

TURNING A BROWNFIELD INTO A GREENFIELD AT THE ALLIED WASTE NIAGARA FALLS LANDFILL NIAGARA FALLS, NEW YORK

Bart A. Klettke, P.E.
Associate Principal
GZA GeoEnvironmental of New York
535 Washington Street, 11th Floor
Buffalo, New York 14203
Bart.Klettke@gza.com

Abstract: This paper presents the design steps in developing a long-standing industrial waste fill site into a permitted solid waste disposal facility, for eventual end-use as an aesthetically pleasing Greenfield. Key design aspects included: removal of 2 million cubic yards of acetylene lime leaving 1 million cy of lime in-place for the landfill liner subbase; utilizing 0.5 million cy of existing cementitious slag for subgrade material; configuring landfill cell locations and floor grades to account for settlement of landfill liner due to lime consolidation and proper transitioning of interface between hard slag and compressible lime; investigation, excavation and disposal of contaminated slag/lime soils underlying a former hazardous waste treatment facility for heavy metal precipitation; and developing cost models to determine economic feasibility in developing this 90-acre portion of the landfill site. Post-construction monitoring during active landfilling activities was done for leachate head measurement on primary liner and is currently being done for measurement of lime subbase consolidation using settlement posts and pressure cells.

Keywords: landfill design; brownfield development; industrial fill use; lime consolidation; remedial investigations; construction cost estimates.

Introduction

Allied Waste Niagara Falls Landfill, LLC (Allied) currently operates a 370-acre landfill facility located in Niagara Falls, New York. Since 1983, Browning-Ferris Industries (BFI) and CECOS International, Inc. (CECOS) have permitted, constructed and operated on-site solid waste management (landfills) and chemical (hazardous/waste) facilities, respectively. In 1999, Allied Waste Industries, Inc. (Allied) purchased the assets of BFI. The 370 acre Site now operates as a wholly owned subsidiary of Allied.

Prior to constructing permitted landfill cells the site had been used as a dumping ground for local industries dating back to the early 1900s. The past use of portions of the facility resulted in the accumulations of lime (a calcium hydroxide/carbonate) of varying

thickness up to about 50 feet thick. The lime was generated as a by-product of an acetylene manufacturing process from local industry. Cementitious slag materials consisting of silt to boulder size particles were used for construction of berms to contain the lime in lagoons. Slag waste was generated as a by-product of the manufacturing of alloy metals by local industries. The slag material is typically distributed around the perimeter of the lime/slag area and grades into the lime material.

Prior to landfill cell development begun in the 1980s, this high-profile site, located on the outskirts of Niagara Falls and adjacent to Interstate I-190 (a major highway connecting Buffalo to Toronto), appeared as an unattractive elevated gray moonscape.

Approximately 160 acres of sanitary landfill cells and 44 acres of secure hazardous waste cells were constructed during the years 1983 through 2003. Construction of these cells were generally done around the site perimeter where existing industrial fill quantities were relatively minimal. An interior 85-acre portion of the site, having a large volume (about 3.5 million cubic yards) of lime and slag above the original topography, had not been used for landfill construction. In 1999, Allied directed GZA to determine the feasibility of developing this 85-acre area for landfill cell construction. This area was designated Sanitary Landfill VIII (San 8).

Challenges in Developing Sanitary Landfill VIII

Large Volume of Lime - The majority of the proposed area consisted of about 3 million cy of lime having the following properties:

1. pH = 12-13
2. High moisture content: as much as 300% by weight
3. Thickness up to 50 feet above native soils
4. Thixotropic: has good strength properties until disturbed, then becomes slurry-like and difficult to work with.

Presence of a Closed Hazardous Waste Treatment Facility – CECOS operated this facility (Phase I) between 1979 and 1988. Wastewater from industrial sources and contaminated water generated from an on-site waste management area were processed. The treatment process involved neutralization, heavy metal precipitation and dewatering using a filter press. A 130-foot diameter concrete tank and clay-lined lagoons were used for water clarification as part of the treatment process. The Phase I area was closed by construction of a 2-foot thick clay cap and 6-inch thick topsoil layer.

Reportedly, leaks through the concrete tank may have occurred during CECOS and prior operations in this area by others. The main concern in developing in this area was the concentration and extent of contamination was unknown. Since the Phase I area was about centrally located in the proposed San 8 footprint, it would be detrimental to develop the landfill around this area due to the large quantity of airspace lost.

Landfill Cell Development Costs – Given the extensive subgrade development costs for the conditions listed above, would landfill cell development be economically viable?

Regulatory and Public Approval – The New York State Department of Environmental Conservation (NYSDEC) determined that San 8 development required undergoing the State Environmental Quality Review Act (SEQRA) process. This would require a public scoping session, and submittal of an environmental impact statement all subject to local municipalities and agencies for comment and acceptance. Given the sites high profile, located on the edge of the city of Niagara Falls, NY, significant public opposition might occur.

Design Strategies and Concepts

Lime Volume Problem – The following general design alternatives were considered.

1. Remove lime from about two-thirds of the available footprint and place atop the remaining one-third. This was determined problematic due to the difficulty of mounding the lime due to its unstable condition once disturbed. Additionally, the resulting airspace was insufficient to make the project economically viable.
2. Remove lime from the entire landfill footprint and use the lime to raise and improve grades (to facilitate stormwater runoff) in other existing landfill areas. This option was determined to not be practical, again due to the difficulty in handling the lime, nor desirable to expand the footprint of the lime across the site.
3. Remove portions of lime and place back into the operational landfill cells to gain the largest landfill footprint. Leave portions of lime in place to serve as subgrade, since this was needed for achieving floor grades for leachate drainage. This option provided greatest amount of airspace: roughly 10 million cubic yards of net airspace after removing amount taken up by displaced lime volume of about 2 million cubic yards.

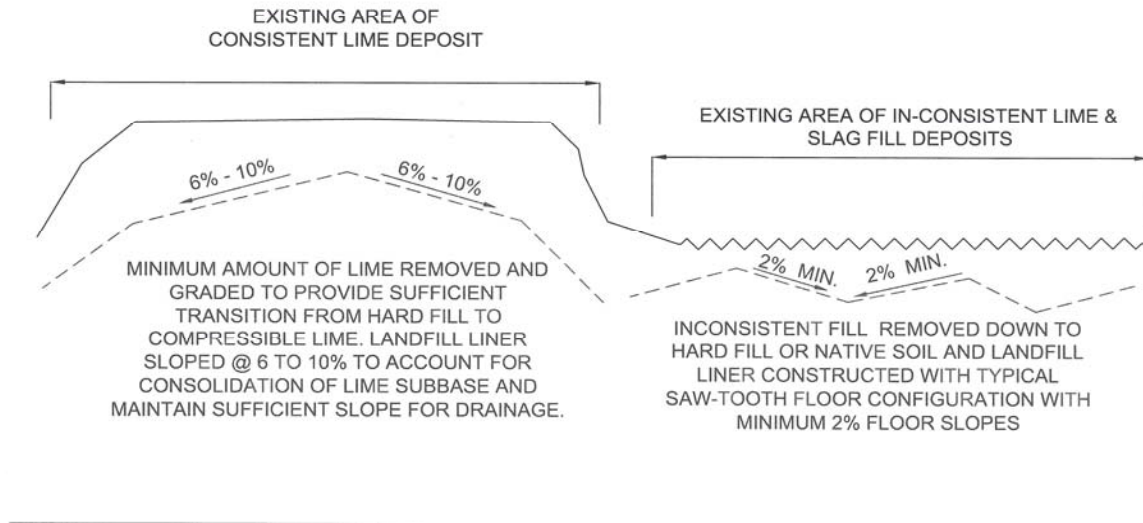
Implementation of Option 3 required evaluation of the following.

1. Identifying existing fill materials (lime vs. slag) based on review of existing aerial photos, along with boring log and test pit data.
2. Developing cell configurations to match existing fill conditions to maximize airspace, and utilizing existing fill materials to maximize their potential as subgrade fill. In areas where the existing fill had a consistent cross-section of lime the cell design required construction of the landfill liner to mound over the lime (versus a typical saw-tooth configuration) with 6 to 10% floor grades to accommodate settlement of the lime subgrade and provide sufficient drainage of leachate. In areas where the existing fill was inconsistent (i.e. lime intermixed with slag), the cell design required removal of the random fill down to consistent hard fill or native soils and construction of a typical saw-tooth configuration with

2% minimum floor slopes. The following schematic (Figure 1) demonstrates this.

FIGURE 1

SCHEMATIC OF CELL DESIGN RATIONALE FOR GIVEN FILL CONDITIONS
NO SCALE



3. Ordering cell construction properly to optimize lime excavation in conjunction with using available slag for subgrade fill construction to avoid costly double-handling of materials.
4. Timing of cell construction predicated on estimated lime volume requiring excavation for construction of new cells and corresponding airspace volume consumed in placing lime back into operational cell.
5. Allied's waste filling operations meshing with Contractor's lime displacement operations and accommodating access routes for each.

Differential Lime Settlement for Varying Constructed Subgrade Conditions

Settlement of the landfill subbase will result mainly from consolidation of the lime fill due to the weight of the overlying landfill liner, landfill waste and cap. Consolidation test results for the lime indicated a pre-consolidation pressure ranging from approximately 1 to 1.5 tons per square foot (tsf), a recompression ratio of 0.005 and a virgin compression ratio of 0.2. Figure 2 shows the estimated settlement of the lime fill for the proposed construction.

An important design element was to ensure that a proper transition occurred from large deposits of the compressible lime left in-place to the compacted subgrade fill. Figure 2

shows that the construction required sloping of the lime/compacted fill interface at a 3H:1V slope to accommodate the differential settlement anticipated across the interface. Additionally, the landfill floor was sloped at a combination 10% to 6% slope, as shown, so that the post-settlement floor slope is about 5 to 9 percent.

FIGURE 2

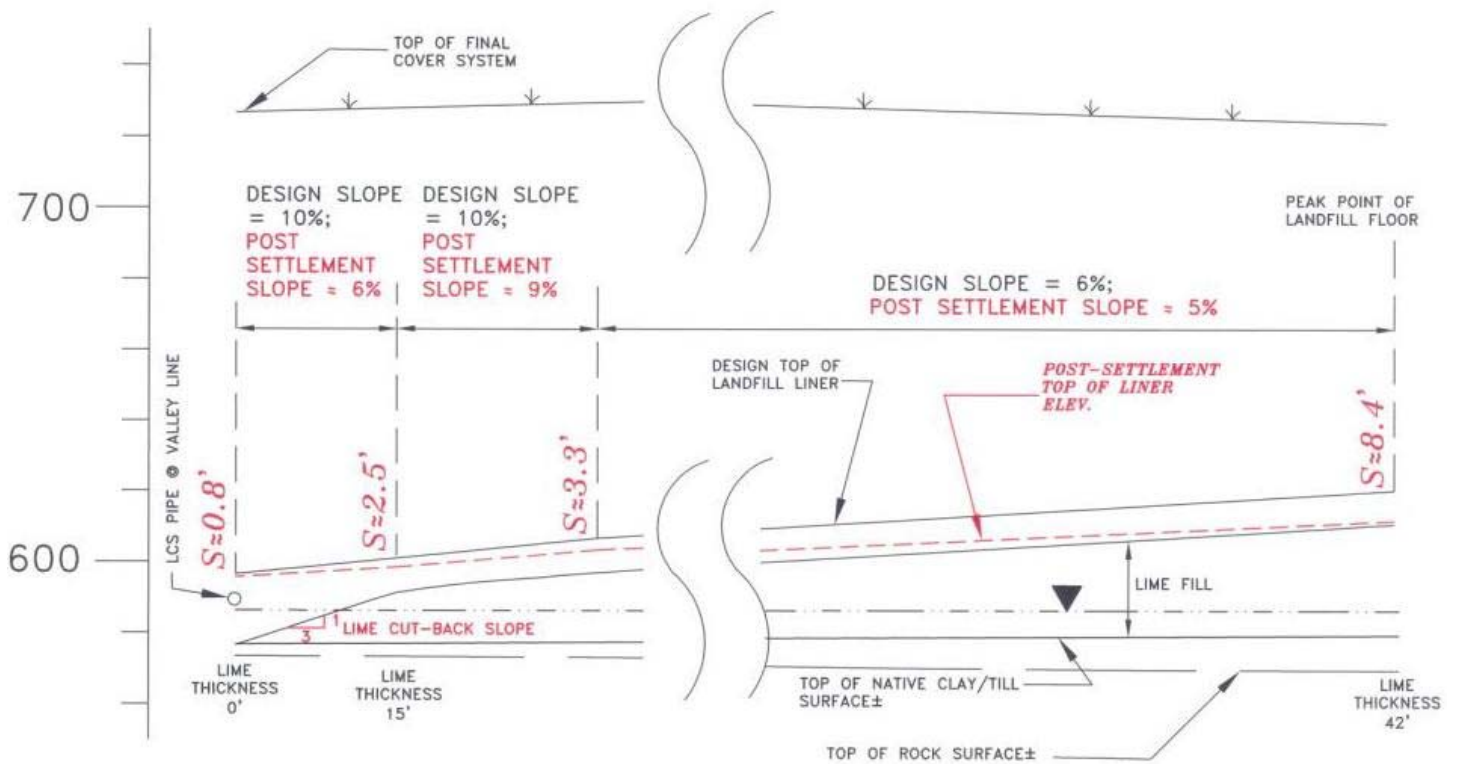
LIME CONSOLIDATION TEST DATA

PRE-CONSOLIDATION (P_p) \approx 1.5 TSF

VIRGIN COMPRESSION RATIO (C_{ec}) \approx 0.2

RECOMPRESSION RATIO (C_{er}) \approx 0.005

$$S = H \times [C_{er} \times \text{Log}(P_p/P_o) + C_{ec} \times \text{Log}(P_f/P_p)]$$



(Ref. 1)

Another important aspect in constructing the landfill cells over the compressible lime subbase was to require placement of waste uniformly over the cell and not allow unbalanced loading over the cell. Unbalanced loading could cause catastrophic stressing and rupture of the liner system.

Evaluate Leachate Mounding

An evaluation was made to check that the leachate head does not exceed the maximum allowable 1.0 feet. The evaluation was made using the Hydrologic Evaluation of Landfill

Performance (HELP) model (Ref. 2). Figure 3 shows that the estimated maximum leachate head for an open landfill condition for the maximum leachate flow length is approximately 11.5 inches. Since this was approaching the maximum allowable head of 1.0 feet, we incorporated an additional leachate collection pipe as shown on Figure 4.

FIGURE 3

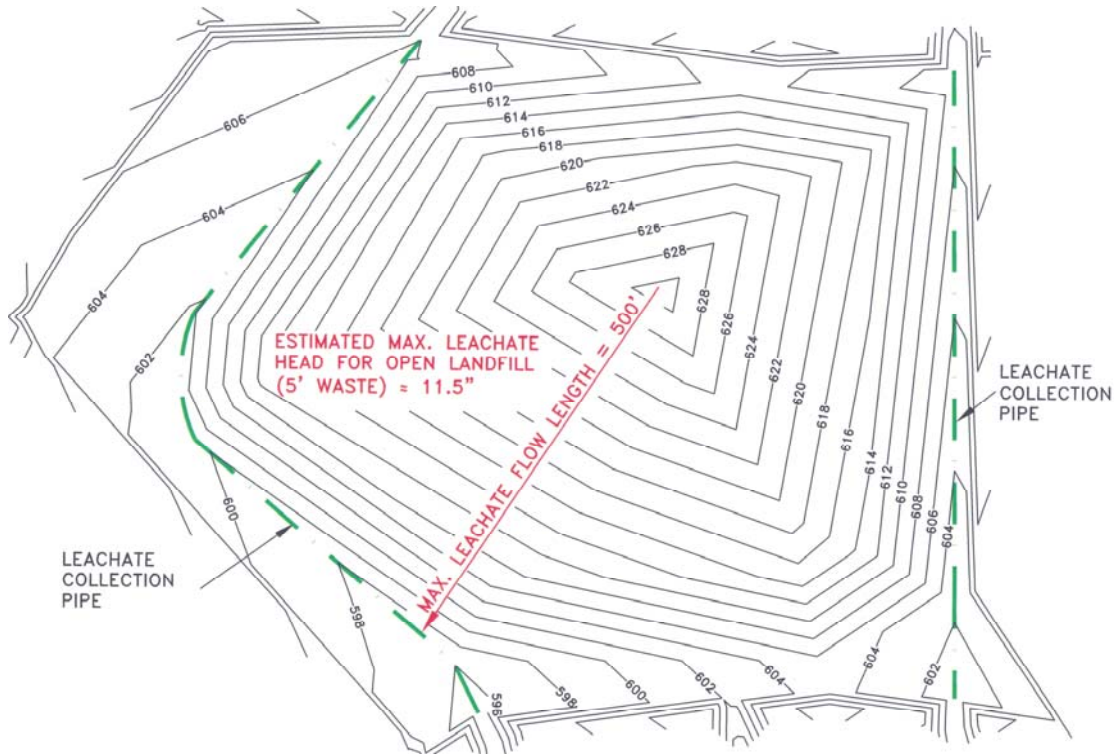
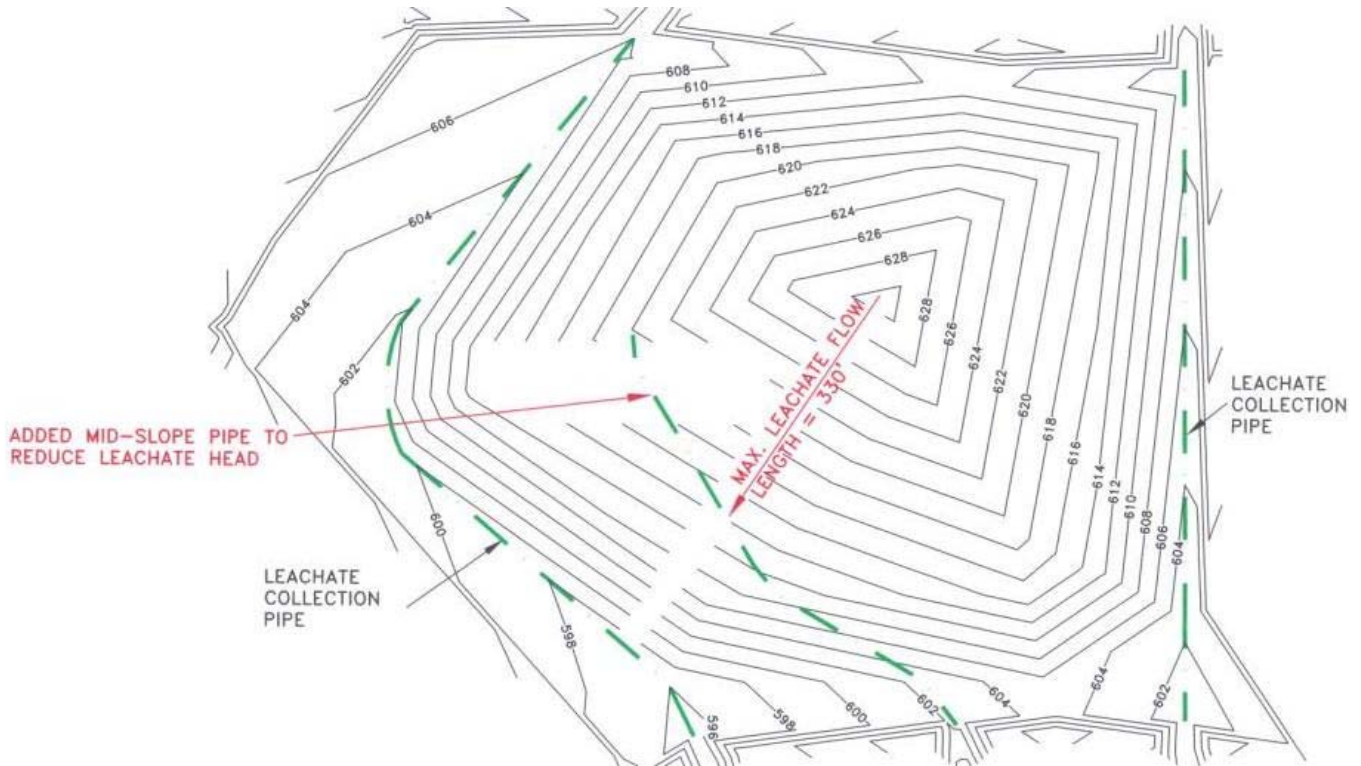


FIGURE 4



Landfill Cell Development Costs

GZA conducted a cost model analysis to determine the economic viability of San 8 development. Extensive ACAD surface modeling was done to develop the following.

1. Establish excavation grading plans for the 6 subareas planned for San 8. The excavation grading plans accounted for the differing subgrade conditions to remove existing fill soils down to native or acceptable hard fill, and shaping large areas of existing lime fill and associated transitions to hard fill conditions. The grading plans enabled accurate means for calculating volumes of lime to be displaced and available slag for subgrade construction.
2. Establishing top of subgrade and landfill liner elevations to determine volumes of subgrade fill and liner materials.
3. Establishing top of waste grades for intermediate and final fill conditions. The intermediate filling conditions accounted for volumes of lime relocated back into the operational landfill cells to estimate cell life and associated timelines for construction.

A major item incorporated into the cost model was estimating for the disposal of impacted soils beneath the former Phase I treatment area. This was difficult to evaluate due to the relatively unknown concentrations and extents of contamination in this area. A rough approximation of the anticipated cost was established at \$5 million.

The initial San 8 landfill development engineers estimate of costs was estimated as follows for the 6 subareas.

SUBAREA	ACREAGE	TOTAL CELL COST	SUBGRADE CONSTRUCTION COST	TOTAL COST PER ACRE	NET CY OF AIRSPACE	COST PER CY OF NET AIRSPACE
A	19.5	\$12.4 MIL	\$4.75 MIL	\$635,000	1.4 MIL	\$8.85
B*	16	\$17 MIL	\$9.8 MIL*	\$1,000,000	2.3 MIL	\$7.39
C	17	\$16 MIL	\$8.6 MIL	\$945,000	1.9 MIL	\$8.42
D	13	\$11.2 MIL	\$5.0 MIL	\$864,000	1.2 MIL	\$9.33
E	16	\$8.8 MIL	\$1.7 MIL	\$550,000	1.6 MIL	\$5.50
F	9.5	\$5.3 MIL	\$1.2 MIL	\$560,000	1.6 MIL	\$3.31
TOTAL	91	\$71 MIL	\$31 MIL	\$780,000	10 MIL	\$7.10

*Subarea B costs include costs of Phase I Area Evaluation and Soil End-Disposition – estimated @ \$5 Mil.

Regulatory and Public Approval

The SEQRA process was successful in that very little comment was provided by the general public and lasted for about a 3-year period. Key potential significant environmental impacts and positive results of the proposed landfill were as follows.

ENVIRONMENTAL IMPACT	POSITIVE RESULT
Aesthetics	Short term: Waste not attractive but existing background consists of active and abandoned industrial sites, smoke stacks and electric transmission lines. Long term: Green terraced slopes replace existing gray moonscape.
Groundwater & Surface Water	Removal of large amount of industrial fill and construction of low perm landfill liner reduces rainwater infiltration/contact improving GW & SW quality.
Economics	Provides construction and site jobs, continues Host Agreement with Town and purchasing of services, goods and products from local vendors.
<p>COMMUNITY RESPONSE: At the Public Scoping Meeting held at the Town of Niagara Town Hall, the only person to attend that was not connected with Allied, GZA or NYSDEC was a representative of the local U.S. Congresswoman. The SEQRA process lasted approximately 3 years from October 2002 to September 2005.</p>	

Construction Highlights to Date

Subgrade Conditions Encountered –

Construction of San 8, Subarea A commenced in 2006 and was completed in two phases with the 2nd phase finished in 2007. The first half of Subarea B was constructed in 2008.

Major highlights of the construction were as follows.

1. Design estimates of lime to be relocated from Subarea A back into the operational landfill was about 500,000 cy. The actual volume of lime encountered was approximately 450,000 cy. The amount of slag encountered was greater than the design estimate. These 2 benefits contributed savings to the project in terms of less airspace consumed by the smaller displaced lime volume and less subgrade fill needed. The overall construction costs for Subarea A came under budgeted costs.
2. Evaluation of the Phase I Area and Subsequent End-Disposition of Soils - GZA retained a drilling subcontractor to conduct soil borings for sampling of the existing fill soils in the Phase I area. Based on the analytical results, GZA/Allied in consultation with NYSDEC, developed an extensive sampling plan for excavating and properly disposing of the impacted soils under Phase I. Samples were collected at a rate of about 1 sample for every 200 to 250 cubic yards excavated. The end costs for disposal of the impacted soils was about \$1 to \$1.5

million, or about 20% of the preliminary cost estimate of \$5 million used for the project planning cost model. Additionally, much of the slag beneath the Phase I area was deemed suitable for subgrade fill, providing additional savings.

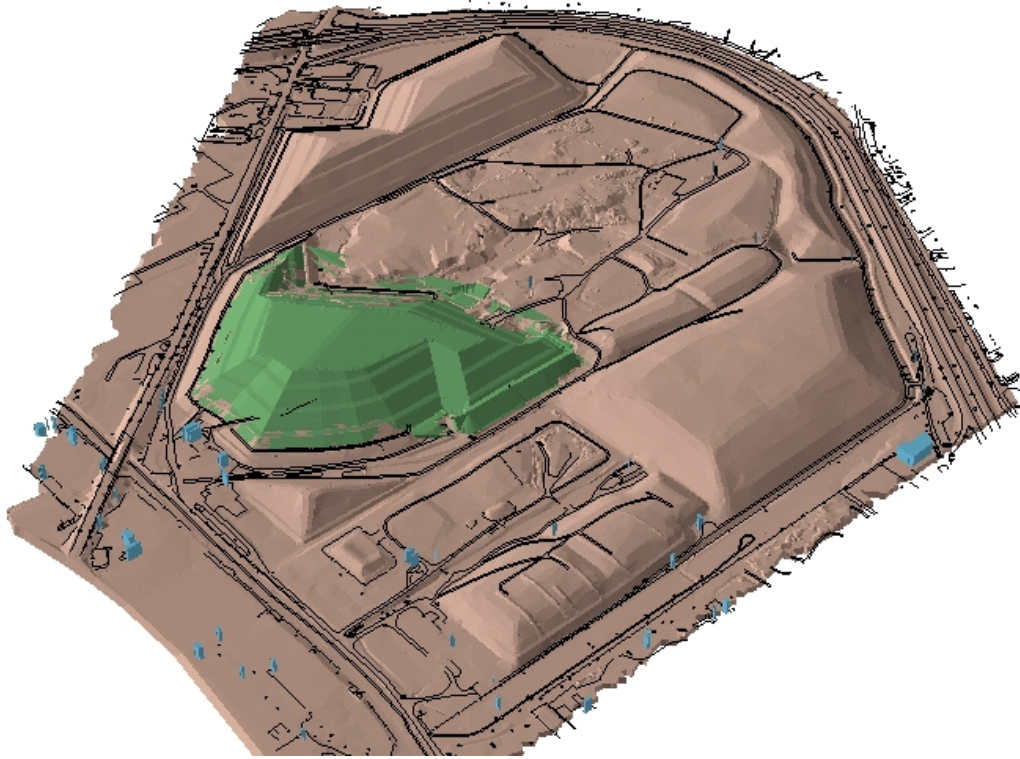
3. Upon finishing construction of Sanitary LF 8, Subarea A (west portion), there was an opportunity to monitor the leachate head in the primary drainage layer since the majority of floor area was left open for a 1-year duration with a smaller portion loaded with waste. 6 temporary shallow piezometers were installed and monitored during and after heavy rain events. Measurements showed water levels less than 0.2' above the primary liner demonstrating effectiveness of the drainage layer for the constructed conditions.
4. A settlement standpipe and pressure cell was installed to measure consolidation of the lime subbase. As of December 2008, approximately 18 feet of waste had been placed above the landfill liner at the standpipe location. The predicted settlement of the liner system, due mainly to lime consolidation, was calculated to be about 1.70'. Measurement via the settlement standpipe showed the landfill floor settlement to be about 1.50'. Therefore, the calculated approximation of the landfill floor settlement appears to be accurate.

Summary

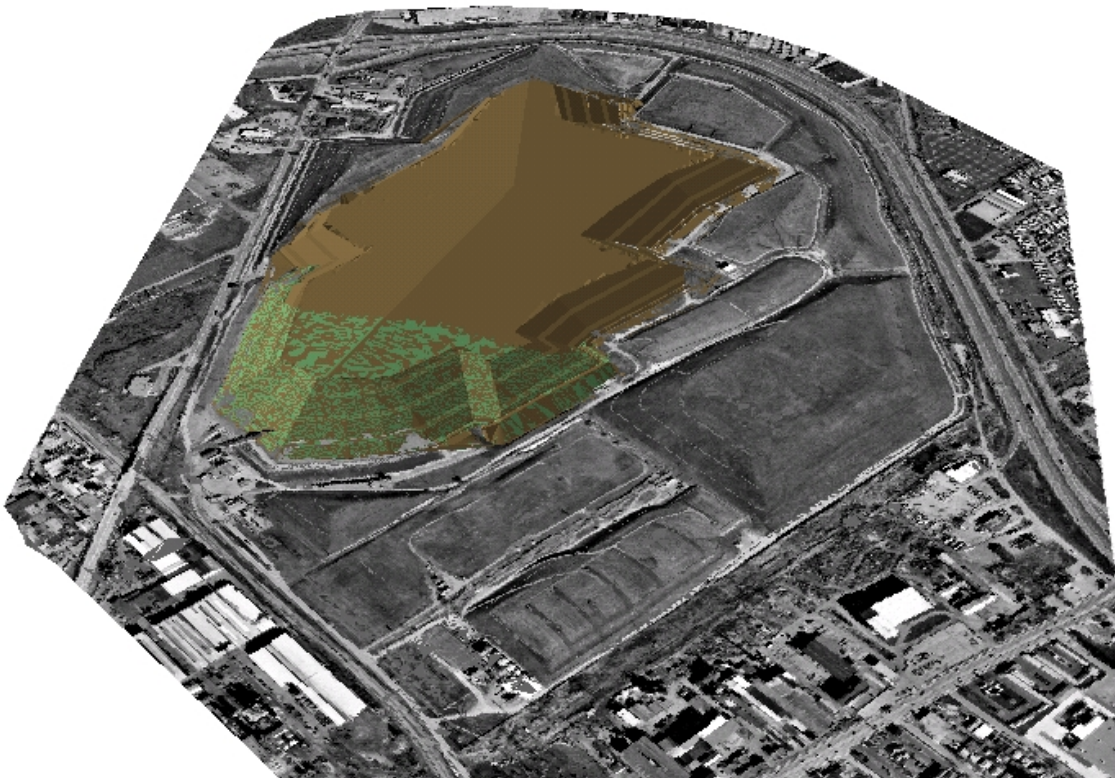
The development of Sanitary Landfill VIII has been successful in utilizing an old industrial fill site to make it a productive solid waste management facility. These successes are as follows.

- Utilizing 85 acres of property that could not be developed for any other purpose and utilizing up to 0.5 million cubic yards of on-site slag as subgrade fill.
- Eliminating an eyesore that has existed at the site since the early 1900s and replacing it with an eventual contoured Greenspace.
- Cleaning up a former hazardous waste facility (Phase I area) and capping over this area and the remaining areas of uncovered lime with the landfill liner to limit infiltration of rainwater and subsequent groundwater contamination.
- Providing construction and site jobs, and purchasing of services, goods and products from local and national vendors.

ALLIED LANDFILL SITE IF SANITARY LANDFILL 8 NOT CONSTRUCTED



**ALLIED LANDFILL SITE UPON COMPLETION OF SANITARY LANDFILL 8
CIRCA 2023**



REFERENCES

1. “An Engineering Manual for Settlement Studies”, J.M. Duncan, A.L. Buchignani, June 1976, University of California at Berkeley.
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