INNOVATIVE USES OF MINED LANDS

CASE STUDY OF THE SOUTHEAST COUNTY LANDFILL HILLSBOROUGH COUNTY, FLORIDA

by

Larry E. Ruiz
Sheila Carpenter-van Dijk

Abstract. The Southeast County Facility located in Picnic, Florida currently includes a 162-acre Class I landfill, a waste tire processing facility, and a leachate treatment facility. The Southeast County Landfill (Landfill) is constructed in an abandoned phosphate mine settling basin and uses 4 to 18 feet of in-situ phosphatic clay slimes as the Landfill bottom liner. The Landfill site was built in 1984 on portions of the Lonesome mine that was in operation from 1945 through 1967. Upon consolidation of the phosphatic clay liner, the low point for the final collection and removal of leachate within the Landfill was projected to be near the center of the Landfill. The leachate collection and removal system for the Landfill was designed to drain to the projected low point. This location coincides with the location where the highest waste fill will occur (i.e., 127 feet). In addition, the location of the sump is in the area with the thickest phosphatic clays deposit (i.e., 18 feet) with an average shear strength of zero degrees. This paper will present the design guidelines and construction procedures used to make possible the construction of the Landfill on a phosphatic clay liner with low shear strength and will describe the design innovations and actual field construction of the internal leachate collection sump at the Landfill.

Introduction

The Southeast County Facility is located in Hillsborough County, south of Tampa, Florida and currently includes a 162-acre Class I Landfill (Landfill), a waste tire processing facility, and a leachate treatment facility. The Landfill accepts incinerated municipal solid waste ash residues, non-processibles, and bypass waste (Figure 1). The Landfill site was built in 1984 on portions of the Lonesome mine that was in operation from 1945 through 1975. The area was reclaimed over a 5-year construction period beginning in 1989 and included regrading of the spoils pile berms. Wetlands areas within the reclamation area were left intact.

The area currently used for landfilling operations was previously a settling basin. It was originally built on natural ground by constructing embankments out of sand borrowed from adjacent areas. The settling basin was used to dispose of, and contain waste clays washed from phosphate ore during the mining operation. It is these phosphatic clays which provide a bottom liner for the Landfill.

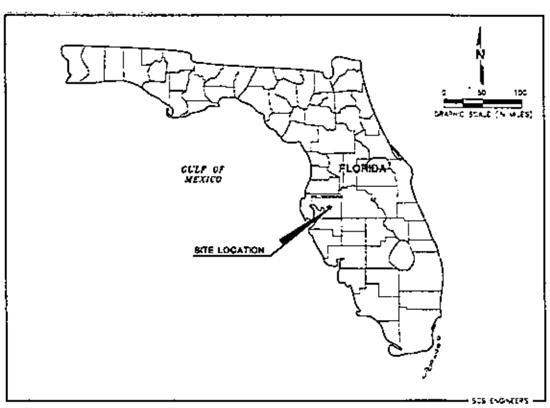

Figure 1. Site Location Map

[1]Paper presented at the 2000 Annual Meeting of the American Society for Surface Mining and Reclamation (ASSMR) in Tampa, Florida, June 11-15, 2000.

[2]Larry E. Ruiz, Project Manager, SCS Engineers, Tampa, FL 33619.
Sheila Carpenter-van Dijk, Staff Engineer, SCS Engineers, Tampa, FL 33619.

Proceedings America Society of Mining and Reclamation, 2000 pp 501-510
DOI: 10.21000/JASMR00010501

https://doi.org/10.21000/JASMR00010501

The phosphatic clay deposits are 4 to 18 feet in thickness and serve as an impervious base liner that acts as a barrier to impede landfill leachate from percolating into the groundwater. A synthetic material was installed along the sidewalls and keyed into the phosphatic clay bottom liner to prevent leakage through the perimeter berm (Figure 2). A sand drainage layer, (minimum of 3-feet in thickness) was constructed before any waste was placed. The phosphatic clay surface, though initially fairly flat, will settle uniformly to create a sump into which leachate will flow after the clay consolidates. The design of the leachate collection system and the phased development of the Landfill were based on the calculated uniform compression and settlement of the phosphatic clay liner.

Figure 2. Perimeter berm liner anchor trench

In addition, the location of the final sump is in the area with the thickest phosphatic clay deposit (i.e., 18 feet) and an average shear strength of zero degrees. This paper will present the design guidelines and construction procedures used to make possible the construction of the Landfill over the low shear strength phosphatic clay liner and will describe the design innovations and actual field construction of the internal leachate collection sump at the Landfill.

Landfill Development Site Studies

Hydrogeological and geotechnical investigations were conducted to evaluate the suitability of the proposed site for the Landfill. The goals were to utilize idle phosphate mining land for landfill development by using in-situ phosphatic clay as an economical liner system to contain leachate and protect the ecosystem.

The results of the investigations characterized the in-situ phosphatic clays as follows:

- Specific gravity (G_s) = 2.80
- Coefficient of consolidation (C_v) = 1.5×10^{-4} cm^2/sec. $\cong 5$ ft^2/yr.
- Permeability (k) = 6×10^{-7} to 3×10^{-10} cm/sec.
- Plasticity Index (PI) = 100 to 200%
- Undrained shear strength (S_u) = 25 to 250 psf
- Moisture content W_n = 70 to 174%

- Total unit weight γ_t = 83 to 85 PCF
- Shear strength: Internal friction (Φ) = 0 degrees
  Cohesion (c) = 70 psf

The studies concluded that the site was suitable to be developed as a landfill. However, as shown above the phosphatic clays were found to be highly expansive, moist, and with very little strength. Therefore, in order to provide a stable foundation with an adequate factor of safety against slope failure, the development of specific construction and operation guidelines was required.

Design Criteria

These design guidelines were developed to provide a factor of safety of 1.5 against slope failure, which is conservative but adequate for this type of project. The design guidelines were as follows:

Leachate Collection System. A 3-foot deep sand drainage layer was placed over the entire Landfill footprint before landfill construction began. This sand layer would serve as a drainage layer for the new leachate collection system as well as provide a loading counterweight and pre-load on the phosphatic clays to begin the consolidation process.

For this purpose, the County used on-site sand tailings generated by the mining activities. The sand was placed using track dozers pushing the sand over the phosphatic clay from the landfill southern boundary towards the northern perimeter (Figure 3). Heavy equipment traffic directly on the phosphatic clay was not allowed.

Figure 3. Sand drainage layer construction

Slope Construction. The Landfill crest elevation was not to exceed 220 feet NGVD (National Geodetic Vertical Datum). Waste filling slopes were to be maintained as follows:

- Side slopes 4H:1V.
- Internal slopes 10H:1V.
- Top slopes not steeper than 20H:1V.

Filling Sequence. To protect the integrity of the phosphatic clay liner, waste was placed first in Landfill areas with thinner deposits of phosphatic clay, and then in the areas with thicker clay deposits (Figure 4). Six phases were identified in which solid waste loading would occur in 15 to 20-foot thick lifts beginning in Phase I and proceeding consecutively through Phase IV for two lifts. After the two lifts were placed in Phases I through IV,

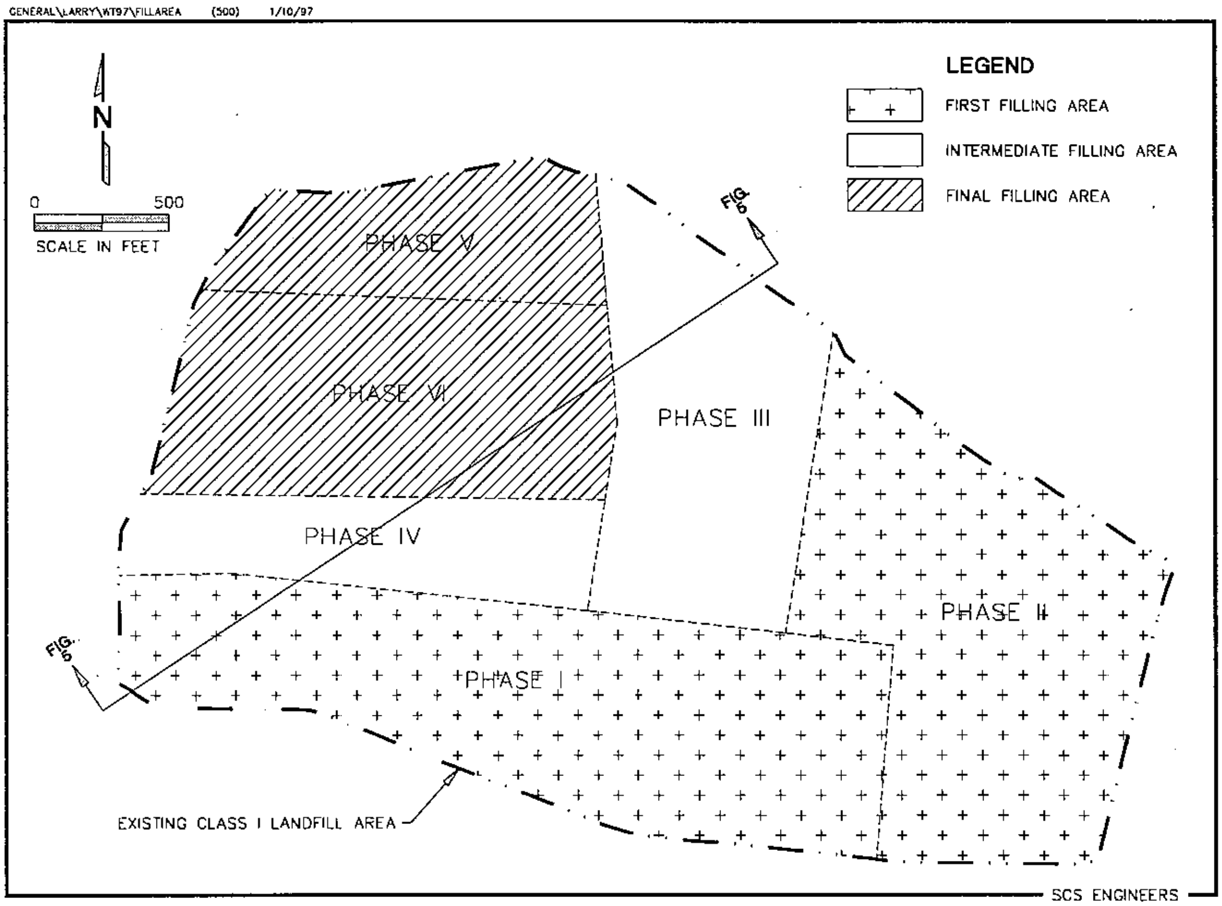

Figure 4. Filling Plan

the filling was to expand into Phases V and VI sequentially.

Based on the measured coefficient of consolidation of the phosphatic clay, for a 12-foot layer of phosphatic clay, each 20-foot lift was to be followed by a 7-year waiting period to allow the phosphatic clay to reach 95 percent consolidation and gain sufficient strength to support successive lifts of waste. The time required to reach 95 percent consolidation was calculated using the following equation:

$$t = 1.5\ H^2/C_v$$

Where:

t = time to 95 percent consolidation
H = average drainage distance during consolidation period
C_v = coefficient of consolidation

LANDFILL CONSTRUCTION

Leachate Collection System. A sand drainage layer was constructed first, over Phases I through Phase IV in 1984 (Figure 3). The sand layer for Phases V and VI was constructed in 1991.

Slope Construction. Designed and constructed with 4H:1V side slopes, 10H:1V internal slopes, and top slopes not steeper than 20H:1V (Figure 5.).

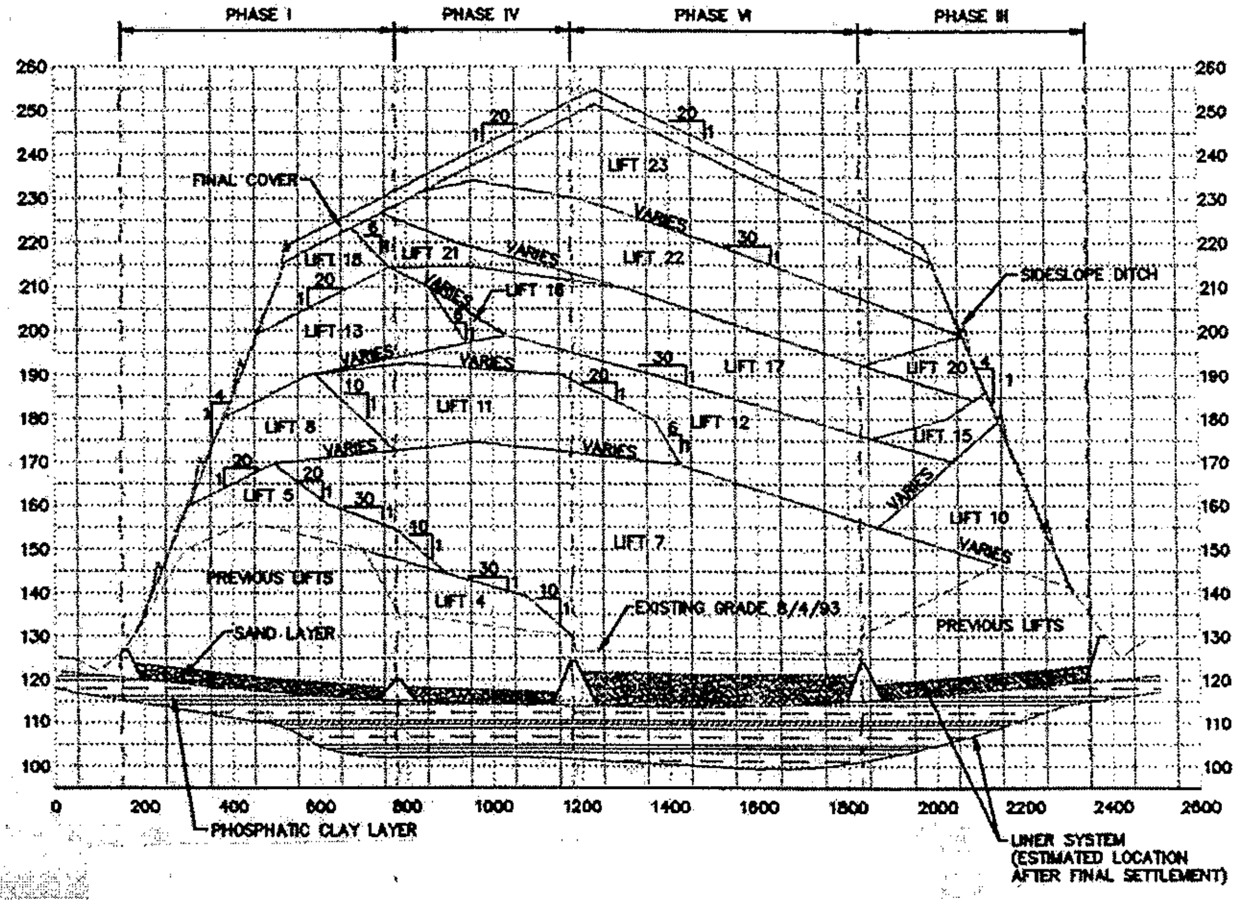

Figure 5. Landfill Cross Section

<u>Filling Sequence</u>. Solid waste filling began by placing the first 20-foot thick lift on Phase I through Phase III (1984 though 1990). However, before the first lift in Phase III was completed, a partial 5-foot lift was placed in Phase IV in 1990. Due to the design deviations described below, waste filling could not proceed into Phase III because the 7-year waiting period was not completed. Filling resumed in Phase III and continued until 1994. Phase IV filling resumed in 1994 and the initial lift was completed. Phase I was completed in May 1995, and Phase II in August 1997. Waste filling continued into Phases V and VI in April 1999 (current lift).

<u>Deviation from Design</u>

The following are construction and operation activities that did not follow the design guidelines:

- Pre-loading of Phases V and VI: As mentioned above, the pre-loading was placed 7 years late. Phases V and VI were not preloaded with the sand drainage layer until 1991; therefore, the phosphatic clays under Phases V and VI did not begin the consolidation process in 1984 as intended by the design.

- Due to stormwater management issues, the first lift of solid waste in Phase IV was placed 4 years early thereby prematurely beginning the settlement process in Phase IV. If the design guidelines had been followed, a full lift of 10 to 15-feet should have been placed on Phase IV at the end of the first lift in Phase III (i.e. in 1994 vs. the actual 1990 date).

<u>Cost Savings</u>. In 1999 dollars, the cost per acre to construct a composite liner bottom for a landfill is \$175,000. The cost per acre to construct the Landfill

using the phosphatic clay liner as described is $50,000. The difference translates to a savings of $125,000 per acre for the County.

Liner Characteristics and Performance

The minimum liner design specified by the Resource Conservation and Recovery Act, Code of Federal Regulations Title 40 part 258 (Subtitle D) is a composite liner system consisting of a minimum 60 mil thick geomembrane liner placed over and in direct contact with a 3-foot thick low permeability soil barrier with a hydraulic conductivity of less than or equal to 1×10^{-7} cm/sec. The maximum allowable design leachate head over the liner is 12 inches. Chapter 62-701, Florida Administrative Code (FAC) provides for alternative liner designs based on the design leachate head (maximum of 12 inches) and hydraulic conductivity of the soil component of the composite liner system. Chapter 62-701, also allows for the use of a double geomembrane liner system in lieu of a composite liner system.

The Landfill phosphatic clay liner exceeds the requirements of Subtitle D for the following reasons:

- Hydraulic characteristics of the liner design: The initial hydraulic conductivity of the phosphatic clay deposits (i.e., before waste loading) was measured to be 6×10^{-7} cm/sec or less. The post-consolidated hydraulic conductivity (i.e., after placement of 60 feet of solid waste and 95 percent consolidation is achieved) is projected to decrease to 1.3×10^{-8} cm/sec.

- Performance of the liner design: As the Landfill-induced stresses consolidate the phosphatic clay deposits, an upward gradient is created by pore water being expressed upward into the sand drainage layer. It is estimated that the liner will not be subjected to a downward gradient until 5 to 10 years after placement of the final cover. Recent geotechnical investigations have confirmed that an upward gradient has developed in the waste phosphatic clay deposits.

- Equivalency analysis: Chapter 62-701.400, FAC specifies the minimum thickness of the lower component of a composite liner system as a function of the maximum design hydraulic head and hydraulic conductivity of the soil barrier layer. The allowable liner design configurations were developed based on an equivalency analysis with the EPA Subtitle D liner design. The rule allows for thinner soil layers in the bottom component of the composite liner system with lower design leachate heads and lower hydraulic conductivities. In all cases, the rule assumes a downward gradient and an allowable leakage rate of approximately 0.008 to 0.41 gallons per day per acre (g/d/a) from the bottom of the liner system. As stated above, the Landfill liner system should not experience a downward gradient until 5 to 10 years after the Landfill closes and the final cover is installed. As such, the current phosphatic clay liner exceeds the minimum performance requirements of Chapter, 62-701.400 FAC.

Leachate Collection System and Sump Pump Station

The design layout of the leachate collection and removal system (LCRS) is shown on Figure 6. In Phases I through IV, the LCRS is a network of granite-filled trenches and 8-inch diameter perforated Schedule 80 PVC pipes. In Phases V and VI the LCRS consists of a network of trenches containing granite rock and 8-inch diameter perforated HDPE pipes or trenches filled with chipped tires. Clean outs are located around the perimeter of Phases V and VI.

The clay surface of the Landfill, though initially fairly flat, was projected to settle uniformly to create a low point in the center of the Landfill into which leachate would flow after consolidation. As shown on Figure 6, the design of the LCRS and the phased development of the Landfill was based on the calculated uniform settlement of the clay liner. Settlement in the low point area was projected to be a maximum of 10 feet.

Upon consolidation of the phosphatic clay liner, the low point for the final collection and removal of leachate within the Landfill was projected to be near the center of the Landfill. The entire LCRS for the Landfill was designed to drain to this projected low point. This location also coincides with the location where the highest waste fill (127 feet) will occur. In addition, the sump is located in the area with the thickest phosphatic clay deposit (i.e., 18 feet) and an average shear strength of zero degrees.

SCS Engineers evaluated and proceeded with the design and construction of a perimeter riser sump with a concrete collection vault housing the pump. The perimeter sump design represented a less costly solution and more stable configuration with respect to future failure due to buckling or lateral deformation as compared to a traditional manhole riser. Nevertheless, the perimeter riser sump provided for a challenging

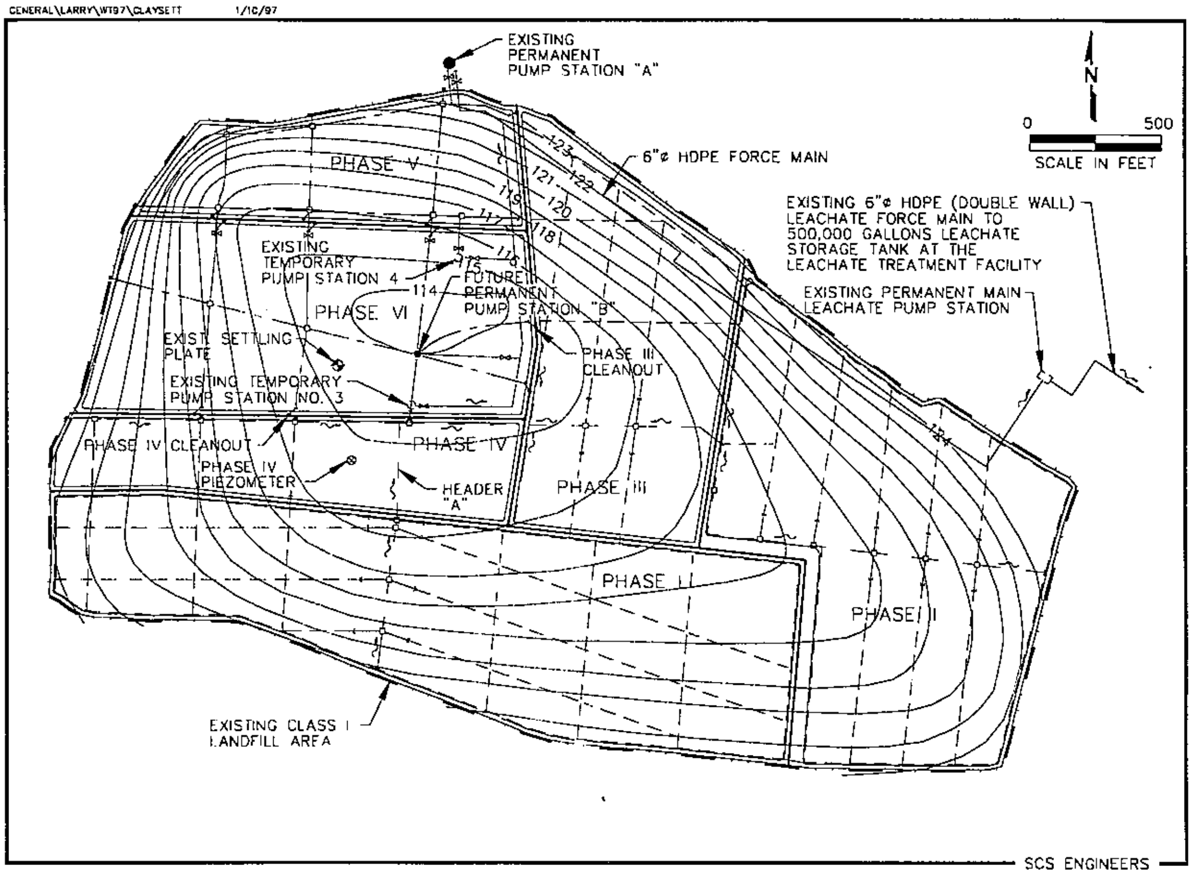

Figure 6. Leachate Collection and Removal System with Projected Top of Clay After Settlement

engineering problem due to accessibility, a corrosive environment, the expected high settlement (i.e. 4.5 feet), and the low bearing capacity and shear strength of the phosphatic clay liner.

The evaluation of the perimeter riser sump resulted in the following loads:

- Dead loads (P_D) = 9,800 PSF.
- Foundation bearing capacity (P_B) = 430 PSF.

The first challenge addressed was the development of a plan to complete the required excavation into soils with an average shear strength of zero degrees and bearing capacity of 430 PSF. Enough foundation bearing capacity was needed to support the initial construction of the concrete vault without causing damage to the phosphatic clay liner.

To provide free flow of leachate into the concrete vault and maintain sufficient leachate storage for the pump cycle, the design included a 3.5-foot excavation into the soft phosphatic clays. Because of the low strength of the phosphatic clay foundation, the construction followed a controlled excavation plan using 5-psi ground pressure equipment and maintaining excavation slopes at a maximum of 3H:1V. The controlled excavation plan provided a safety factor of 1.6 against slope failure.

The foundation preparation before placement of the concrete sump consisted of the installation of two double layers of geogrid to improve the bearing capacity of the phosphatic clays (Figure 7). Calculations showed the geogrid tensile force equivalent to 5,656 psf provided the additional bearing capacity necessary to support the concrete vault, pump and accessories within the vault, and subsequent waste fill above the vault. Additionally, to reduce the initial dead weight on the foundation, the concrete vault was built in two sections. The concrete vault footer was prefabricated and lowered into position by two 75-ton cranes before the vault walls were cast in place (Figures 8 and 9).

Failure of concrete within landfills is typically caused by the corrosive environment produced by the waste material. Therefore, to prevent deterioration and subsequent failure of the concrete vault due to the expected corrosive environment, both the steel reinforcement and the high-strength concrete were epoxy coated (Figure 8).

The concrete vault was surrounded with a soil filter system. The soil filter system would facilitate the movement of leachate into the sump. In addition, as a contingency, the soil filter system is of sufficient quantity to allow for a well-point system to be incorporated into the LCRS if necessary. Two horizontal 18-inch diameter SDR 13.5 HDPE pipes were installed to provide pump access into the concrete sump from the north and from the west. One 18-inch pipe would serve as the main access with a 4-inch force main discharging into the existing lift station. The second 18-inch access pipe would serve as backup access in case of failure of the main access or if additional leachate removal becomes necessary.

To provide adequate support for the pipes during the expected settlement, the 18-inch diameter HDPE access pipes were installed in gravel trenches and wrapped in a geotextile fabric (Figure 10). The gravel trench provides for a stable pipe support and relatively low friction resistance (acting as a sleeve) to allow the access pipes to move as the Landfill settles.

At a cost of $186,000, construction of the perimeter riser sump was completed successfully in December 1998 and as of the date of this publication the system is operating as designed.

CONCLUSION

The State of Florida currently encourages reclamation of mined sites by providing financial and technical assistance for the proper reclamation activity. The Southeast County Landfill is not alone and it will not be the last landfill to be built on mined lands. Other sites in the State of Florida have received state grants for the reclamation of mined lands to be used as landfills. The solutions presented in this publication were engineered to meet regulations and protect the environment. Our innovative design conquered specific challenges and met special conditions to reclaim unusable land for a practical and revenue-generating purpose.

References

Ardaman & Associates, Inc., 1983, "Hydrogeological Investigation, Southeast Landfill".

Ardaman & Associates, Inc., 1994, "Geotechnical Investigation, Southeast Landfill".

Florida Administrative Code (FAC), Chapter 62, 1997.

Petroff, L.J., 1994. "Design Methodology for High Density Polyethylene Manholes".

SCS Engineers, 1994, "Operation Permit Renewal Application, Southeast County Landfill, Hillsborough County, Florida".

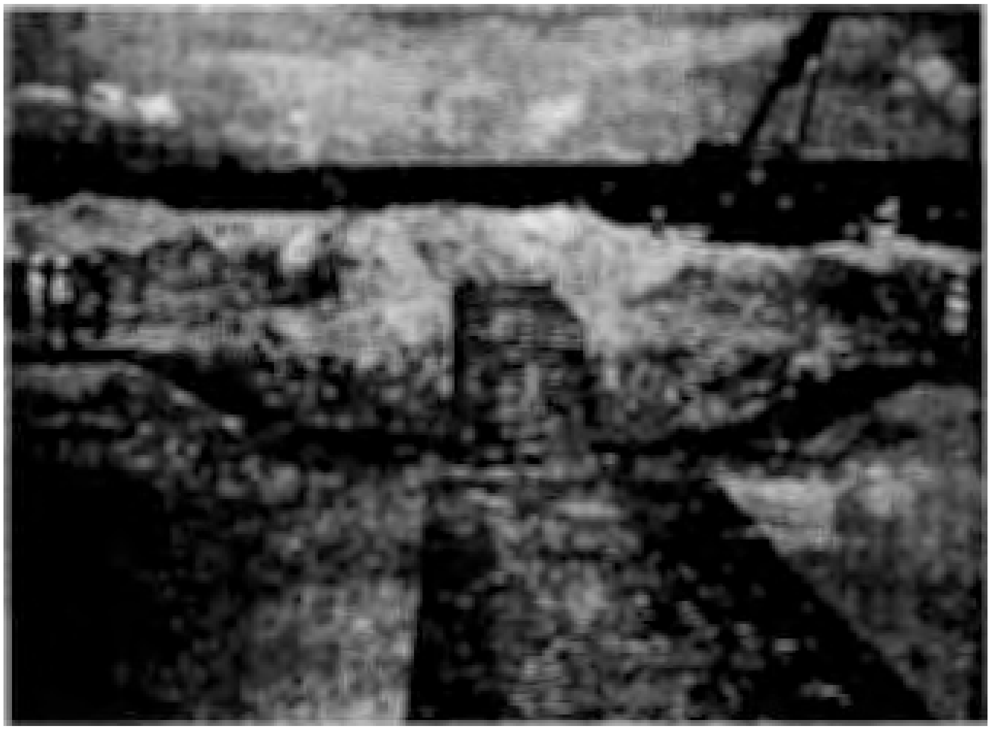

Figure 7. Excavation with one layer of geogrid installed

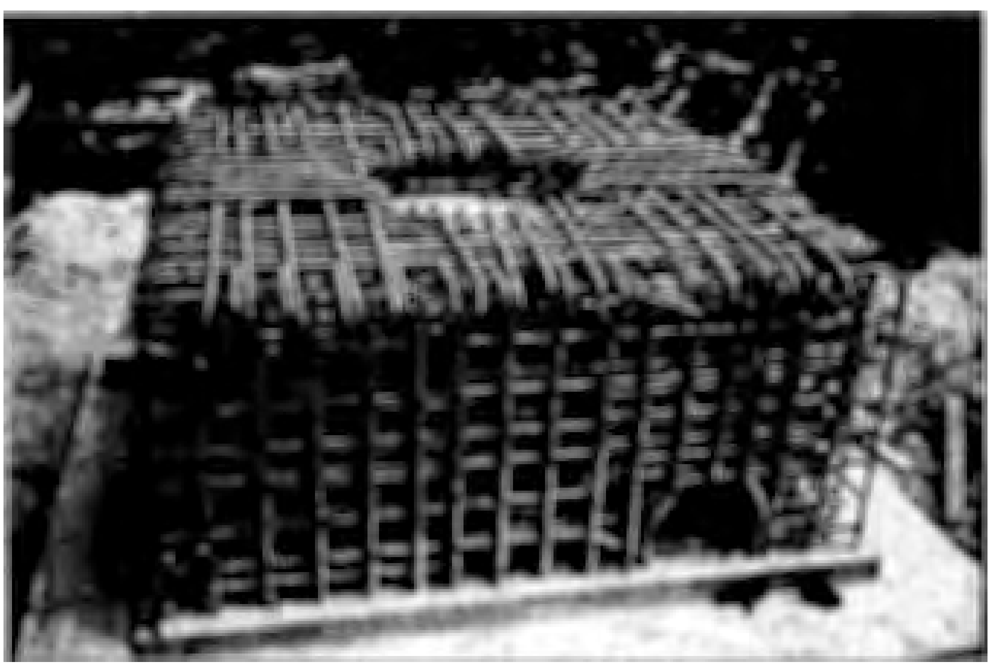

Figure 8. Concrete sump footer and epoxy coated reinforcement steel

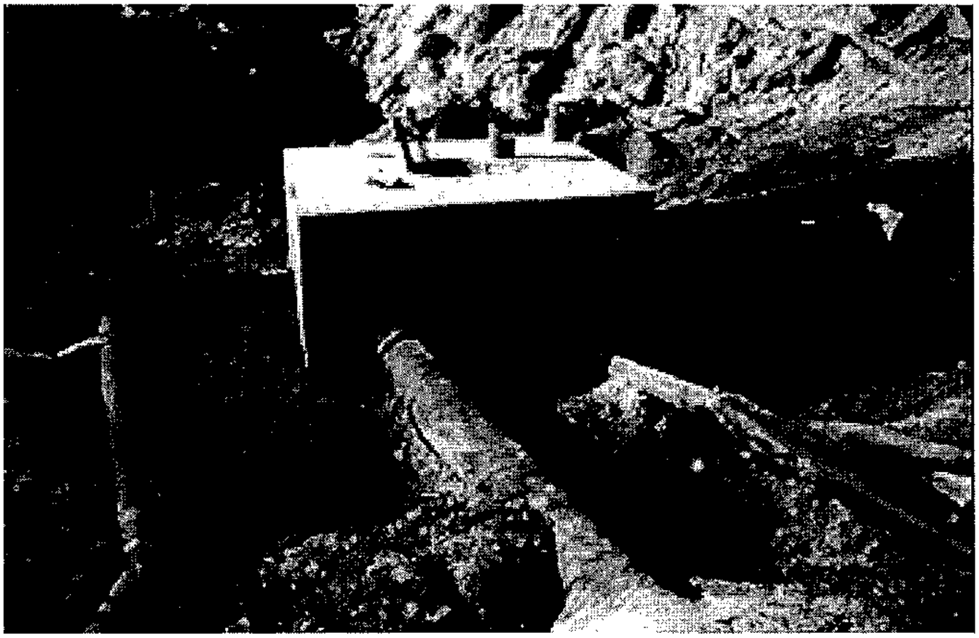

Figure 9. Completed concrete sump with leachate collection system and access pipes connections

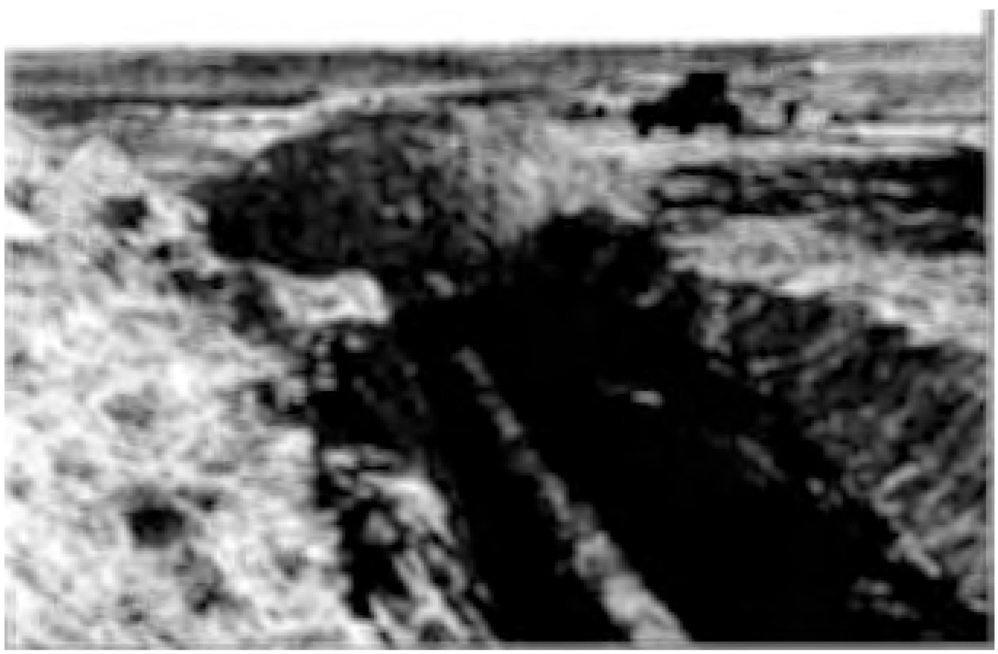

Figure 10. Gravel trench for 18-inch diameter HDPE access pipes