, and on the backslopes of the benches to minimum lengths ranging from approximately 4.6 to 10 meters, depending on the steepness of the slope which the backslope tied into. The entire landfill cap, with the exception of a small area on the west side of the landfill cap, was covered with the temporary ECB.

The project specification called for the installation of an ECB comprised primarily of straw (70 percent by weight) with a combined nominal weight of 0.3 kilograms per square meter. The composite was to be contained within two layers of biodegradable, organic netting, as opposed to conventional polypropylene netting. The netting and fibers were to be stitched together and supplied in rolls 2 meters wide by 27 meters long, having a gross area of 50 square meters.

Installation of the ECB involved mechanical anchorage to the subgrade using the customary technique of steel wire staples at the rate of approximately 1 anchor per square meter. Longitudinal joints between blankets were overlapped to allow installation of a common row of staples and joints at the end of each rolls were overlapped ("shingled") by approximately 30 centimeters, with additional staples at this location.

Stormwater Management and Soil Erosion and Sediment Controls

Construction Activities

Sequencing of construction activities on a landfill capping project is critical to ensure proper stormwater, and soil erosion and sediment control. During construction activities, it is also critical that stormwater runoff be properly managed and controlled. Prior to commencing construction at the site in 1996, a silt fence was installed around the perimeter of the site, downgradient from all construction activities, and stone check dams were constructed in natural drainage ditches, prior to the ditches draining stormwater from the site.

Construction of the sedimentation basins was completed in 1996, prior to the commencement of construction of the landfill cap. In 1996, the LCS was installed around the perimeter of the landfill, and the perimeter access road was constructed to subgrade elevation around the landfill, and downgradient from the LCS trench. The sedimentation basins were modified by constructing silt fence and stone baffles across the basin to assist in slowing the flow of sediment-laden water and settling out the sediment prior to discharge of the water from the sedimentation basins.

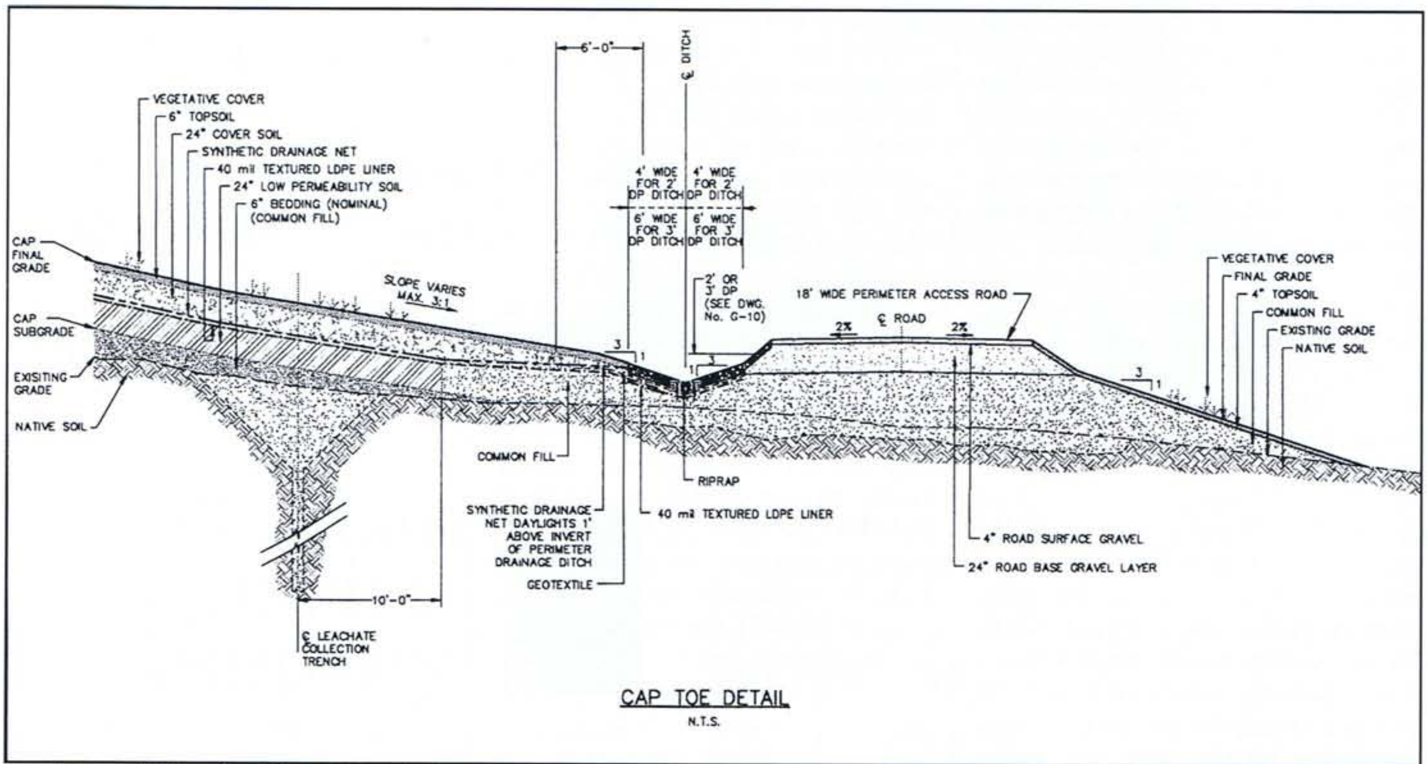
Constructing the perimeter access road around the landfill created an approximate 60 centimeter deep ditch between the landfill and the perimeter access road around the entire perimeter of the landfill. This ditch served to intercept surface water runoff from the landfill construction activities, and divert the sediment-laden surface water to the sedimentation basins. The landfill perimeter drainage ditch was a critical element to the management of stormwater runoff from the site during the construction activities.

During landfill cap construction activities, daily monitoring of weather systems was maintained. Prior to anticipated rainfall events, the areas of the landfill cap under construction were rolled with a smooth drum roller. The smooth rolled surfaces helped to minimize the amount of sediment migration to the sedimentation basins during rainfall events.

Pregrading of the landfill, consisting of placing common fill on the existing landfill surface, commenced in November 1996, and continued throughout the winter season as weather and temperature permitted. The winter earthwork activities allowed the 1997 construction activities to be completed during the construction season, and helped minimize soil erosion during common fill generation and placement. In early spring of 1997, areas of the cap were ready to be constructed. Construction of the cap commenced on the south side of the landfill, and proceeded in a clockwise direction around the landfill. By sequencing the layer construction activities, up to four different layers of the cap were under construction at any one time. This sequencing minimized construction time for the cap, and hence minimized the amount and effort required to ensure adequate soil erosion and sediment control activities.

The construction of the benches and downchutes commenced in June 1997 on the south face of the landfill. The bench construction activities were sequenced with the cover soil layer construction activities, and also continued in a clockwise direction around the landfill.

The landfill cap synthetic drainage net (SDN) was extended to "daylight" into the upper and lower benches, as the cover soil was placed in areas upgrade and downgrade to the benches. Prior to extending the SDN from the landfill to daylight in the benches, an additional 40 mil textured LDPE liner was placed on the compacted bench



Landfill cap details; site of Laurel Park in Naugatuck, Connecticut.

cover soil, and installed to overlay the landfill LDPE liner and extend to the bench drainage ditch.

The construction of the cover soil backslope portion of the upper benches was sequenced with the placement of the cover soil layer of the landfill cap in the area underneath the benches. The construction of the geotextile fabric and riprap lining in the benches was sequenced with the LDPE bench finer installation.

To the extent practical and feasible, construction activities were implemented, managed, and sequenced to minimize the amount of temporary open or disturbed areas which could be subject to potential soil erosion or sediment migration. When required, the following soil erosion and sediment controls were utilized:

- hay bales and silt fences at areas downgrade from construction activities;
- stone check dams in diversion ditches or locations of concentrated surface water flow;
- seeding, and/or mulching, or placement of wood chips on open or disturbed areas which are anticipated to remain exposed for 30 or more days; and
- sedimentation basins.

Soil erosion and sediment controls were constructed and installed in 1996 prior to implementing the landfill cap construction activities. These control features were maintained throughout landfill capping activities, and proactive and reactive measures were implemented to minimize soil erosion and sediment migration.

Seeding was accomplished using a broadcast seeder and brillion roller, which allowed placement of the specified seed mix, in a cost-effective manner.

Installation of the specified ECB started in late July 1997, immediately after seeding operations began. The contractor employed a five man crew to install the blanket. Blanketing work continued without interruption until September 1997, when the supply of the specified blanket was interrupted due to a lack of raw material inventory of the organic netting. Approximately 3/4 of the 10.5 hectare landfill surface of the specified straw/coconut blanket had been installed at that point. After a week long delay and inability of the manufacturer to confirm subsequent product availability and delivery, the project team determined that an alternative ECB be secured.

After a rapid, but thorough search, the decision was made to install an excelsior ECB over the remainder of the landfill. The new material was comprised of 100 percent aspen wood excelsior, together with biodegradable netting to meet the project's environment requirements. The excelsior blanket was furnished in rolls 2.5 meters wide by 27 meters long having a gross area of 67.5 square meters. The larger coverage of this blanket reduced by 25 percent the number of rolls required and the related handling effort. In addition, a green-dyed excelsior was selected to improve aesthetics. Installation of ECB resumed and continued until early October when this scope of work was substantially complete.

The benches and downchutes were protected from erosion with standard measures, such as geotextile fabric and riprap lining.

In 1997, a storm event similar to a 50-year 24-hour return storm event occurred approximately one-half the way through landfill construction activities. During this extreme storm, and other storms which occurred through the construction activities, the stormwater management and soil erosion and sediment controls maintained their integrity as designed. Some additional control were implemented to further minimize potential soil erosion and sediment migration, however, the primary controls were generally adequate to control erosion and sediment migration.

In November 1997, a final site inspection was conducted upon substantial completion of the landfill closure construction activities. The agencies provided concurrence with satisfactory completion of the construction, with the major exception of wanting to wait until the landfill vegetative cover became fully established. Operation and maintenance activities have been ongoing since substantial construction completion. From April to June 1998, final construction activities including the closure and/or conversation of sedimentation basins to stormwater retention ponds, were completed. In July 1998, a final site inspection was completed and all parties agreed that the vegetative cover on the landfill had become very well established. Other stormwater management structures (e.g., benches, downchutes, and drainage ditches) also were well established with vegetative growth along their banks, and their integrity was observed to be excellent.

Operation and maintenance, including soil erosion and sediment control inspections, are ongoing at the site. However, due to the exceptional success at establishing a good vegetative cover and stormwater management, the frequencies of inspection have been substantially reduced.

The excelsior ECB provided noticeably superior initial results, although there was no noticeable difference between the excelsior blanket and the straw blanket in the long term, once the grass was fully established. Initially, the excelsior blanket allowed for earlier higher plant density, while the straw blanket appeared to somewhat suffocate the grass and slow down the establishment of thick grass growth. The organic nettings are currently biodegrading, but are still intact. The landfill benches and downchutes and the perimeter stormwater management system are performing as designed.

Through good design and construction monitoring, the stormwater management and sediment and erosion control measures for the Laurel Park Landfill closure performed successfully. Potential significant problems typically created by the loss of fine soil particles also were minimized by the use of appropriate best management practices incorporated in the stormwater management and soil erosion and sediment control plan. The use of an erosion control blanket was an integral part of the design, as the blanket acted to keep soils in place until the vegetative cover was established.

Significant differences in initial vegetation establishment were noted between the two ECBs installed on this project. The green excelsior blanket generally provided noticeable superior results compared to the straw/coconut

material during the key germination and seeding establishment period. This was particularly interesting, given that the straw/coconut material was installed approximately 3 weeks prior to the excelsior. Since identical soil and seed conditions were involved, it is likely that the difference in performance was directly attributable to the unique material properties of these blankets - principally the fiber type and content. This difference is likely due to the following material differences:

1. **The darker color of the green excelsior absorbed more solar radiation and warmed the seedbed during the cooler nights of the early autumn season.**
2. **The excelsior blanket provided approximately twice the organic material compared to the straw/coconut blanket (0.5 kg/m^2 vs. 0.25 kg/m^2).**
3. **The greater open area of the excelsior blanket allowed better seed germination and hence higher plant density.**
4. **The straw blanket became matted after rainfall events and tended to suffocate the germinating grass.**

While initial differences were noted, the long-term performances of these materials appeared relatively similar, based on the vegetation density observed on regular site inspections after installation, and a site survey conducted approximately 9 months after installation. **During this survey, it was also noted that the excelsior fibers were still intact, but had become an integral part of the soil surface.** The organic netting of both products was still intact, but with significantly reduced strength from their initial condition.

The riprap-lined diversion channels (benches) and gabion-lined downchutes were performing as intended. Consideration of Turf Reinforcement Mattings (TRMs), which are 100 percent synthetic rolled erosion control materials, may be warranted as a cost-effective alternative to conventional riprap in diversions. Likewise, Articulating Concrete Block (ACB) revetments, which are interlocking, precast concrete blocks with a geotextile underlayment, may also provide a cost-effective alternative to gabion installation for the heavy-duty lining of downchutes. These products were considered for this project, but due to the abundance of riprap from the adjacent borrow area, they were not used in the design.

Conclusions

Stormwater management and soil erosion and sediment control design and construction are critical to landfill design, construction, and long-term operation and maintenance, particularly for the Laurel Park Landfill. Sequencing of installation of stormwater management and soil erosion and sediment controls also are critical to ensure proper management of stormwater and sediment runoff during construction.

Long steep landfill slopes and highly exposed areas on landfill caps develop better and are more easily maintained if erosion control blankets are used. Use of ECBs also can allow soil loss design criteria to be met.

Good topsoil with sufficient organic content, and a good seed mix design help in quick establishment of permanent soil erosion control. Also, the benefit of a high seed application rate outweighs the small additional cost for the extra seed, relative to the overall landfill closure cost.

The excelsior erosion control blanket reduced vulnerability, and generally evidenced superior initial seed germination results compared to a straw blanket for this project.

The Laurel Park Landfill provides an excellent reference for design and construction considerations regarding stormwater management and soil erosion and sediment control. This is particularly true for projects with large areas exposed at one time, and where long steep slopes can exacerbate soil erosion and sediment migration. **L&W**

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