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JONES EDMUNDS

Dept. of Environmental Protection

APR 14 2006

Southwest District

April 14, 2006

Ms. Susan J. Pelz, P.E.
Solid Waste Program Manager
Southwest District
13051 North Telecom Parkway
Temple Terrace, Florida 33637

RE: 2006 Annual Monitoring of the Phosphatic Clays
Southeast County Landfill, Hillsborough County, Florida
Jones Edmunds Project No. 08449-022-01

Dear Susan:

Please find attached to this cover letter an evaluation report, prepared by Ardaman and Associates, Incorporated (Ardaman), for the annual monitoring of the phosphatic clays beneath the Phase I through VI areas at the Southeast County Landfill (SCLF) located in Hillsborough County, Florida. The evaluation report for the phosphatic clays was prepared in accordance with Specific Condition No. 16f of Operations Permit No. 35435-006-SO.

Jones Edmunds has reviewed the report and agrees with the assessments made by Ardaman on the current status of the phosphatic clays. The report supports the following observations;

- Under the current conditions, the piezometric heads below the phosphatic clays are lower than the piezometric heads in the middle of clays; therefore, no downward gradient exists within the test area locations.

- The observed dissipation of excess pore pressure and the projected rate of consolidation and strength gain of the phosphatic clays are generally consistent with the current filling sequencing.

In summary, the attached report supports the conclusion that the phosphatic clays and the current filling sequence are performing as designed.

Please call with any questions.

Sincerely,

Joseph H. O'Neill, P.E.
Solid Waste Department Manager

Attachments

cc: Patricia V. Berry, SWMD
Ron Cope, HCEPC
Richard A. Siemering, Jones Edmunds
John Arnold, P.E., Jones Edmunds

April 14 2006
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Geotechnical Study Associated with 2006 Annual Monitoring of the Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County, Florida

April 13, 2006

FILE

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Materials Consultants

April 13, 2006
File Number 05-072

Jones Edmunds
324 South Hyde Park Avenue
Suite 250
Tampa, FL 33606-4110

Attention: Mr. Richard A. Siemering, P.E.

Subject: Geotechnical Study Associated with 2006 Annual Monitoring of the Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County, Florida

Gentlemen:

As requested by Jones Edmunds, Ardaman & Associates, Inc., (Ardaman) has completed a geotechnical study associated with annual monitoring of the phosphatic clay liner beneath the Southeast Landfill in Hillsborough County. The annual monitoring program was mandated by the Florida Department of Environmental Protection (FDEP) under Specific Condition No. 16f of the Landfill Operation Permit No. 35435-006-SO issued on June 25, 2002. The monitoring program involves performance of piezocone soundings and measurements of pore water pressures in the vicinity of the following four test sites where a number of piezocone soundings and pore water pressure measurements had previously been performed by Ardaman and Madrid Engineering Group, Inc., (Madrid) in 2001/2002: (i) PC-1B and PC-1F in the Phase I area; (ii) PC-4B and PC-4C in the Phase IV area; (iii) PC-3 and PC-3B in the Phase III area; and (iv) PC-1F in the Phase I area. Specifically, the permit condition required documentation and interpretation of the following data:

- Piezometric elevations in the drainage sand layer above the phosphatic clay.
- Top and bottom elevations of the phosphatic clay layer.
- Pore water pressures near the top, middle, and bottom of the phosphatic clay layer.
- Piezometric elevations in the natural soils below the phosphatic clay.

Evaluations of the phosphatic clay liner in 2003, 2004, and 2005 in accordance with permit requirements were documented in Ardaman reports dated April 12, 2003, April 15, 2004, and May 27, 2005, respectively. This report contains the results of the piezocone soundings and pore water pressure measurements obtained by Ardaman in February and March 2006, and presents our interpretation of the test data.

Site Location

The Southeast Landfill is located within Sections 14, 15, 22, and 23 of Township 31 South, Range 21 East, in unincorporated Hillsborough County, Florida. More specifically, the landfill site is located between Picnic and Pinecrest, about 2 miles west of County Road 39 and about 0.5 miles north of County Road 672. The approximate site location, as superimposed on a reproduction of the United States Geological Survey (USGS) quadrangle map of Lithia, Florida (1955, photorevised 1987), is shown in Figure 1.

Project History

Phases I through VI of the Southeast Landfill are constructed directly above a waste clay settling area at a former phosphate mine known as Lonesome Phosphate Mine or Boyette Mine. The settling area, also known as Settling Area No. 1, was built on natural ground within a perimeter dike constructed of sand borrowed from surrounding areas. Waste phosphatic clay was deposited within the settling area for a number of years during the mining operation.

A comprehensive geotechnical study was conducted by Ardaman between 1981 and 1983 to characterize the phosphatic clay deposit and to evaluate the feasibility of constructing a landfill within the waste clay settling area. Results from that study were documented in an Ardaman report titled "Hydrogeological Investigation, Southeast County Landfill, Hillsborough County, Florida," dated February 22, 1983. Based on the data and analyses documented in that report, Ardaman concluded that a landfill could be constructed directly on top of the phosphatic clay. However, to maintain an adequate factor of safety against slope failure, the waste disposal area was divided into different phases, and each phase had to be filled in lifts such that filling above a previous lift would occur only when the underlying phosphatic clay had consolidated under the weight of the previous refuse lift and experienced sufficient increase in shear strength to support the additional load. In areas where the clay thickness was greater than 14 feet, it was recommended that the clay should be pre-loaded prior to placement of the first lift of refuse. A diagram that shows the original thickness of the phosphatic clay within the settling area, as reproduced from the 1983 Ardaman report, is shown in Figure 2. As shown, the phosphatic clay deposit had an original thickness that varied between 4 and 18 feet.

Another comprehensive geotechnical study was completed by Ardaman in 1994 in association with operation permit renewal for the Southeast Landfill. Results from that study were documented in an Ardaman report titled "Geotechnical Investigation at Southeast Landfill, Hillsborough County, Florida," dated March 7, 1994. The strength and consolidation properties of the phosphatic clay obtained from that study were in good agreement with those used in the original stability analyses and affirmed the recommended filling schedule.

In support of the operation permit renewal application in 2002, SCS Engineers retained Madrid Engineering Group and Ardaman to perform supplemental studies to confirm the engineering properties of the phosphatic clay, and to determine whether the material had been consolidating and gaining strength as predicted, and whether the 7-year waiting period for placements of successive refuse lifts in the landfill should be modified. Results from that study were presented in an Ardaman report titled "Geotechnical Study Associated with Operation Permit Renewal for Hillsborough County Southeast Landfill," dated March 4, 2002. In that report, Ardaman concluded that:

- There was a consistent trend of increased tip resistance from the cone soundings within the phosphatic clay deposit, which was expected as a result of landfill loading.

- The measured undrained shear strengths of the phosphatic clay under existing conditions were generally within the expected range.

- The coefficients of consolidation of the waste phosphatic clay were generally consistent with those documented from previous studies.

The original geotechnical investigation completed in 1983 and the follow-up studies completed in 1994 and 2002 recommended that each lift of refuse should have a thickness no greater than 20 feet and that a minimum waiting period of 7 years should be provided between placements of successive refuse lifts. These requirements were derived based on stability analyses using an undrained shear strength to effective vertical stress ratio of 0.21 and a coefficient of consolidation of 1.5×10^{-4} cm^2/sec for the waste phosphatic clay. The undrained shear strength to effective vertical stress ratio determines the magnitude of strength increase in the phosphatic clay, whereas the coefficient of consolidation governs the rate of strength increase.

Field Testing Program

Current operation at the Southeast Landfill divides the waste disposal area into six phases designated Phases I through VI, as shown on a topographic site plan in Figure 3. The topographic site plan was generated from photogrammetric data obtained by Pickett & Associates from aerial photography taken on July 5, 2005. We understand that landfilling has occurred in the Phase II and III areas subsequent to the flight date of the aerial photograph.

As part of our scope of work for the annual monitoring program stipulated in Specific Condition No. 16f of the FDEP Permit No. 35435-006-SO, Ardaman performed piezocone soundings and pore water pressure measurements at four test sites within the Phase I, III, and IV areas near test sites where the annual monitoring program had previously been performed by Ardaman in 2001 through 2005.

Four test sites for the 2006 annual monitoring program were selected by Jones Edmonds for performance of piezocone soundings and installation of piezoprobes.

(i) PC-1M in the western portion of the Phase I area
(ii) PC-1N in the eastern portion of the Phase I area
(iii) PC-3F in the Phase II area slightly to the east of the previous test sites in the Phase III area
(iv) PC-4G in the Phase IV area.

The approximate locations of these test sites are shown in Figure 3 along with the test site locations for the 2001/2002 studies performed by Madrid and Ardaman and for the 2003, 2004, and 2005 annual monitoring programs. As shown in Figure 3, PC-1M was located in close proximity to the previous PC-1B, PC-1H, PC-1J, and PC-1K test site locations, and PC-1N was selected adjacent to the previous PC-1, PC-1F, PC-1G, PC-1GA, PC-1I, and PC-1L test site locations. PC-3F was located approximately 250 feet southeast of the PC-3E test site location in 2005. PC-4G was selected between the PC-4E test site location in 2004 and the PC-4F test site location in 2005. The current field work and testing were performed by Ardaman in February and March 2006.

The surveyed coordinates and ground surface elevations at the current test site locations, as provided by Jones Edmonds, are summarized in Table 1. The coordinates were referenced to the Florida State Plane Coordinate System (NAD83). The elevations were surveyed using the National Geodetic Vertical Datum of 1929 (NGVD29). The elevation data used in the previous geotechnical studies were also based on NGVD29.

Ardaman performed the field work in two stages. The first stage of our work involved drilling through the refuse using an auger rig at the four test sites followed by performance of piezocone soundings by a cone penetrometer rig from the drainage sand layer, through the phosphatic clay layer, and into the underlying natural soils. The objective of the first stage of work was to determine the depths to the top and bottom of the phosphatic clay layer and, where possible, the depths to the drainage sand layer, and to establish the depths where the piezoprobes for measurements of pore water pressures should be installed. We also documented the pore water pressures within the sandy soils above and below the phosphatic clay layer based on the piezocone data. The second stage of our work involved drilling of additional test holes through the refuse adjacent to the piezocone sounding locations, installation of piezoprobes at different depths within the phosphatic clay layer at each of the four test sites, and monitoring of pore water pressure dissipation in the piezoprobes.

The test holes were grouted upon completion of the piezocone soundings and piezoprobe measurements and the test site locations were staked for surveying by Jones Edmunds.

Because methane was expected to be encountered and organic compounds might be encountered during drilling through the refuse/ash, the drilling program was performed in accordance with the health and safety plan developed by Ardaman for this project. Continuous air monitoring by an Ardaman technician with a landfill gas/methane detection meter and organic vapor analyzer was performed during drilling operations.

Piezocone Penetration Tests

The piezocone consists of a conical point attached to a steel rod and a friction sleeve. The test is performed by pushing the assembly into the soil at a constant rate of penetration. Resistance to penetration at the cone tip and on the friction sleeve are measured by load cells placed within the assembly and the pore water pressure in the soil is measured using a pressure transducer connected to the porous element placed near the cone tip. Prior to pushing of the piezocone through the waste phosphatic clay, an auger was used to create a borehole through the refuse.

Results of the four piezocone penetration tests (i.e., PC-1M, PC-1N, PC-3F, and PC-4G) performed at the four test site locations are presented in Figures 4 through 7, respectively. As shown in the figures, results are presented in the form of tip resistance (i.e., the resistance to penetration at the cone tip), sleeve resistance (i.e., the resistance to penetration of the friction sleeve), pore water pressure (i.e., the total pore water pressure including the pore pressure generated due to penetration of the cone) and friction ratio (i.e., the ratio of sleeve resistance to tip resistance).

Since sandy soils typically exist above and below the phosphatic clay, the depth and thickness of the phosphatic clay layer could be inferred by examining the variations of tip resistance and pore water pressure with depth. The tip resistance and the pore water pressure in a clayey soil are expected to be lower and higher, respectively, than those in a sandy soil. Higher friction ratios are generally indicative of clayey soil types, whereas lower ratios generally indicate the presence of silty and sandy soils. Sudden changes in tip resistance, pore water pressure, and friction ratio are expected to occur at the interface between the drainage sand layer and the underlying phosphatic clay as well as the interface between the phosphatic clay and the underlying natural sandy soils.

Thickness of Refuse/Ash

Based on results of the auger borings and piezocone soundings, the refuse/ash thicknesses at the four test sites (i.e., PC-1M, PC-1N, PC-3F, and PC-4G) in February 2006 ranged from approximately 53 feet at PC-3F to 70 feet at PC-1N, assuming that the drainage sand is 2 feet thick.

PC-1M was located in the western portion of the Phase I area. The refuse/ash thickness at PC-1M in February 2006 was estimated to be 53 feet, compared to a refuse/ash thickness of 51 feet at PC-1K in March 2005 and a refuse/ash thickness of 65 feet at PC-1J in March 2004. The reason for the variation in refuse thickness was because the test sites were not at identical locations. PC-1K was located approximately 110 feet northwest of PC-1J and at the toe of slope between the Phase I and IV areas. The land surface elevation at PC-1K was approximately 14 feet lower than the land surface elevation at PC-1J. PC-1M is located approximately 62 feet northwest of the PC-1K test location and the land surface elevation is less than 1.5 feet higher at PC-1M than at PC-1K.

PC-1N was located in the eastern portion of the Phase I area. The refuse/ash thickness at PC-N was estimated to be 70 feet in February 2006 compared to a refuse/ash thickness of 65 to 70 feet at PC-1L in March 2005 and a thickness of 50 feet at PC-1I in March 2004. PC-1N has approximately the same land surface elevation as PC-1L but the land surface elevation at PC-1N and PC-1L is more than 15 feet higher than the land surface at the other nearby test locations at the time of testing.

The refuse/ash thickness at PC-3F in February 2006 was approximately 53 feet compared to a refuse/ash thickness at PC-3E in March 2005 of approximately 35 feet. The difference in refuse/ash thickness is accounted for by placement of refuse/ash creating a land surface elevation approximately 19.5 feet higher at PC-3F than at PC-3E in 2005.

The refuse/ash thickness at PC-4G during the current field program was approximately 55 feet. The refuse/ash thickness at PC-4F in March 2005 was slightly greater than 60 feet, compared to a refuse thickness of slightly greater than 50 feet at PC-4E in March 2004. The land surface elevation at PC-4G is roughly 10 feet lower than the elevation of PC-4F in March 2005. We understand that some filling short of a full 20-foot lift occurred in the area near these test site locations in March/April 2003.

Filling Sequence

Since 2003, filling in the landfill has generally proceeded counterclockwise from Phase IV through Phase I from west to east and from there to Phase II and Phase III. In the Phase IV area, no full lift of refuse/ash has been placed since May 1995. Approximately 13 feet of refuse/ash was placed in the vicinity of PC-4F in March/April 2003 (i.e., just prior to filling of the Phase I area) as part of the grading transition from the refuse lift placed in the adjacent Phase VI area that was completed in March 2003. Filling occurred in the vicinity of PC-1K around June 2003. The filling sequence proceeded to the eastern part of Phase I between March 2004 and March 2005. Filling occurred in the vicinity of PC-1L around July 2004. A comparison of the surveyed data in the Phase I area indicated that the thickness of the refuse lift was approximately 16 to 17 feet. The previous refuse/ash lift in the Phase I area was completed in August 1997. During our previous field program in March 2005, refuse/ash was being placed in the southern part of the Phase II area. In February 2006, refuse/ash was being placed in the not on Fig 3

Phase II and Phase III areas near our test site location PC-3G. Placement of the previous lift in the Phase III area began in December 1990 and ended in June 1994.

Elevations and Thicknesses of Phosphatic Clay

Prior to landfill construction, the top surface of the waste phosphatic clay within the former settling area was documented to have typical elevations in the range of +121 to +123 feet (NGVD) and the bottom of the phosphatic clay reportedly occurred at typical elevations ranging from +103 to +117 feet (NGVD). As indicated previously, the original thickness of the phosphatic clay ranged from 4 to 18 feet.

Based on results of the piezocone soundings, the top and bottom elevations of the phosphatic clay and the phosphatic clay thicknesses encountered at the four test sites are summarized in Table 2. As shown, the top elevations of the phosphatic clay ranged from a low of +109.3 feet (NGVD) at PC-1M to a high of +119.0 feet (NGVD) at PC-3F. The bottom elevations of the phosphatic clay layer ranged from a low of +101.3 feet (NGVD) at PC-1M to a high of +112.5 feet (NGVD) at PC-1N.

At the location of PC-1M, the top and bottom of the phosphatic clay layer were encountered at approximately +109.3 and +101.3 feet (NGVD), respectively, for a clay thickness of about 8 feet. This thickness was close to the clay thickness (7.4 feet) documented at PC-1K in March 2005. As indicated previously, approximately 17 feet of refuse was placed south of PC-1K and PC-1M in June 2003.

The piezocone sounding for PC-1M indicates a material below the phosphatic clay with higher pore water pressure and tip resistance than the phosphatic clay. A similar layer was evident in the piezocone sounding for PC-1K in 2005. During the annual monitoring in 2001, auger borings were performed within 100 feet of piezocone PC-1B to confirm the results of the piezocone sounding. Soil samples recovered from below the phosphatic clay indicated the presence of a layer of dark brown peat that occurred at a depth of 52.5 to 57.5 feet below land surface. The peat deposit was underlain by a brown fine sand soil. The peat deposit around PC-1B was projected to have a maximum radius of approximately 200 feet. PC-1M was located approximately 75 feet from PC-1B. The peat deposit is expected to have a much higher coefficient of consolidation than the phosphatic clay and to have fully consolidated by this time.

Based on the piezocone sounding performed at the location of PC-1N, the phosphatic clay had top and bottom elevations of +116.4 and +112.5 feet (NGVD), respectively, for a phosphatic clay thickness of 3.9 feet, which is very close to the thickness (4.0 feet) documented at the nearby PC-1L in 2005. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1L and PC-1N in July 2004.

The piezocone sounding performed at the location of PC-3F revealed the top elevation of the phosphatic clay at +119.0 feet (NGVD) and the bottom elevation at +111.2 feet (NGVD), for a clay thickness of 7.8 feet, The piezocone sounding performed at the location of PC-3E in 2005 revealed the top elevation of the phosphatic clay at +118.7 feet (NGVD) and the bottom elevation at +110.3 feet (NGVD), for a clay thickness of 8.3 feet. Because PC-3F is approximately 250 feet southwest of PC-3E, the clay thicknesses should not necessarily be identical. In addition, refuse/ash has been placed in this area subsequent to the March 2005 testing. The thickness of the phosphatic clay in this area has decreased from 9.3 feet at PC-3A in 2001 to 7.8 feet at PC-3F in 2006.

Based on the piezocone sounding performed at the location of PC-4G, the top and bottom elevations of the phosphatic clay were documented at +110.5 and +103.3 feet (NGVD), for a clay thickness of 7.2 feet, which is almost identical to the thickness (6.9 feet) documented at the nearby PC-4F test site in 2005.

In summary, the phosphatic clay elevations and thicknesses documented at the four test sites in 2006 (i.e., PC-1M, PC-1N, PC-3F, and PC-4G) indicated that there were changes in clay thickness of 0.1 to 0.6 feet from March 2005 to February 2006.

Piezometric Elevations on Top of Phosphatic Clay

The piezometric heads in the drainage sand layer on top of the phosphatic clay could be inferred from the piezocone penetration test results. As the piezocone was pushed through the drainage sand layer on top of the phosphatic clay, it was held stationary at selected depths to allow the excess pore water pressure generated as a result of pushing of the piezocone to stabilize. Because of the relatively high permeability of the sand, any excess pore water pressure should dissipate in a short duration. The pore pressures were monitored for several minutes to make sure that the final readings represented the stabilized pore pressures at the selected depths.

The boring for piezocone PC-1M penetrated slightly into the phosphatic clay layer because the drainage sand layer was too dense for cone penetration. Therefore, no pore water pressure readings could be taken in the sand. The piezometeric elevation in the drainage sand at the top of the clay was approximated as the pore water pressure at the start of the piezocone sounding.

Based on the piezocone soundings performed at the four test sites, the piezometric heads in the drainage sand layer on top of the phosphatic clay are summarized in Table 3 and are further displayed in Figure 8. Piezometric heads documented from previous studies are also shown on the same figure for comparison.

As shown in Table 3 and Figure 8, results of the piezocone soundings indicated that the piezometric heads on top of the phosphatic clay at the four test site locations ranged from 1.4 to 7.7 feet. The highest piezometric elevation of +124.1 feet (NGVD), which was 7.7 feet above the top of the phosphatic clay, was observed at PC-1N. The piezometric heads in the drainage sand on top of the phosphatic clay at PC-1M, PC-3F, and PC-4G were measured to be 2.3, 1.4, and 6.5 feet above the top of the phosphatic clay, respectively. The piezometric heads in the drainage sand layer in February 2006 ranged from 0.5 feet higher to 5.5 feet lower than the previous readings obtained in March 2005.

Piezometric Elevations Below Phosphatic Clay

Based on the piezocone sounding results, the piezometric elevations in the natural soils below the phosphatic clay are summarized in Table 4. As shown, the piezometric elevations at the test site locations were documented at approximately +117 to +123 feet (NGVD) versus approximately +118 to +122 feet (NGVD) in March 2005. The piezometric elevations below the phosphatic clay at PC-1M and PC-4G were within 1 to 2 feet of the elevations at the corresponding locations PC-1K and PC-4F in March 2005. The piezometric elevations below the phosphatic clay at PC-1N and PC-3F were 4 feet higher and 5 feet lower, respectively, than the elevations at test site locations PC-1L and PC-3E in March 2005.

Piezoprobe Tests within Phosphatic Clay

The piezoprobe tests were performed by installing piezoprobes to pre-selected depths within the phosphatic clay and holding them stationary until the excess pore water pressure generated from probe penetration completely dissipated, and the measured pore water pressure reached the actual pore water pressure before probe penetration.

The dissipation of excess pore water pressures generated by piezoprobe penetrations are presented in Figures 9 to 12 for PC-1M, PC-1N, PC-3F, and PC-4G, respectively. Figures 9, 10 and 12 are in the form of normalized excess pore pressure (i.e., the ratio of excess pore water pressure at any time to the maximum excess pore water pressure after piezoprobe penetration) versus time. In some cases, the pore water pressure first increased to a peak level before it began to dissipate. As shown in the figures, all pore water pressures reached equilibrium conditions at the end of the monitoring periods. The rate of dissipation of excess pore water pressure generated by piezoprobe penetration can be used to estimate the *in situ* coefficient of consolidation of the phosphatic clay.

At the location of PC-1M, with approximately 8 feet of phosphatic clay, piezoprobe tests were performed at four different depths to measure the pore water pressures near the top, middle, and bottom of the phosphatic clay layer. At the location of PC-1N, with approximately 4 feet of phosphatic clay, piezoprobe tests were performed at two different depths to measure the pore water pressures near the top and middle of the phosphatic clay layer. At the location of PC-3F, with approximately 8 feet of phosphatic clay, piezoprobe tests were performed at three different depths. At the location of PC-4G, with approximately 7 feet of phosphatic clay, piezoprobe tests were performed at two different depths to measure the pore water pressures straddling the middle of the phosphatic clay layer. Results from the piezoprobe tests are summarized in Table 5.

At the location of PC-1M, the equilibrium piezometric elevations for the four piezoprobes installed with tip elevations at +108.3, +106.3, +104.3, and +102.3 feet (NGVD) were documented to be approximately +112.7, +126.3, +130.7, and +126.1 feet (NGVD), respectively. The excess pore water pressures within the phosphatic clay layer at the tip elevations were estimated to be 0.0 (i.e., no excess pore water pressure), 10.4, 12.0, and 4.5 feet of water, respectively. Excess pore water pressures at PC-1K in 2005 ranged from 10.4 to 14.8 feet of water. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1M in June 2003, which would have caused an excess pore water pressure of 22 feet of water, based on a refuse/ash weight of 80 lb/ft^3, prior to dissipation.

At the location of PC-1N, two piezoprobe tests were performed with the piezoprobe tip elevations at +116.4 and +114.9 feet (NGVD). The piezoprobe with the tip elevations at +116.4 feet (NGVD) was at the top elevation of the phosphatic clay. The piezoprobe readings indicated no excess pore water pressure. The piezometric elevation for the tip elevation at +114.9 feet (NGVD) was documented to be +130.9 feet (NGVD), corresponding to an excess pore water pressure that is equivalent to approximately 7.4 feet of water, which compares to 7.1 feet of water at the location of PC-1L in 2005. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1N in July 2004. Because the phosphatic clay thickness at PC-1N (3.9 feet) was less than that at PC-1M (8.0 feet), the excess pore water pressure from refuse/ash loading would be expected to dissipate at a faster rate.

At the location of PC-3F, piezoprobe tests were performed with the piezoprobe tip elevations at +118.2, +115.4, and +114.2 feet (NGVD)). Results of the piezoprobe tests performed with the piezoprobe tip elevations at +115.4, and +114.2 feet (NGVD) were erratic. Accordingly, we were not able to interpret the piezoprobe data to obtain meaningful results. The piezoprobe test at elevation +118.2 feet (NGVD), near the top of the phosphatic clay, indicated an excess pore water pressure of 3.3 feet of water. Additional loading from the current lift is expected to cause higher excess pore water pressures toward the middle of the phosphatic clay layer. At test location PC-3E in 2005 excess pore water pressures of 0.2 to 1.8 feet of water were measured. This indicated that excess pore water pressures from the previous lift had largely dissipated.

At the location of PC-4G, two piezoprobe tests were performed within the phosphatic clay layer with the piezoprobe tip elevations at +107.8 and +105.8 feet (NGVD). The equilibrium piezometric elevations were at +132.2 and +133.3 feet (NGVD), respectively. The excess pore water pressures near the middle of the phosphatic clay were equivalent to approximately 15 feet of water. High excess pore water pressures were also observed in the Phase IV area in previous piezoprobe measurements in 2003, 2004, and 2005. The high excess pore water pressures could be attributed to refuse/ash loading in the Phase IV area. As noted previously, approximately 13 feet of refuse was added in the vicinity of PC-4F in April 2003. Excess pore water pressure decreased substantially from 19 to 32 feet of water in 2005 to approximately 15 feet of water in 2006.

Coefficient of Consolidation

The coefficient of consolidation governs the rate of strength increase in the phosphatic clay upon loading from a refuse lift and thus the waiting period between placements of successive refuse lifts in an area. The filling schedule at the Southeast Landfill was originally based on a design vertical coefficient of consolidation, c_v, of 1.5×10^{-4} cm^2/sec.

Based on the rates of excess pore water pressure dissipation shown in Figures 9 through 12, the *in situ* horizontal and vertical coefficients of consolidation, c_h and c_v, were calculated based on empirical relationships proposed by Baligh and Levadoux (ASCE Journal of Geotechnical Engineering, Vol. 112, No. 7, July, 1986). Based on the equations in this reference, $c_v = 0.05 \times c_h$. The results of the calculations are presented in Table 6.

The *in situ* vertical coefficients of consolidation from the piezoprobe measurements near the tops of PC-1M and PC-1N, and for all depths in PC-4G are equal to or greater than the design vertical coefficient of consolidation. The average c_v value for these points is 2.1×10^{-4} cm^2/sec. However, the *in situ* vertical coefficients of consolidation from the piezoprobe measurements at greater depths in the phosphatic clay layer at PC-1M and PC-1N had an average c_v value of 2.4×10^{-5} cm^2/sec. The PC-1M piezoprobe with tip elevations of +104.3 and +102.3 feet (NGVD) had computed c_v values that are atypically low. Based on annual monitoring data since 2001, these values are questionable. Although the vertical coefficients of consolidation documented at the middle and bottom of PC-1M and PC-1N were lower than the original design value of 1.5×10^{-4} cm^2/sec, the piezoprobe measurements in 2003 and 2004 at nearby test sites had computed vertical coefficients of consolidation that were consistent with the design value.

The piezoprobe pore water dissipation monitoring data for PC-3F indicates a c_v value of 3.5×10^{-5} to 1.8×10^{-4} cm^2/sec. In 2005, the *in situ* c_v value from the piezoprobe measurements at the top of PC-3E was 2.4×10^{-4} cm^2/sec and the mid-depth and bottom of the phosphatic clay layer at PC-3E had an average c_v value of 3.1×10^{-5} cm^2/sec. Although the vertical coefficients of consolidation documented at the middle and bottom of the phosphatic clay for PC-3E were lower than the original design value of 1.5×10^{-4} cm/sec, the piezoprobe measurements in 2003 and 2004 at nearby test sites had vertical coefficients of consolidation that were consistent with the design value.

In our 2005 report, because the c_v values of the phosphatic clay layer at PC-4F averaged 2.8×10^{-5} cm^2/sec for the three measurements at different depths and because c_v values lower than the design value were also documented at the nearby test site PC-4E in 2004, Ardaman recommended performance of additional field tests to measure the undrained shear strength of the clay or any excess pore water pressure in the phosphatic clay prior to placement of the next lift of refuse/ash in the Phase IV area. Because the c_v values for PC-4F exceed the design value and the excess pore water pressures have been reduced substantially, additional field tests are not required at this time.

Settlement plate data at the location of Pump Station B in the Phase VI area, as provided by Hillsborough County, are plotted in Figure 13. At this location, the initial thickness of the phosphatic clay in July 1997 was approximately 13 feet. The phosphatic clay was assumed to have settled 2 feet by the time the settlement observation was started in March 1999. As shown in Figure 12, the phosphatic clay has undergone an average settlement of about 4.6 feet over a period of 5.85 years since filling started on March 30, 2000. Assuming that an average degree of consolidation of 95 percent has been reached under double drainage conditions with an average consolidating thickness of 11 feet, the back-calculated c_v from the settlement observations is 1.7×10^{-4} cm^2/sec, which is consistent with the design value.

Comparisons of Piezometric Heads

The piezometric elevations in the materials directly above and below the phosphatic clay layer, as documented from the piezocone soundings, are summarized in Table 7. The piezometric heads within the phosphatic clay layer (except for PC-3F) are also shown on the same table for comparison.

The piezometric head within the phosphatic clay will be highest after loading of a new refuse/ash lift and will decrease gradually as excess pore water pressure dissipates. If the piezometric head within the phosphatic clay is higher than the piezometric head on top of the phosphatic clay, there will be no downward migration of leachate. Once the excess pore water pressure from landfill loading dissipates, the flow direction through the phosphatic clay will be a function of the piezometric head difference across the phosphatic clay. If the piezometric elevation in the natural soils below the phosphatic clay is higher than the piezometric elevation on top of the phosphatic clay, upward flow will occur. Conversely, if the piezometric elevation in the natural soils is lower than the piezometric elevation on top of the phosphatic clay, leachate will migrate downward, at a rate governed by the piezometric head difference, and the hydraulic conductivity and thickness of the phosphatic clay deposit.

As shown in Table 7, the existing maximum piezometric heads within the phosphatic clay layer are higher than the piezometric heads in the materials above and below the phosphatic clay at the PC-1M, PC-1N, PC-3F and PC-4G test site locations. Accordingly, under existing conditions, there should be no downward leachate migration or upward groundwater flow through the phosphatic clay layer at these locations.

Summary of Observations

The following key observations were made from the 2006 annual monitoring data based on the field work completed:

- The refuse/ash surface elevations increased by 19.5 feet at test location PC-3F compared to March 2005 at test location PC-3E. At test locations PC-1M and PC-1N, the existing grade remained unchanged. At test location PC-4G, the refuse/ash elevation was approximately 9.5 feet lower than test location PC-4F in 2003 because of the relative elevations of the landfill at two different locations within Phase IV.

- The top elevations of the phosphatic clay were as expected and generally consistent with the range of elevations obtained in 2005.

- The thicknesses of the phosphatic clay were also generally consistent with the data obtained in 2005. The phosphatic clay thicknesses at PC-1M, PC-1N, PC-3F, and PC-4G were found to 0.5 feet lower to 0.6 feet higher than the comparable thicknesses estimated in 2005.

- Excess pore water pressure was documented within the phosphatic clay layer at PC-1M, PC-1N, PC-3F, and PC-4G. The area around PC-1M was loaded in 2003 and 2004. The area around PC-1N was loaded in 2004 and 2005. The area around PC-4G was loaded in 2003. The area around PC-3F was loaded in 2005 and 2006. Because these areas have been loaded in 2003 through 2006, the excess pore water pressure was expected. Because the area around PC-3F has recently been loaded with the next lift of refuse/ash and we would expect high excess pore water pressures in the middle of the phosphatic clay layer.

- The piezometric heads above the phosphatic clay at the PC-1M, PC-1N, PC-3F, and PC-4G test site locations were measured to be 2.3, 7.7, 1.4, and 6.5 feet, respectively compared to piezometric heads above the phosphatic clay at the PC-1K, PC-1L, PC-3E, and PC-4F 2005 test site locations of 8.8, 7.2, 6.6, and 6.9 feet, respectively. Compared to 2005, the piezometric heads in 2006 ranged from 6.5 feet lower to 0.5 feet higher. On the average, the 2006 measurements were about 3 feet lower than the readings obtained in 2004.

- The maximum piezometric elevation within the phosphatic clay liner is higher than the piezometric elevation in the leachate collection and recovery system (LCRS) on top of the clay at the PC-1M, PC-1N, PC-3F and PC-4G test site locations. Accordingly, under existing conditions, there should be no downward leachate migration through the phosphatic clay layer at these locations..

- The piezometric elevations below the phosphatic clay were observed to be at approximately +117 to +123 feet (NGVD). These elevations are within a similar range to those observed in 2003, 2004, and 2005.

Recommendations

Excess pore water pressures at PC-1M and PC-1N were recorded but are not unexpected because of recent (2003-2005) refuse/ash placement in this area. However, because of the lower than expected coefficients of consolidation documented at different depths of the phosphatic clay layer at PC-1M and PC-1N, additional monitoring should be performed to measure the excess pore water pressure in the clay prior to placement of the next lift of refuse/ash.

Because of the calculated coefficient of consolidation less than the design value in PC-3E in 2005 and possibly at PC-3F in 2006, and limited pore water pressure dissipation data for PC-3F in 2006, the response of the Phase II and Phase III areas to placement of the refuse/ash lift that is currently taking place should be carefully monitored during the next event. There is no need to address scheduling of future lifts at this time.

Placement of the next full lift of refuse/ash may proceed in the portions of Phase IV where refuse/ash was last placed in 1995. In the portions of Phase IV where a partial lift of refuse/ash was placed in 2003, the difference between the thickness of refuse/ash placed in 2003 and the maximum recommended lift thickness of 20 feet may also be placed at this time. The 7-year waiting period for the placement of the next lift begins from the point in time of placing the last amount of waste in the previous lift.

The observed dissipation of excess pore water pressures and, therefore, the projected rate of consolidation and strength gain of the phosphatic clay liner are generally consistent with the filling schedule. In accordance with the design, any excess pore water pressure generated from a refuse lift should be dissipated prior to placement of the next lift of refuse.

Closure

This report has been prepared for the exclusive use of Jones Edmunds and the Hillsborough County Solid Waste Department for specific application to annual monitoring of the phosphatic clay liner at the Southeast Landfill in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made.

Ardaman appreciates the opportunity to assist you on this project. Please contact us if you have any questions concerning this report or need additional information.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Patrick A. Kennedy

Patrick A. Kennedy, P.E.
Project Manager

Francis K. Cheung

Francis K. Cheung, P.E.
Senior Project Engineer
Florida License No. 36382

04/13/06

Table 1

Test Site Locations and Elevations

Test Site	Area	Florida State Plane Coordinates		Approximate Ground Surface Elevation
		Northing (feet)	Easting (feet)	[feet (NGVD29)]
PC-1M	Phase I	1,250,453.47	595,948.13	+164.8
PC-1N	Phase I	1,249,919.35	597,250.64	+188.4
PC-3F	Phase III*	1,250,993.08	597,646.79	+174.2
PC-4G	Phase VI	1,250,701.58	596,061.77	+168.6

Coordinates and elevations are the averages of the coordinates and elevations for the piezocone and piezoprobe borings at each test site.

* PC-3F was actually located within the Phase II area and adjacent to the Phase III area.

Table 2

Top and Bottom Elevations of Phosphatic Clay

Area	Test Site	Date	Approximate Ground Surface Elevation [feet (NGVD)]	Top of Clay		Bottom of Clay		Clay Thickness (feet)
				Depth (feet bls)	Elevation [(feet, (NGVD)]	Depth (feet bls)	Elevation [feet (NGVD)]	
Phase I	PC-1M	02/17/06	+164.8	55.5	+109.3	63.5	+101.3	8.0
	PC-1N	02/28/06	+188.4	72.0	+116.4	75.9	+112.5	3.9
Phase III	PC-3F	02/21/06	+174.2	55.2	+119.0	63.0	+111.2	7.8
Phase IV	PC-4G	02/17/06	+168.6	58.1	+110.5	65.3	+103.3	7.2

Table 3

Piezometric Levels on Top of Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation [feet (NGVD)]	Piezometric Elevation on Top of Phosphatic Clay [feet (NGVD)]	Top of Clay Elevation [feet (NGVD)]	Piezometric Head on Top of Phosphatic Clay (feet)
Phase I	PC-1M	02/17/06	+164.8	+111.6	+109.3	2.3
	PC-1N	02/28/06	+188.4	+124.1	+116.4	7.7
Phase III	PC-3F	02/21/06	+174.2	+117.7	+116.3	1.4
Phase IV	PC-4G	02/17/06	+168.6	+117.0	+110.5	6.5

Table 4

Piezometric Elevations Below Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation [feet (NGVD)]	Piezometric Elevation Below Phosphatic Clay [feet (NGVD)]
Phase I	PC-1M	02/17/06	+164.8	+123.0
	PC-1N	02/28/06	+188.4	+122.5
Phase III	PC-3F	02/21/06	+174.2	+116.9
Phase IV	PC-4G	02/17/06	+168.6	+119.0

Table 5

Pore Water Pressure within the Phosphatic Clay

Area	Test Site	Ground Surface Elevation	Top of Clay Elevation	Bottom of Clay Elevation	Piezoprobe Tip Below Ground Surface (feet)	Elevation of Piezoprobe Tip	Stabilized Pore Water Pressure at Piezoprobe Tip After Dissipation (feet of H_2O)	Piezometric Elevation at Piezoprobe Tip Level	Piezometric Elevation on Top of Phosphatic Clay	Piezometric Elevation Below Phosphatic Clay	Excess Pore Water Pressure at Piezoprobe Tip Level (feet of H_2O)
Phase I	PC-1M	+164.8	+109.3	+101.3	56.5 58.5 60.5 62.5	+108.3 +106.3 +104.3 +102.3	4.4 20.0 26.4 23.8	+112.7 +126.3 +130.7 +126.1	+111.6	+123.0	0.0 10.4 12.0 4.5
	PC-1N	+188.4	+116.4	+112.5	72.0 73.5	+116.4 +114.9	7.7 16.0	+124.1 +130.9	+124.1	+122.5	0.0 7.4
Phase III	PC-3F	+174.2	+116.3	+111.2	56.0	+118.2	3.3	+121.5	+117.7	+116.9	3.9
Phase IV	PC-4G	+168.6	+110.5	+103.3	60.8 62.8	+107.8 +105.8	24.4 27.5	+132.2 +133.3	+117.0	+119.0	14.5 15.0

All elevations are feet (NGVD).

Table 6

Computed Coefficients of Consolidation from Piezoprobe Tests

Area	Test Site	Piezoprobe Designation	Piezoprobe Tip Depth Below Ground Surface (feet)	Elevation of Piezoprobe Tip [feet (NGVD)]	Horizontal Coefficient of Consolidation, c_h (cm^2/sec)	Vertical Coefficient of Consolidation, c_v* (cm^2/sec)
Phase I	PC-1M	PC-1M	56.5	+108.3	3.0×10^{-3}	1.5×10^{-4}
			58.5	+106.3	1.0×10^{-3}	5.1×10^{-5}
			60.5	+104.3	4.7×10^{-5}	2.3×10^{-6}
			62.5	+102.3	1.6×10^{-4}	7.6×10^{-6}
	PC-1N	PC-1N	72.0	+116.4	5.1×10^{-3}	2.5×10^{-4}
			73.5	+114.9	6.7×10^{-4}	3.3×10^{-5}
Phase III	PC-3F	PC-3F	56.0	+118.2	7.2×10^{-4}	3.5×10^{-5}
					3.7×10^{-3}	1.8×10^{-4}
Phase IV	PC-4G	PC-4G	57.8	+110.8	5.1×10^{-3}	2.5×10^{-4}
			60.8	+107.8	4.2×10^{-3}	2.1×10^{-4}
			62.8	+105.8	4.0×10^{-3}	1.9×10^{-4}

* c_v using empirical relationship recommended by Baligh and Levadoux, 1986.

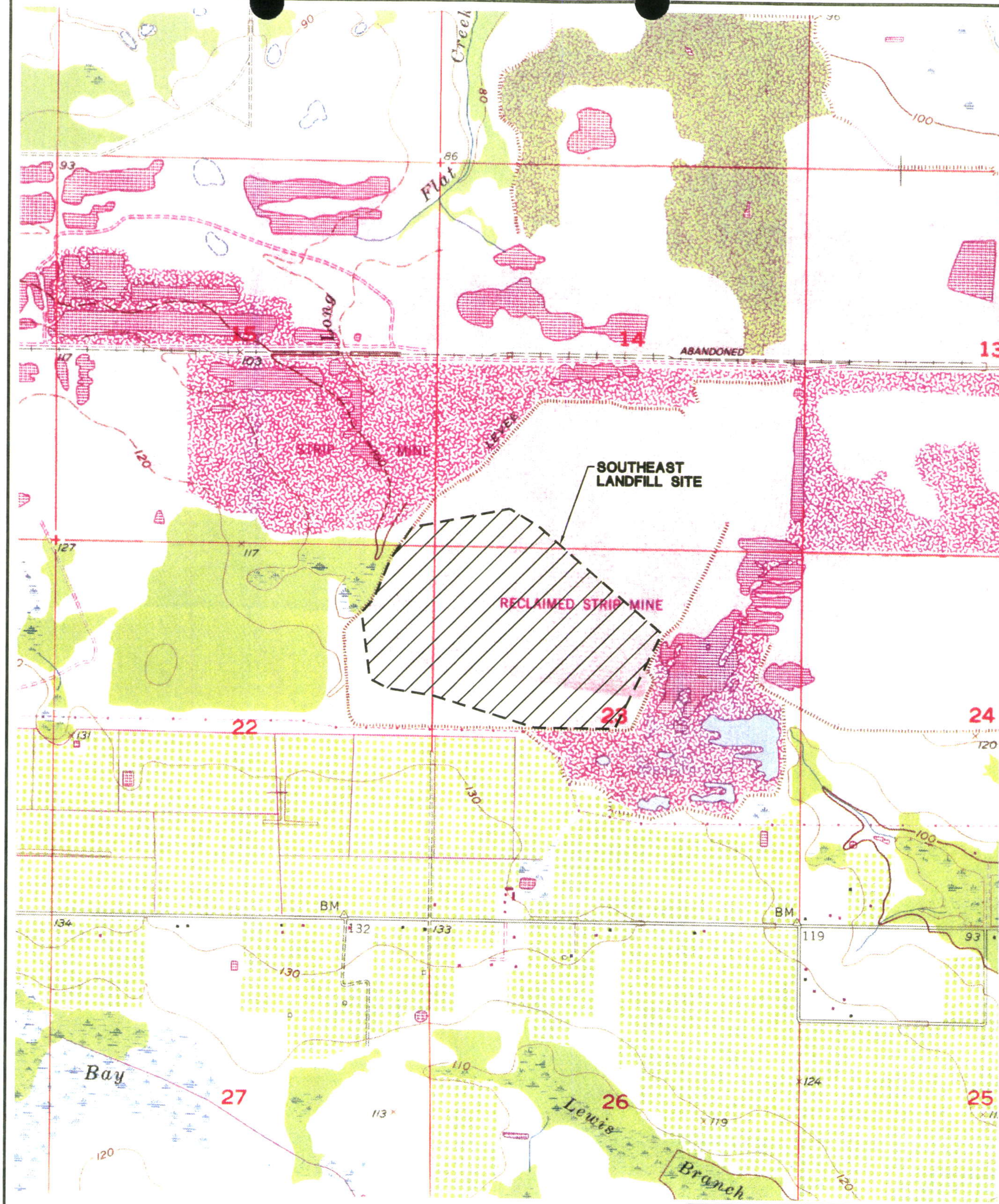
Table 7

Comparisons of Piezometric Elevations

Area	Test Site	Date	Ground Surface Elevation [feet (NGVD)]	Piezometric Elevation on Top of Phosphatic Clay [feet (NGVD)]	Existing Maximum Piezometric Elevation Within Clay [feet (NGVD)]	Piezometric Elevation Below Phosphatic Clay [feet (NGVD)]	Location of Existing Maximum Head
Phase I	PC-1M	02/17/06	+164.8	+111.6	+130.7	+123.0	Within Clay
	PC-1N	02/28/06	+188.4	+124.1	+130.9	+122.5	Within Clay
Phase III	PC-3F	02/21/06	+174.2	+117.7	–	+116.9	In Middle of Clay*
Phase IV	PC-4G	02/17/06	+168.6	+117.0	+133.3	+119.0	Within Clay

*Maximum head not measured but expected to be in the middle of the clay because the area was recently loaded.

1.8



TOWNSHIP 31 SOUTH
RANGE 21 EAST
SECTIONS 14, 15, 22 AND 23

OBTAINED FROM U.S.G.S. QUAD MAP:
LITHIA, FLORIDA 1955
(PHOTOREVISED 1987)

N

0 1000 2000

SCALE: — 1"=2000'

SITE LOCATION MAP

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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FILE NO. 05-072	APPROVED BY: FTCC	FIGURE: 1

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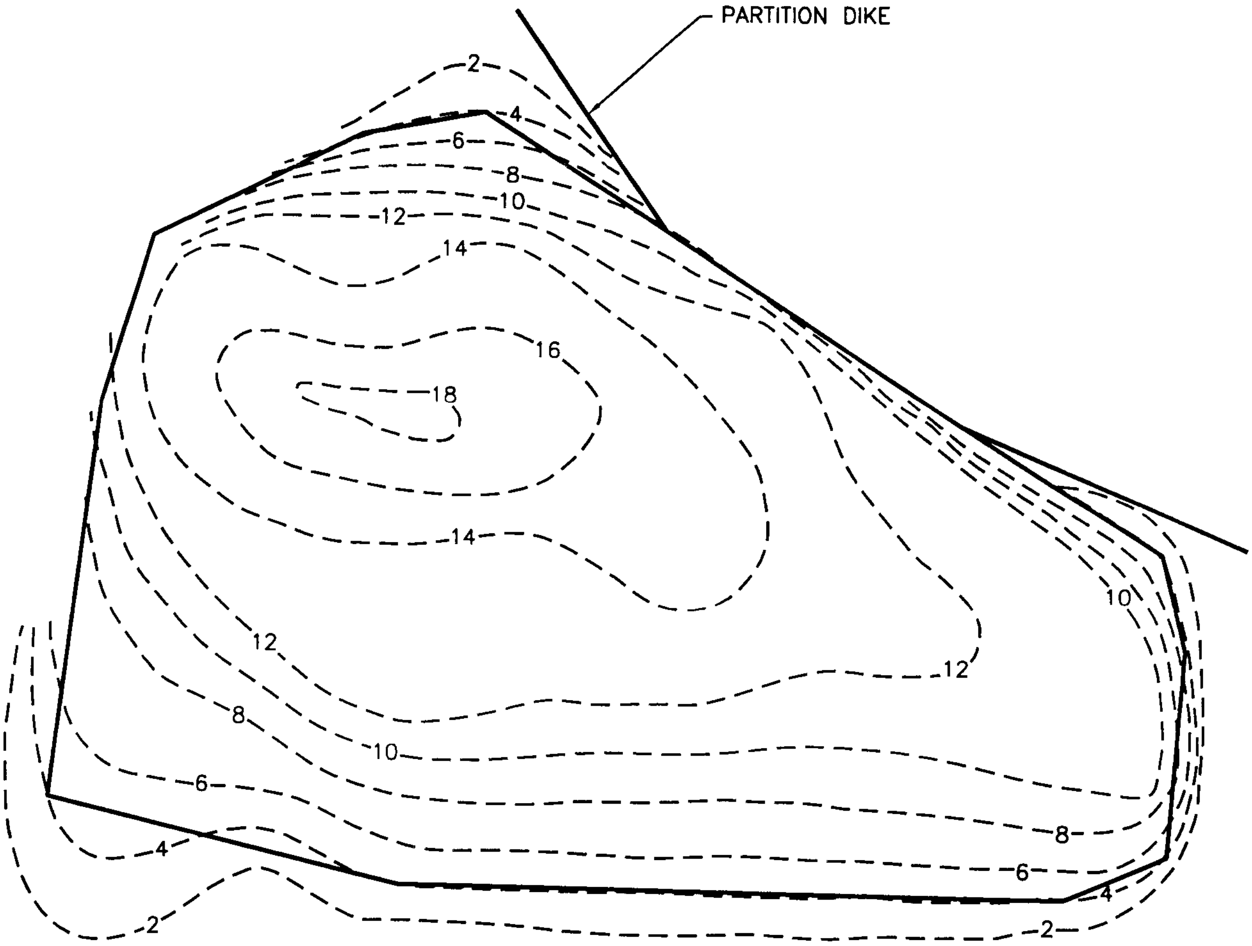

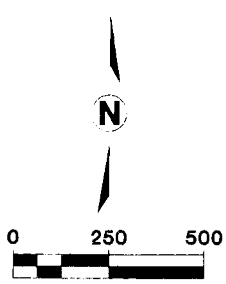

LEGEND

10 CONTOURS OF CLAY THICKNESS IN FEET

NOTE: REPRODUCED FROM ARDAMAN & ASSOCIATES' 1981-1983 STUDY

THICKNESS OF PHOSPHATIC CLAY BEFORE LANDFILL CONSTRUCTION		
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
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FILE NO. 05-072	APPROVED BY:	FIGURE: 2

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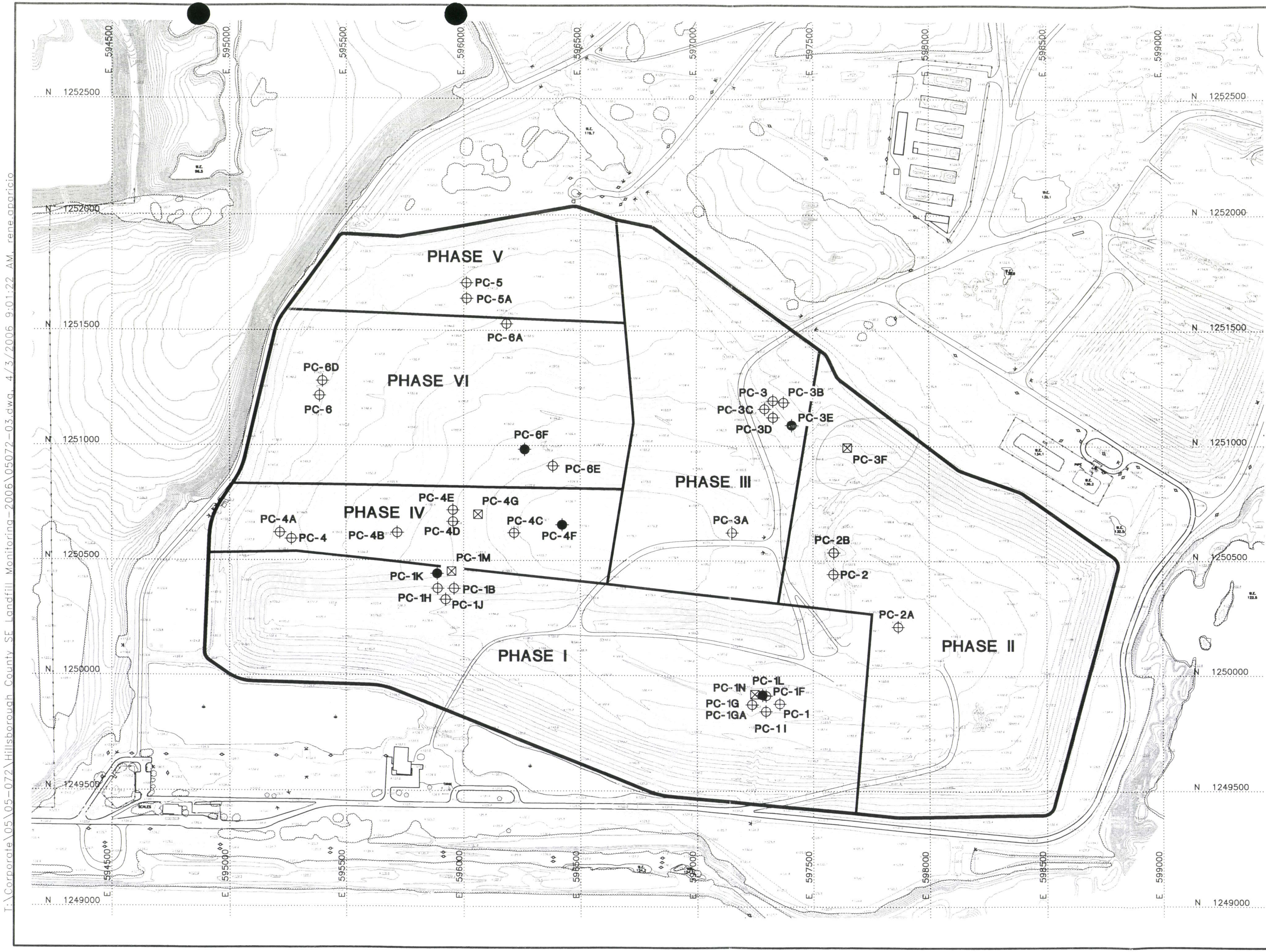

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SCALE: 1"=400'

NOTE: THE TOPOGRAPHY IS BASED ON PHOTOGRAMMETRY FROM AN AERIAL PHOTOGRAPH DATED JULY 5, 2005.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
APR 14 2006
SOUTHWEST DISTRICT TAMPA

LEGEND

- TEST SITES IN 2001–2004
- TEST SITES IN 2005
- TEST SITES IN 2006

LANDFILL LAYOUT AND FIELD TEST LOCATION MAP

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HILLSBOROUGH COUNTY, FLORIDA

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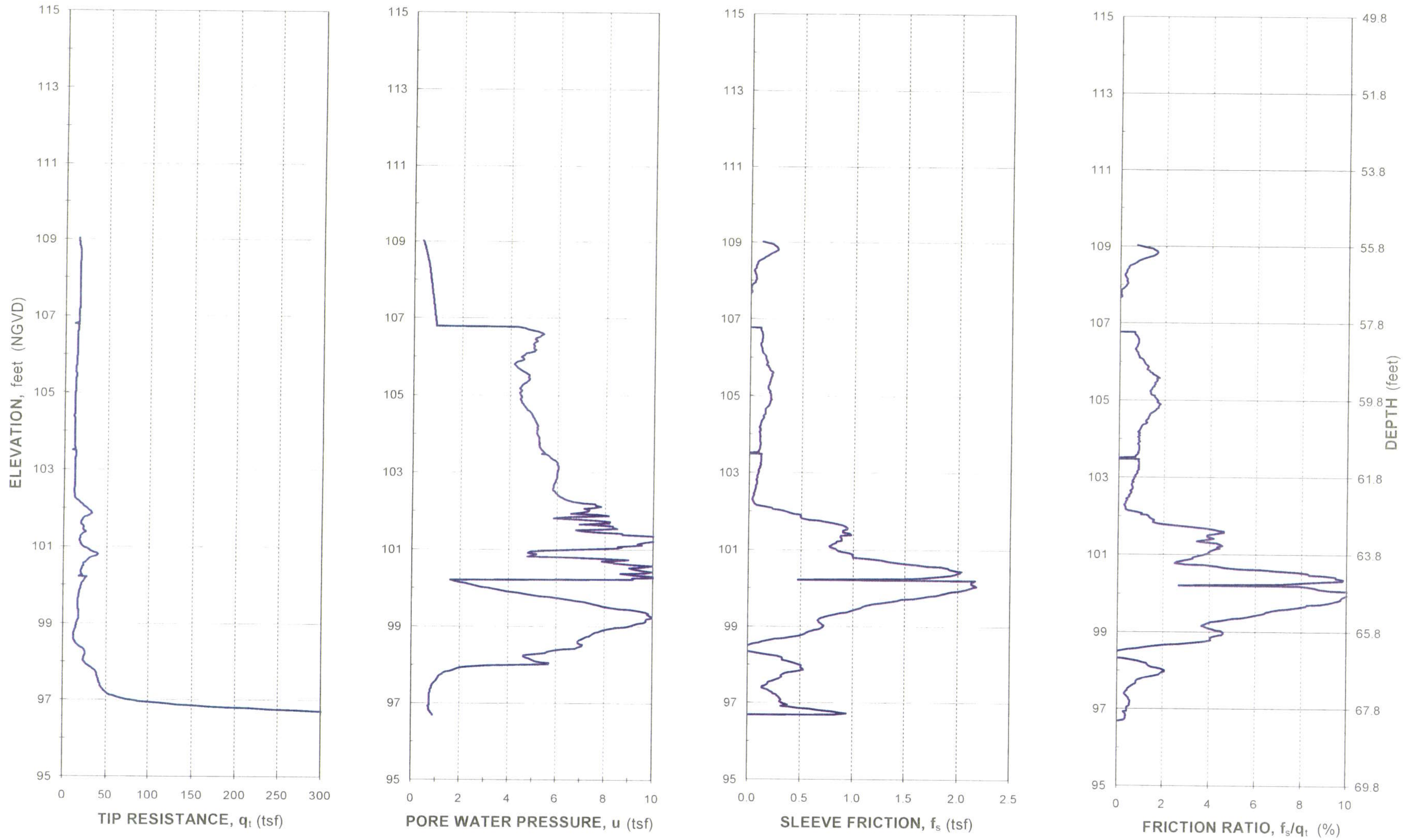
FILE NO. 05-072	APPROVED BY: FKC	FIGURE: 3



Piezocone soundings were performed on 02/17/2006.

CONE PENETRATION TEST RESULTS FOR PC-1M			
Ardaman & Associates, Inc. Geotechnical, Environmental and Material Consultants			
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA			
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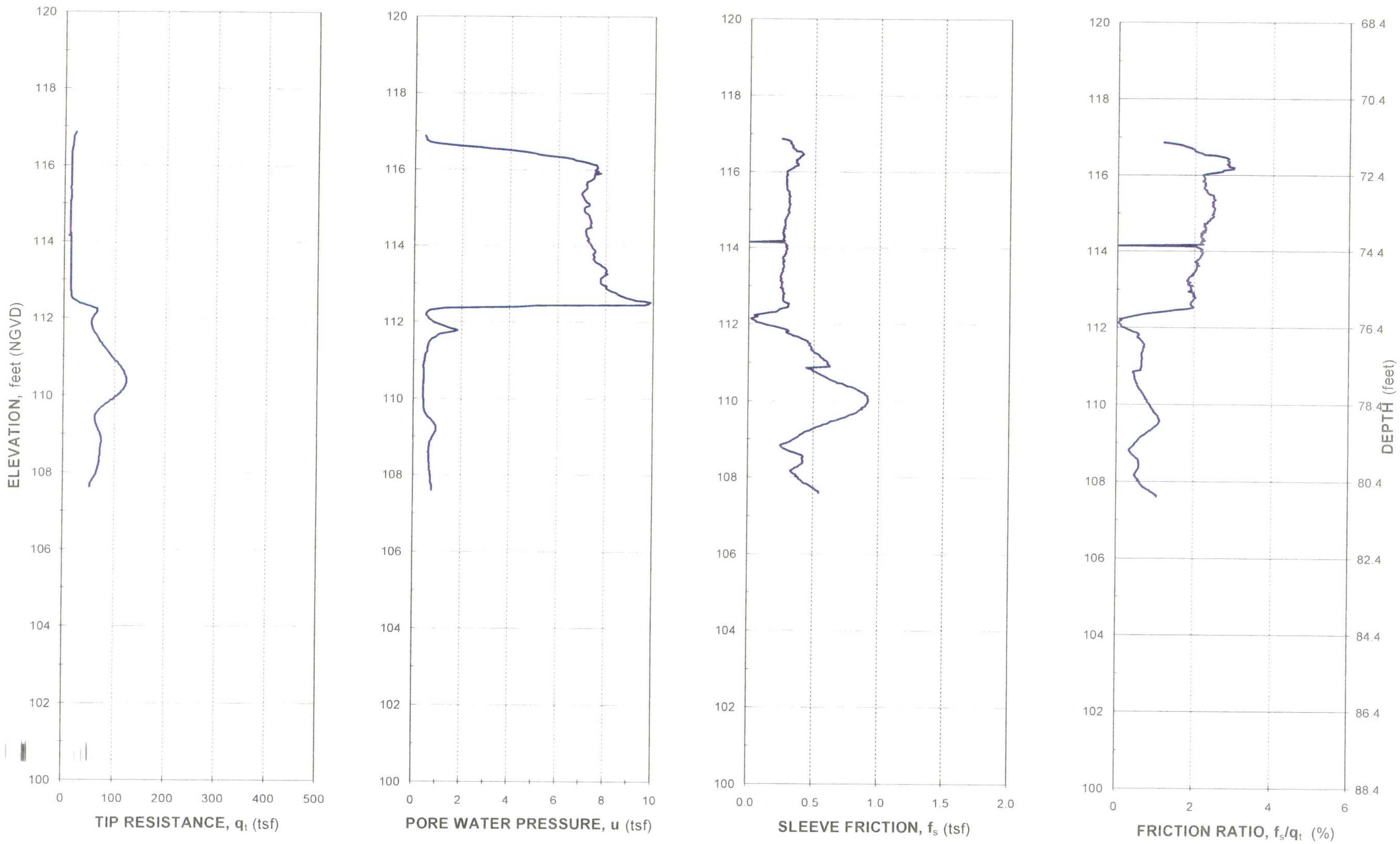
FILE NO. 05-072	APPROVED BY: FKC		FIGURE: 4



Piezocone soundings were performed on 02/28/2006.

CONE PENETRATION TEST RESULTS FOR PC-1N		
Ardaman & Associates, Inc Geotechnical, Environmental and Material Consultants		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
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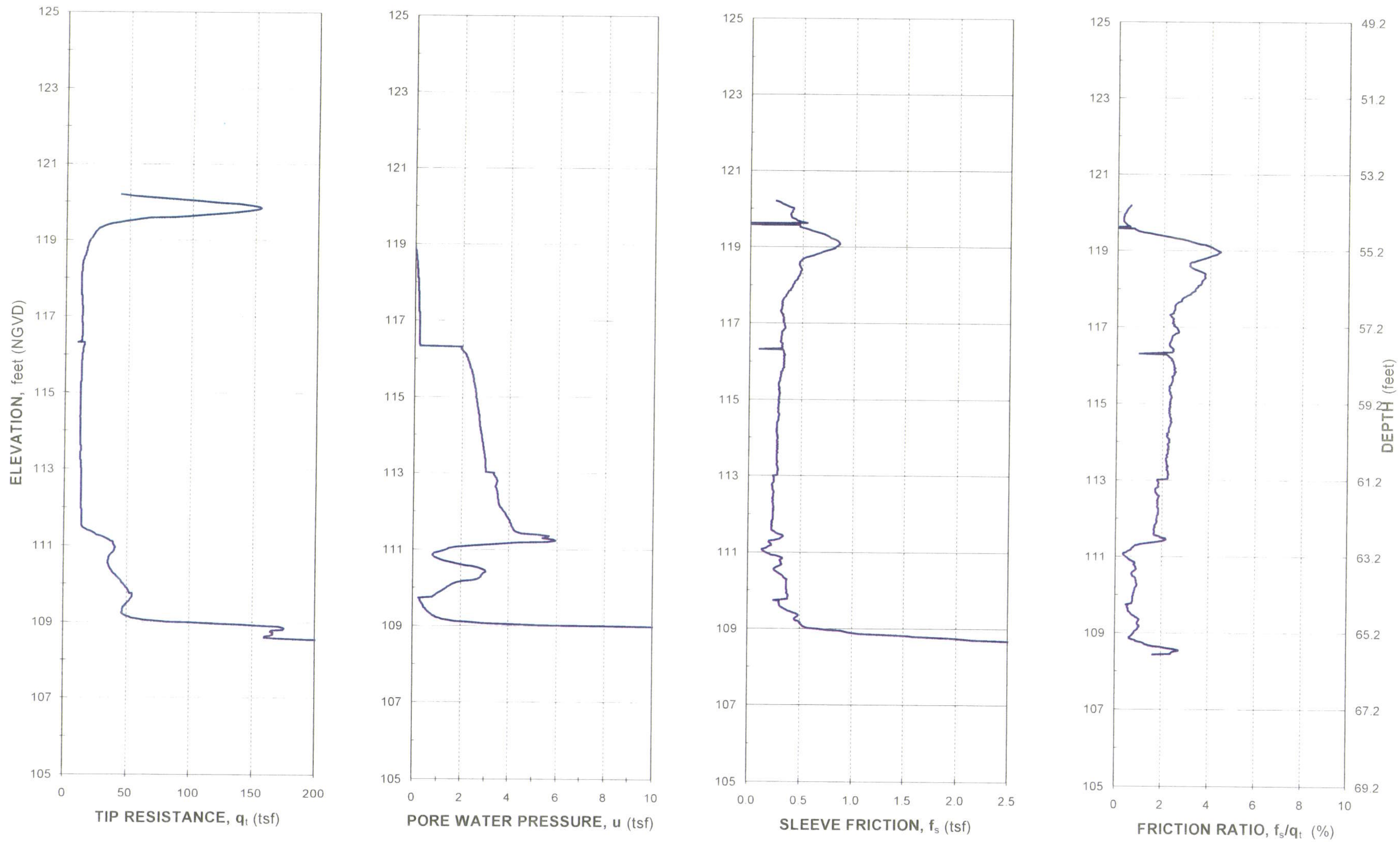

Piezocone soundings were performed on 02/21/2006.

CONE PENETRATION TEST RESULTS FOR PC-3F	
Ardaman & Associates, Inc Geotechnical, Environmental and Material Consultants	
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA	
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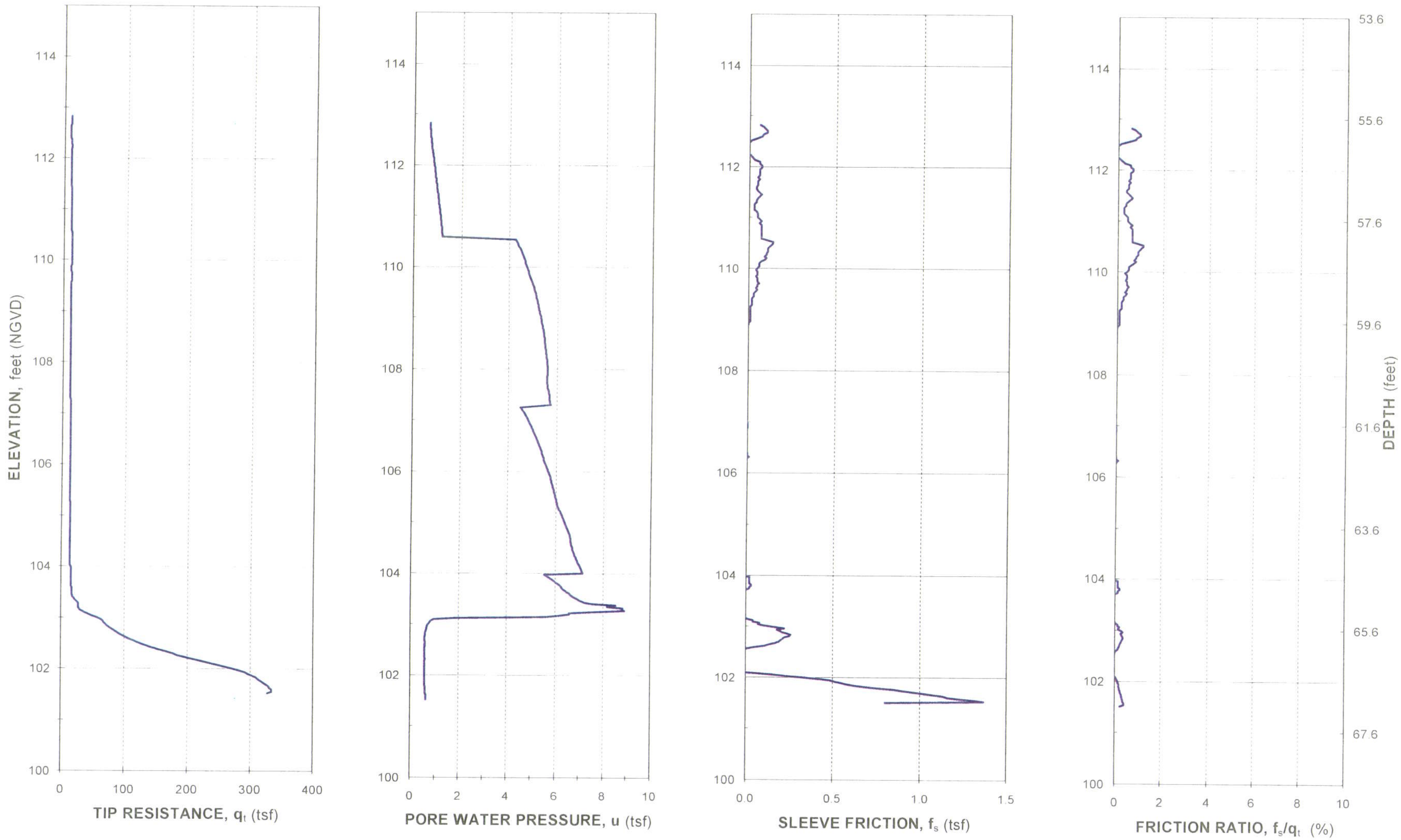
FILE NO. 05-072	APPROVED BY: FKC FIGURE: 6



Piezocone soundings were performed on 02/17/2006.

CONE PENETRATION TEST RESULTS FOR PC-4G

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

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SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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FILE NO. 05-072	APPROVED BY: FICC	FIGURE: 7

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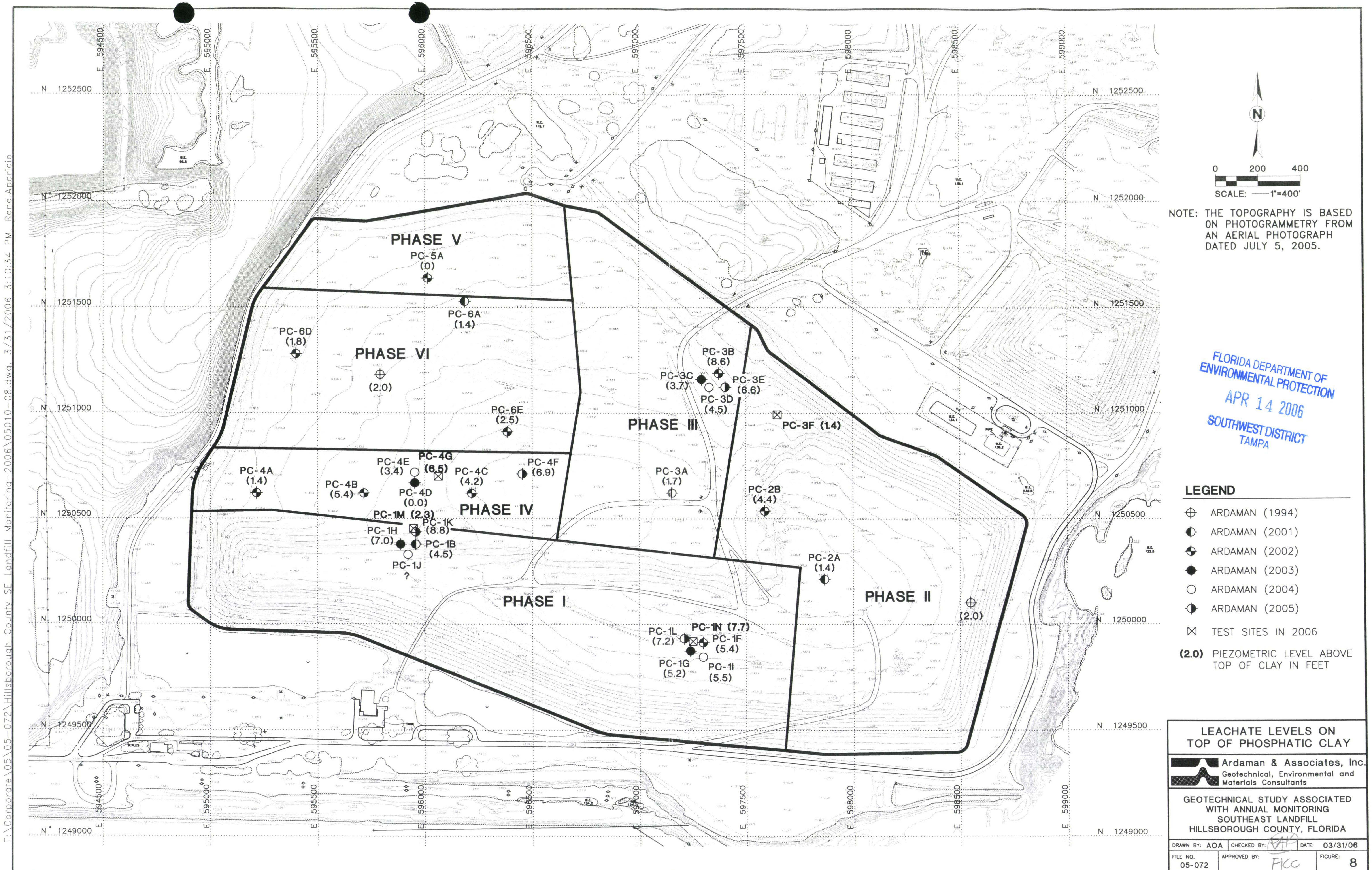

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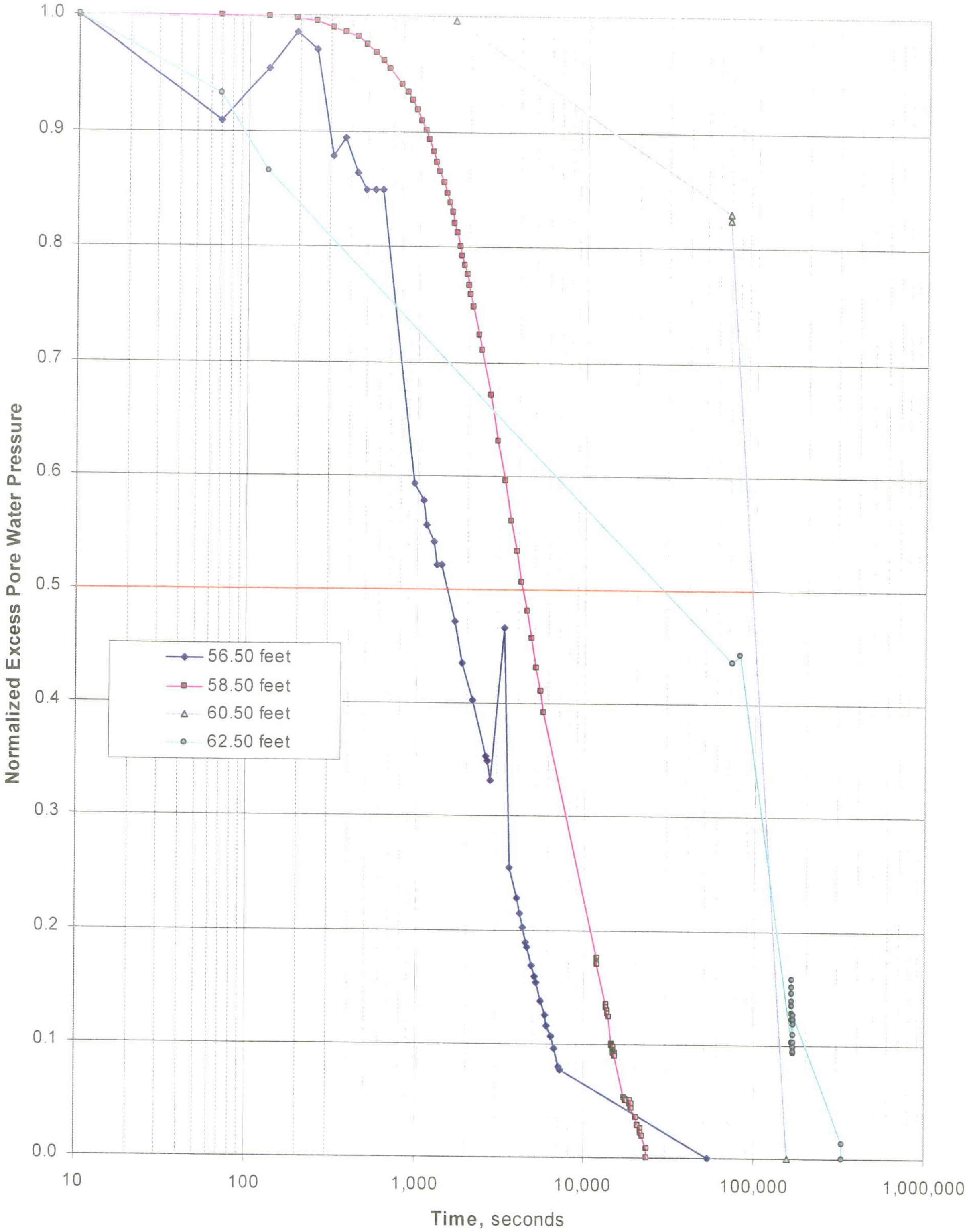

EXCESS PORE WATER PRESSURE DISSIPATION AT PC-1M

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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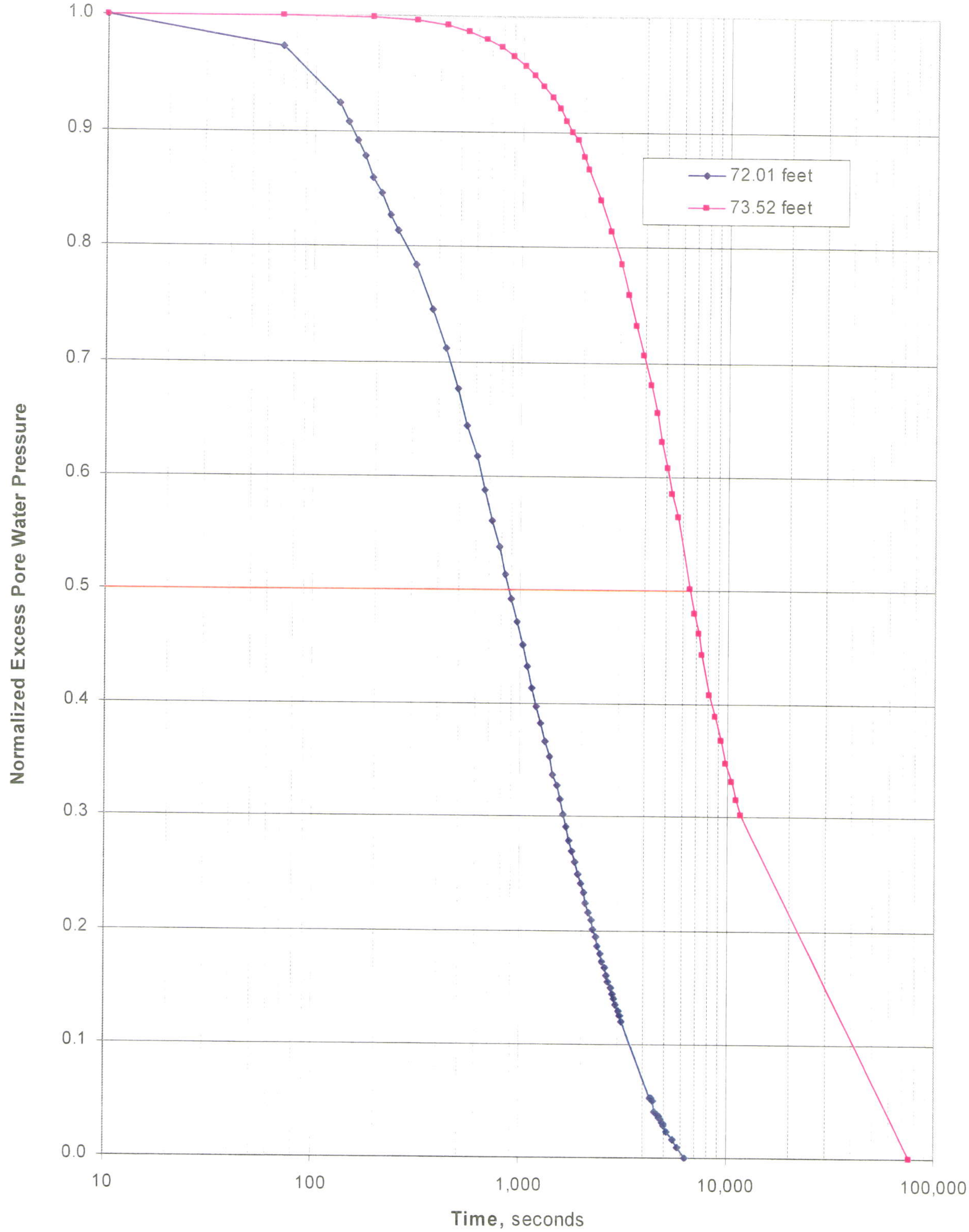
FILE NO. 05-072	APPROVED BY: FKC	FIGURE: 9



EXCESS PORE WATER PRESSURE DISSIPATION AT PC-1N

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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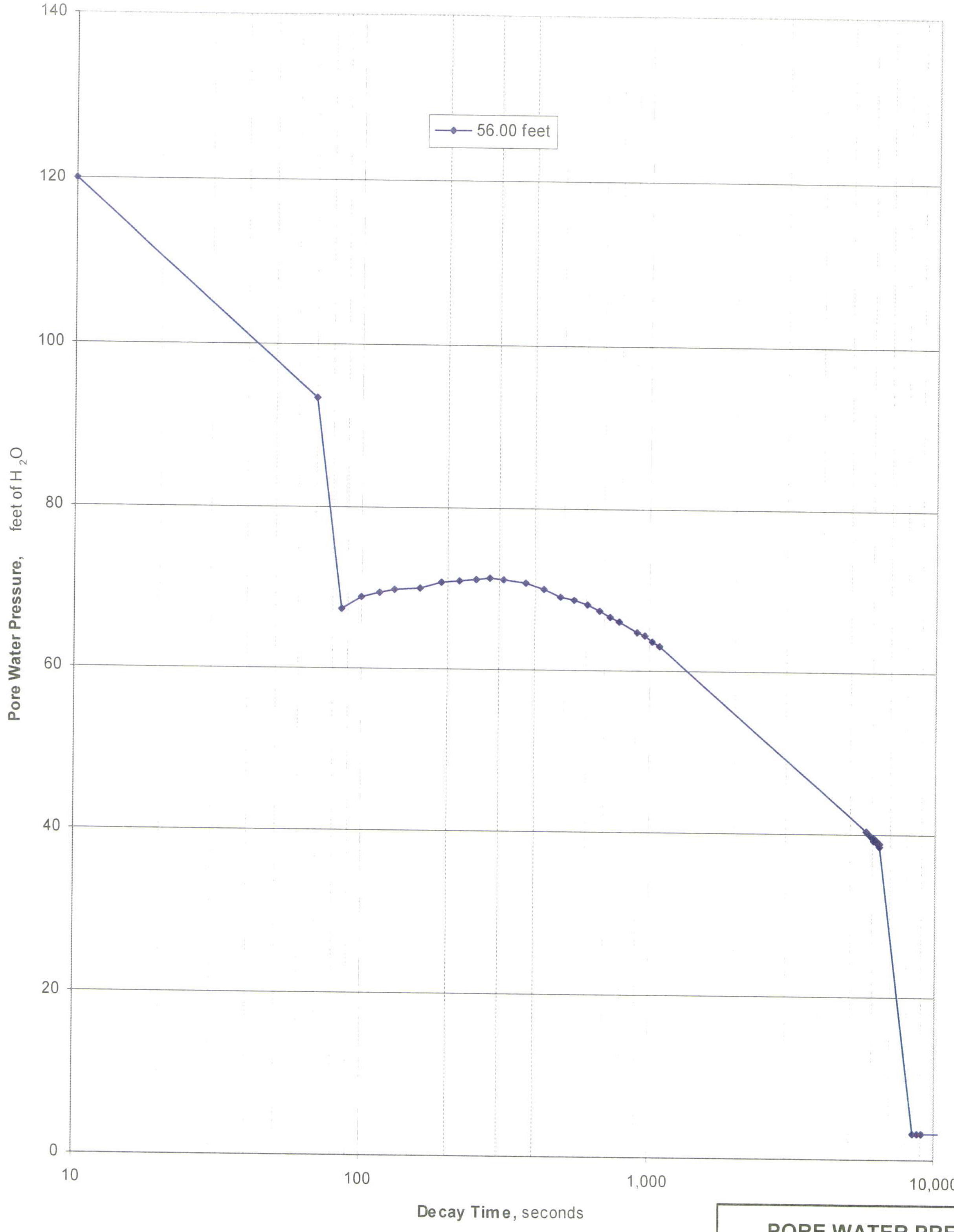
FILE NO. 05-072	APPROVED BY: FKC	FIGURE: 10



PORE WATER PRESSURE DISSIPATION AT PC-3F

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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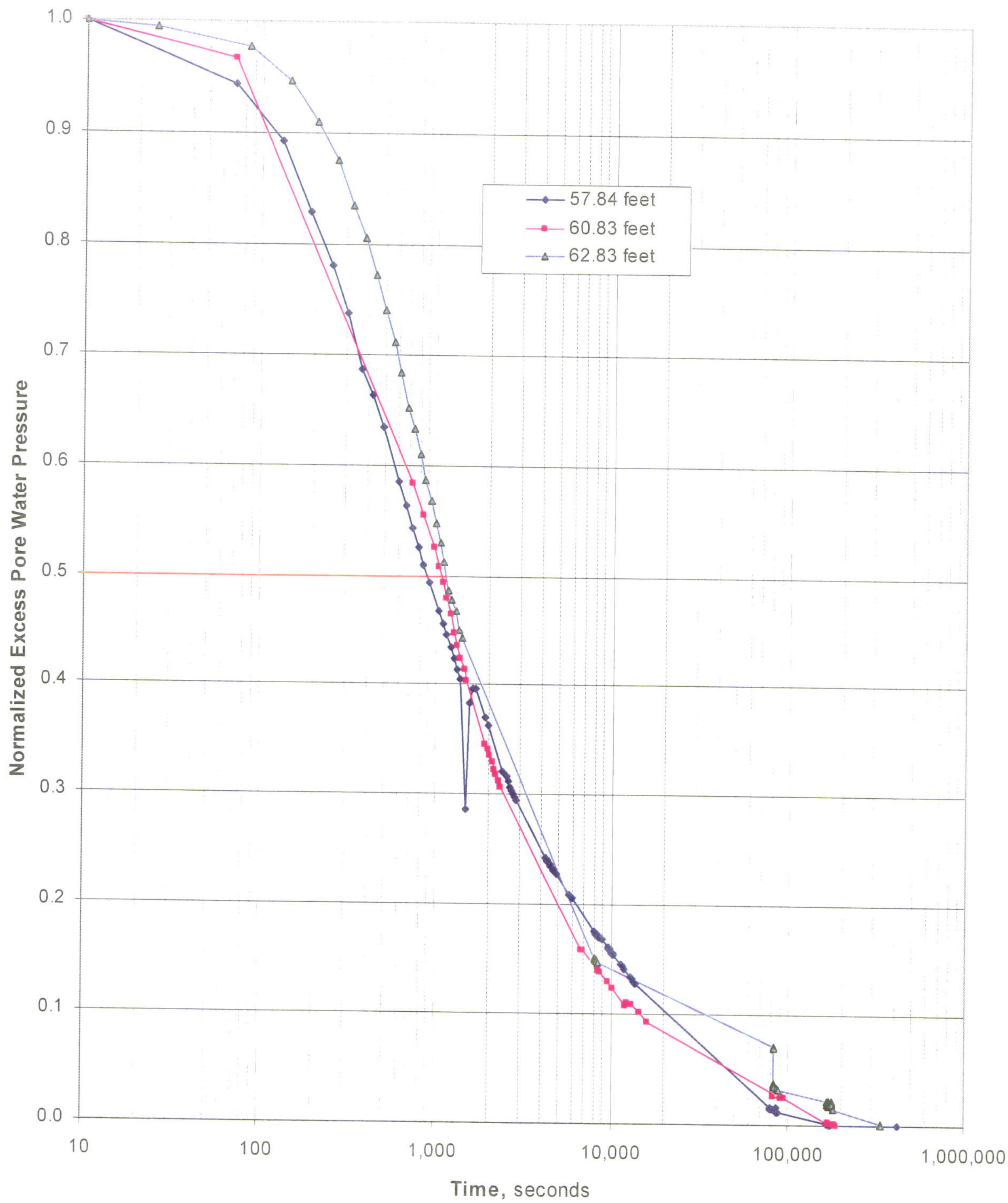
FILE NO. 05-072	APPROVED BY: FKC	FIGURE: 11



EXCESS PORE WATER PRESSURE DISSIPATION AT PC-4G

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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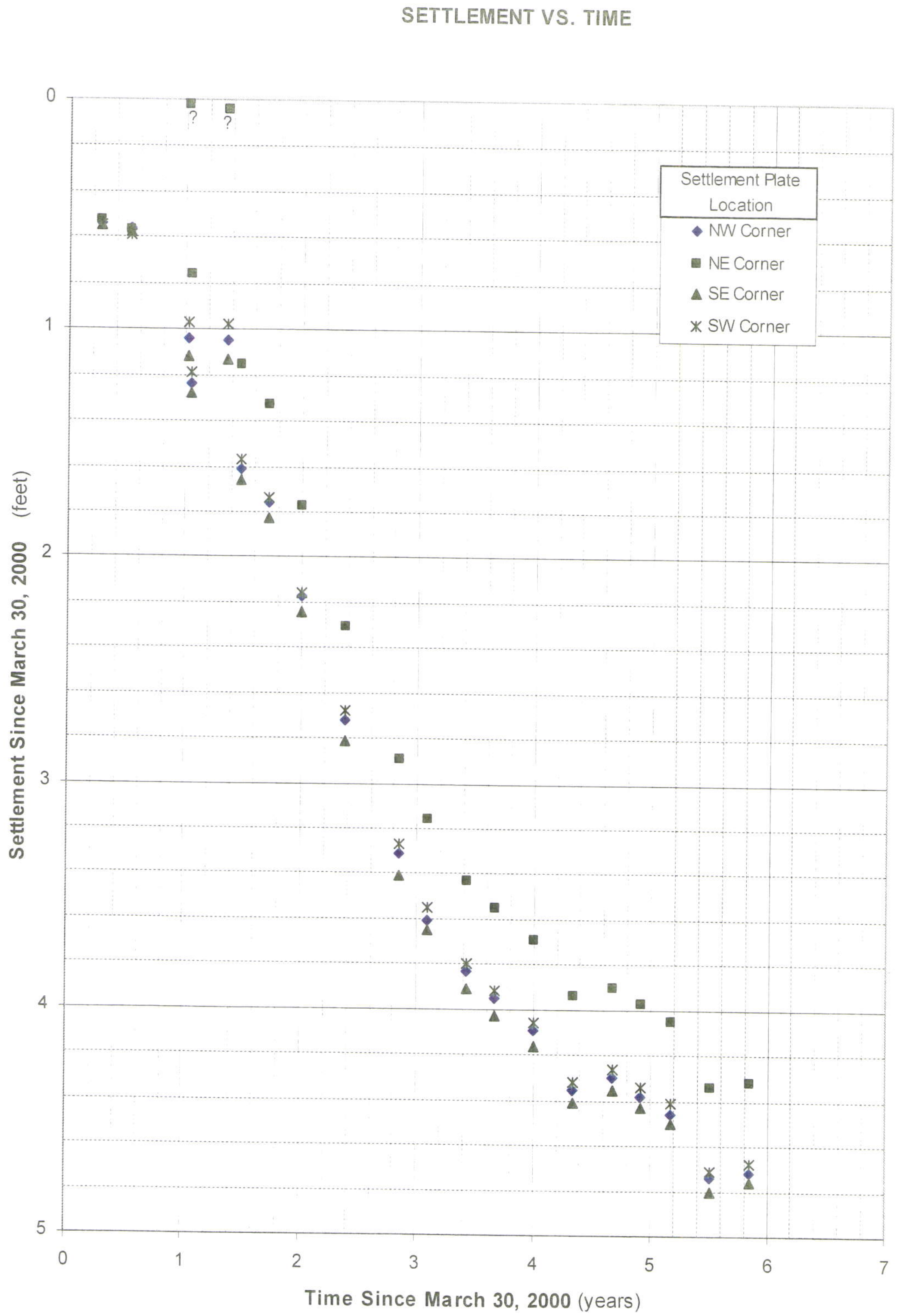

SETTLEMENT OF TOP OF PHOSPHATIC CLAY AT PUMP STATION B SUMP

Ardaman & Associates, Inc
Geotechnical, Environmental and Material Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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FILE NO. 05-072	APPROVED BY: FKCO	FIGURE: 13

Environmental Consultants

3012 U.S. Highway 301 North
Suite 700
Tampa, FL 33619-2242

813 621-0080
FAX 813 623-6757

SCS ENGINEERS

May 31, 2005
File No. 09200020.15

Ms. Susan J. Pelz, P.E.
Florida Department of Environmental Protection
Southwest District
3804 Coconut Palm Drive
Tampa, Florida 33619

Subject: Southeast County Landfill Phosphatic Clay Annual Evaluation
Hillsborough County, Florida - Permit No. 35435-006-SO

Dear Mr. Ford:

On behalf of the Hillsborough County Solid Waste Department, SCS Engineers (SCS) is submitting the attached report regarding the evaluation of the performance of the waste phosphatic clays at the Southeast County Landfill (SCLF) as required by the above referenced permit, specifically Specific Condition No. 16.f. As stated in the attached report by Ardaman and Associates, Inc. (Ardaman), the piezocone soundings show that, under existing conditions, an upward gradient exists at the locations PC-1K, PC-1L, and PC-4F.

At the location of PC-3E, a slight downward potentiometric head 0.4 feet was measured (measured from the head on top of the clay versus the excess pore pressure in the middle of the clay). SCS concurs with Ardaman's assessment that this condition is not significant considering that the phosphatic clay layer has a permeability of less than $1x10^{-8}$ cm/sec and the pore pressures within the clays will increase upon placement of the next lift of waste in this area.

Based on the data obtained by Ardaman, the performance of the waste phosphatic clays are consolidating and strengthening in general accordance with the original design assumptions. SCS recommends that no further action be taken at this time and that the annual evaluation as required by Specific Condition No. 16.f be continued.

Please call should you have any questions or require additional information.

Sincerely,

Joseph H. O'Neill, P.E.
Project Manager
SCS ENGINEERS

Raymond J. Dever, P.E., DEE
Vice President
SCS ENGINEERS

May 31, 2005
053045

JHO/RJD:jho

cc: Patricia V. Berry, SWMD
Ron Cope, EPCHC

Geotechnical Study Associated with
2005 Annual Monitoring of Phosphatic Clay Liner
Beneath the Southeast Landfill
in Hillsborough County

May 27, 2005

FILE

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Department of Environmental Protection
SOUTHWEST DISTRICT
BY

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Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

May 27, 2005
File Number 05-010

SCS Engineers
3012 US Highway 301 North
Suite 700
Tampa, FL 33619

Attention: Mr. Joe O'Neill, P.E.

Subject: Geotechnical Study Associated with 2005 Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County

Gentlemen:

As requested by SCS Engineers (SCS), Ardaman & Associates, Inc., (Ardaman) has completed a geotechnical study associated with annual monitoring of the phosphatic clay liner beneath the Southeast Landfill in Hillsborough County. The annual monitoring program was mandated by the Florida Department of Environmental Protection (FDEP) under Specific Condition No. 16f of the Landfill Operation Permit No. 35435-006-SO issued on June 25, 2002, which requires performance of piezocone soundings and measurements of pore water pressures in the vicinity of the following four test sites where a number of piezocone soundings and pore pressure measurements had previously been performed by Ardaman and Madrid Engineering Group, Inc., (Madrid) in 2001/2002: (i) PC-1B in the Phase I area; (ii) PC-4B/PC-4C in the Phase IV area; (iii) PC-3/PC-3B in the Phase III area; and (iv) PC-1F in the Phase I area. Specifically, the permit condition required documentation and interpretation of the following data:

- Piezometric elevations in the drainage sand layer above the phosphatic clay.
- Top and bottom elevations of the phosphatic clay layer.
- Pore water pressures near the top, middle, and bottom of the phosphatic clay layer.
- Piezometric elevations in the natural soils below the phosphatic clay.

Evaluations of the phosphatic clay liner in 2003 and 2004 were documented in two Ardaman reports dated April 12, 2003 and April 15, 2004. This report contains the results of the piezocone soundings and pore pressure measurements obtained by Ardaman in March and April 2005, and presents our interpretation of the test data.

For this year, in addition to the four test sites in the Phase I, III, and IV areas required by the FDEP permit, SCS requested Ardaman to perform an electric Dutch cone sounding at a test site in the Phase VI area for the sole purpose of determining the top elevation of the phosphatic clay.

Site Location

The Southeast Landfill is located within Sections 14, 15, 22, and 23 of Township 31 South, Range 21 East, in Hillsborough County, Florida. More specifically, the landfill site is located between

Picnic and Pinecrest, about 2 miles west of State Road 39 and about 0.5 miles north of County Road 672. The approximate site location, as superimposed on a reproduction of the United States Geological Survey (USGS) quadrangle map of Lithia, Florida (1955, photorevised 1987), is shown in Figure 1.

Project History

The Southeast Landfill is constructed directly above a waste clay settling area at a former phosphate mine known as Lonesome Phosphate Mine or Boyette Mine. The settling area, also known as Settling Area No. 1, was built on natural ground within a perimeter dike constructed of sand borrowed from surrounding areas. Waste phosphatic clay was deposited within the settling area for a number of years during the mining operation.

A comprehensive geotechnical study was conducted by Ardaman between 1981 and 1983 to characterize the phosphatic clay deposit and to evaluate the feasibility of constructing a landfill within the waste clay settling area. Results from that study were documented in an Ardaman report titled "Hydrogeological Investigation, Southeast County Landfill, Hillsborough County, Florida", dated February 22, 1983. Based on the data and analyses documented in that report, Ardaman concluded that a landfill could be constructed directly on top of the phosphatic clay. However, to maintain an adequate factor of safety against slope failure, the waste disposal area was divided into different phases, and each phase had to be filled in lifts such that filling above a previous lift would occur only when the underlying phosphatic clay had consolidated under the weight of the previous refuse lift and experienced sufficient increase in shear strength to support the additional load. In areas where the clay thickness was greater than 14 feet, it was recommended that the clay should be pre-loaded prior to placement of the first lift of refuse. A diagram that shows the original thickness of the phosphatic clay within the settling area, as reproduced from the 1983 Ardaman report, is shown in Figure 2. As shown, the phosphatic clay deposit had an original thickness that varied between 4 and 18 feet.

Another comprehensive geotechnical study was completed by Ardaman in 1994 in association with operation permit renewal for the Southeast Landfill. Results from that study were documented in an Ardaman report titled "Geotechnical Investigation at Southeast Landfill, Hillsborough County, Florida", dated March 7, 1994. The strength and consolidation properties of the phosphatic clay obtained from that study were in good agreement with those used in the original stability analyses and affirmed the recommended filling schedule.

In support of the last operation permit renewal application in 2002, SCS retained Madrid and Ardaman to perform supplemental studies to confirm the engineering properties of the phosphatic clay, and to determine whether the material had been consolidating and gaining strength as predicted and whether the 7-year waiting period for placements of successive refuse lifts in the landfill should be modified. Results from the latest study were presented in an Ardaman report titled "Geotechnical Study Associated with Operation Permit Renewal for Hillsborough County Southeast Landfill", dated March 4, 2002.

The original geotechnical investigation completed in 1983 and the follow-up studies completed in 1994 and 2002 recommended that each lift of refuse should have a thickness no greater than 20 feet and that a minimum waiting period of 7 years should be provided between placements of successive refuse lifts. These requirements were derived based on stability analyses using an undrained shear strength to effective vertical stress ratio of 0.21 and a coefficient of consolidation of 1.5×10^{-4} cm^2/sec for the waste phosphatic clay. The undrained shear strength to effective vertical stress ratio determines the magnitude of strength increase in the phosphatic clay, whereas the coefficient of consolidation governs the rate of strength increase.

Field Test Program

Current operation at the Southeast Landfill divides the waste disposal area into six phases designated Phases I through VI, as shown on a topographic site plan in Figure 3. The topographic site plan was generated from survey data obtained on January 18, 2005. As part of our scope of work for the annual monitoring program stipulated in Specific Condition No. 16f of the FDEP Permit No. 35435-006-SO issued on June 25, 2002, Ardaman performed piezocone soundings and pore water pressure measurements at four test sites within the Phase I, III, and IV areas where a number of field tests and measurements had previously been performed by Madrid and Ardaman in 2001/2002.

Four test sites, designated PC-1K, PC-1L, PC-3E, and PC-4F, were selected by SCS for performance of piezocone soundings and installation of piezoprobes. The approximate locations of these test sites are shown in Figure 3 along with the test site locations selected in the 2001/2002 studies performed by Madrid and Ardaman as well as the test site locations selected for the 2003 and 2004 annual monitoring programs. As shown in Figure 3, two of the four test sites were located in the Phase I area (i.e., PC-1K and PC-1L), one test site was located within the Phase III area (i.e., PC-3E), and the remaining test site was located within the Phase IV area (i.e., PC-4F). PC-1K was located in close proximity to the previous PC-1B, PC-1H, and PC-1J test site locations, and PC-1L was selected adjacent to the previous PC-1F and PC-1I test site locations. PC-3E was located near the previous PC-3, PC-3B, and PC-3D test site locations. PC-4F was selected adjacent to the PC-4E test site location used in the 2004 annual monitoring program. The current field work and testing were undertaken by Ardaman in March and April 2005.

For this year, in addition to performance of piezocone soundings and installation of piezoprobes at the above four test sites, SCS also requested the performance of an electric Dutch Cone sounding at a test site designated PC-6F in the Phase VI area for the sole purpose of determining the top elevation of the phosphatic clay layer.

The surveyed coordinates and ground surface elevations at the current test site locations, as provided by Pickett & Associates, Inc., are summarized in Table 1. The elevations were surveyed using both the NGVD29 and NGVD88 datums. Although Hillsborough County mostly uses the NGVD88 datum for elevation data, the elevation data used in the previous geotechnical studies were based on the NGVD29 datum. For ease of data comparisons, the elevations based on the NGVD29 datum are used in this report.

Piezocone Penetration Tests

The piezocone consists of a conical point attached to a steel rod and a friction sleeve. The test is performed by pushing the assembly into the soil at a constant rate of penetration. Resistance to penetration at the cone tip and on the friction sleeve are measured by load cells placed within the assembly, and the pore pressure in the soil is measured using a pressure transducer connected to the porous element placed near the cone tip. Prior to pushing of the piezocone through the waste phosphatic clay, a hollow stem auger was used to create a borehole through the refuse.

Results of the four piezocone penetration tests (i.e., PC-1K, PC-1L, PC-3E, and PC-4F) performed at the four test site locations are presented in Figures 4 through 7, respectively. As shown in the figures, results are presented in the form of tip resistance (i.e., the resistance to penetration at the cone tip), sleeve resistance (i.e., the resistance to penetration of the friction sleeve), pore pressure (i.e., the total pore water pressure including the pore pressure generated due to penetration of the cone), friction ratio (i.e., the ratio of sleeve resistance to tip resistance), soil type (i.e., soil classification), and approximate standard penetration test blow count values (i.e., SPT N values) versus depth.

Since sandy soils typically exist above and below the phosphatic clay, the depth and thickness of the phosphatic clay layer could be inferred by examining the variations of tip resistance and pore pressure with depth. The tip resistance and the pore pressure in a clayey soil are expected to be lower and higher, respectively, than those in a sandy soil. Higher friction ratios are generally indicative of clayey soil types, whereas lower ratios generally indicate the presence of silty and sandy soils. Sudden changes in tip resistance, pore pressure, and friction ratio are expected to occur at the interface between the drainage sand layer and the underlying phosphatic clay as well as the interface between the phosphatic clay and the underlying natural sandy soils.

Thickness of Refuse

Based on results of the auger borings and piezocone soundings, the refuse thicknesses at the four test sites (i.e., PC-1K, PC-1L, PC-3E, and PC-4F) in March 2005 ranged from approximately 35 feet at PC-3E to 65 feet at PC-1L.

PC-1K was located in the western portion of the Phase I area. The refuse thickness at PC-1K in March 2005 was estimated to be 50 feet, compared to a refuse thickness of 65 feet at PC-1J in March 2004 and a refuse thickness of 50 to 55 feet at PC-1H in March 2003. The reason for the variation in refuse thickness was because the test sites were not at identical locations. PC-1K was located approximately 110 feet northwest of PC-1J and at the toe of slope between the Phase I and IV areas. The land surface elevation at PC-1K was approximately 14 feet lower than the land surface elevation at PC-1J, but was very close to the land surface elevation at PC-1H.

PC-1L was located in the eastern portion of the Phase I area. The refuse thickness at PC-1L in March 2005 was estimated to be 65 feet, compared to a refuse thickness of 50 feet at the nearby PC-1I in March 2004 and a refuse thickness of 50 to 55 feet at the nearby PC-1G in March 2003.

The refuse thickness at PC-3E in March 2005 was approximately 35 feet. We understand that the refuse thickness in the Phase III area has remained approximately the same since 2001/2002.

The refuse thickness at PC-4F in March 2005 was slightly greater than 60 feet, compared to a refuse thickness of slightly greater than 50 feet at PC-4E in March 2004 and at PC-4D in March 2003. We understand that refuse was last placed near these test site locations in the Phase IV area in March/April 2003.

Filling Schedule

In March 2005, refuse was being placed in the Phase II area. The filling originated in the Phase I area that began in March 2003 and progressed from west to east towards the Phase II area. Filling occurred in the vicinity of PC-1K around June 2003 and in the vicinity of PC-1L around July

2004. A comparison of the surveyed data in the Phase I area indicated that the thickness of the refuse lift was approximately 16 to 17 feet. The previous refuse lift in the Phase I area was completed in August 1997.

Filling of the Phase III area began in December 1990 and ended in June 1994. In the Phase IV area, approximately 13 feet of refuse was placed in the vicinity of PC-4F in March/April 2003 (i.e., just prior to filling of the Phase I area).

Elevations and Thicknesses of Phosphatic Clay

Prior to landfill construction, the surface of the waste phosphatic clay within the former settling area was documented to have typical elevations in the range of +121 to +123 feet (NGVD), and the bottom of the phosphatic clay reportedly occurred at typical elevations ranging from +103 to +117 feet (NGVD). As indicated previously, the original thickness of the phosphatic clay ranged from 4 to 18 feet.

Based on results of the piezocone soundings, the top and bottom elevations of the phosphatic clay as well as the phosphatic clay thickness encountered at the four test sites are summarized in Table 2. As shown, the top elevations of the phosphatic clay ranged from a low of +110.7 feet (NGVD) at PC-1K to a high of +118.7 feet (NGVD) at PC-3E. The bottom elevations of the phosphatic clay layer ranged from a low of +103.3 feet (NGVD) at PC-1K to a high of +112.9 feet (NGVD) at PC-1L.

At the location of PC-1K, the top and bottom of the phosphatic clay layer were encountered at approximately +110.7 and +103.3 feet (NGVD), respectively, for a clay thickness of about 7.4 feet. This thickness was approximately 1.2 feet greater than the clay thickness (6.2 feet) documented at PC-1J in March 2004. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1K in June 2003. Because the PC-1K test site in 2005 was located about 110 feet from the PC-1J test site in 2004, the apparent difference could be a result of variation of phosphate clay thickness between the two test sites.

Based on the piezocone sounding performed at the location of PC-1L, the phosphatic clay had top and bottom elevations of +116.9 and +112.9 feet (NGVD), respectively, for a phosphatic clay thickness of 4.0 feet, which is close to the thickness (3.6 feet) documented at the nearby PC-1I in 2004. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1L in July 2004.

The piezocone sounding performed at the location of PC-3E revealed the top elevation of the phosphatic clay at +118.7 feet (NGVD) and the bottom elevation at +110.3 feet (NGVD), for a clay thickness of 8.3 feet, which is very close to the thickness (8.0 feet) documented at the nearby PC-3D test site in 2004. As indicated previously, no refuse has been placed in the Phase III area since June 1994.

Based on the piezocone sounding performed at the location of PC-4F, the top and bottom elevations of the phosphatic clay were documented at +113.7 and +106.8 feet (NGVD), for a clay thickness of 6.9 feet, which is 2.9 feet less than the thickness (9.8 feet) documented at the nearby PC-4E test site in 2004. As noted previously, approximately 13 feet of refuse was added at this location in April 2003.

In summary, the phosphatic clay elevations and thicknesses documented at the four test sites in 2005 (i.e., PC-1K, PC-1L, PC-3E, and PC-4F) indicated that there were minimal changes in clay thickness from March 2004 to March 2005 at the locations of PC-1L and PC-3E. The apparent increase in clay thickness at PC-1K from 2004 to 2005 could be attributed to variation of clay thickness between the 2004 and 2005 test sites. The observed decrease in phosphatic clay layer thickness at PC-4F from March 2004 to March 2005 (about 3 feet) could be attributed to compression of the phosphatic clay layer by refuse loading. However, it could also be a result of variation of phosphatic clay thickness between the test sites in 2004 and 2005.

Piezometric Elevations on Top of Phosphatic Clay

The piezometric heads in the drainage sand layer on top of the phosphatic clay could be inferred from the piezocone penetration test results. As the piezocone was pushed through the drainage sand layer on top of the phosphatic clay, it was held stationary at selected depths to allow the excess pore water pressure generated as a result of pushing of the piezocone to stabilize. Because of the relatively high permeability of the sand, any excess pore pressure should dissipate in a short duration. The pore pressures were monitored for several minutes to make sure that the final readings represented the stabilized pore pressures at the selected depths.

Based on the piezocone soundings performed at the four test sites, the piezometric heads in the drainage sand layer on top of the phosphatic clay are summarized in Table 3 and are further displayed in Figure 8. Piezometric heads documented from previous studies are also shown on the same figure for comparisons.

As shown in Table 3 and Figure 8, results of the piezocone soundings indicated that the piezometric heads on top of the phosphatic clay at the four test site locations ranged from 6.6 to 8.8 feet. The highest piezometric elevation of +125.3 feet (NGVD) was observed at PC-3E (i.e., 6.6 feet above the top of the phosphatic clay). The piezometric heads in the drainage sand on top of the phosphatic clay at PC-1K, PC-1L, and PC-4F were measured to be 8.8, 7.2 and 6.9 feet above the top of the phosphatic clay, respectively. On the average, the piezometric heads in the drainage sand layer in March 2005 were approximately 3 feet higher than the previous readings obtained in March 2004 and March 2003.

Piezometric Elevations Below Phosphatic Clay

Based on the piezocone sounding results, the piezometric elevations in the natural soils below the phosphatic clay are summarized in Table 4. As shown, the piezometric elevations at the test site locations were documented at approximately +118 to +122 feet (NGVD). These piezometric elevations were generally in good agreement with those obtained in March 2004 and March 2003.

Piezoprobe Tests Within Phosphatic Clay

The piezoprobe tests were performed by installing piezoprobes to pre-selected depths and holding them stationary until the excess pore pressure generated from probe penetration completely dissipated, and the measured pore pressure reached the actual pore pressure before probe penetration.

The dissipation of excess pore pressures generated due to probe penetrations are presented in Figures 9 to 12 in the form of normalized excess pore pressure (i.e., the ratio of excess pore water pressure at any time to the initial excess pore water pressure immediately after piezoprobe penetration) versus time. As shown in the figures, all pore pressures reached equilibrium conditions at the end of the monitoring periods. The rate of dissipation of excess pore pressure generated by probe penetration can be used to estimate the *in situ* coefficient of consolidation of the phosphatic clay.

At the locations of PC-1K, PC-3E, and PC-4F with approximately 7 to 8 feet of phosphatic clay, piezoprobe tests were performed at three different depths to measure the pore pressures near the top, middle, and bottom of the phosphatic clay layer. Because of the limited phosphatic clay thickness at PC-1L (4 feet), only one piezoprobe was installed. Results from the piezoprobe tests are summarized in Table 5.

At the location of PC-1K, the equilibrium piezometric elevations for the three piezoprobes installed with tip elevations at +109.3, +107.2 and +105.2 feet (NGVD) were documented to be approximately +130.4, +135.4 and +132.0 feet (NGVD), respectively. The excess pore water pressures within the phosphatic clay layer at the tip elevations were estimated to be 10.4, 14.9 and 10.8 feet of water, respectively. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1K in June 2003.

At the location of PC-1L, one piezoprobe test was performed with the piezoprobe tip elevation at +115.7 feet (NGVD). The piezometric elevation at that depth was documented to be +129.5 feet (NGVD), corresponding to an excess pore water pressure that is equivalent to approximately 7.1 feet of water. As indicated previously, approximately 17 feet of refuse was placed in the vicinity of PC-1L in July 2004. Because the phosphatic clay thickness at PC-1L (4.0 feet) was less than that at PC-1K (7.4 feet), the excess pore water pressure from refuse loading would have dissipated at a faster rate.

At the location of PC-3E, three piezoprobe tests were performed within the phosphatic clay layer with the piezoprobe tip elevations at +116.7, +114.7 and +112.7 feet (NGVD). The excess pore water pressures documented by the piezoprobes were equivalent to only 0.2 to 1.8 feet of water. This is not unexpected since there has been no refuse placed in the Phase III area since July 1994.

At the location of PC-4F, three piezoprobe tests were performed within the phosphatic clay layer with the piezoprobe tip elevations at +111.9, +110.2 and +108.4 feet (NGVD) with the equilibrium piezometric elevations at +124.7, +124.9 and +124.5 feet (NGVD), respectively. The excess pore water pressures near the top, middle, and bottom of the phosphatic clay were equivalent to 19.4, 29.0 and 31.9 feet of water, respectively. High excess pore water pressures were also observed in the Phase IV area in previous piezoprobe measurements in 2003 and 2004. The high excess pore water pressures could be attributed to refuse loading in the Phase IV area. As noted previously, approximately 13 feet of refuse was added in the vicinity of PC-4F in April 2003.

Coefficient of Consolidation

The coefficient of consolidation governs the rate of strength increase in the phosphatic clay upon loading from a refuse lift and thus the waiting period between placement of successive refuse lifts in an area. The filling schedule at the Southeast Landfill was originally based on a design vertical coefficient of consolidation, c_v, of 1.5×10^{-4} cm^2/sec.

Based on the rates of excess pore pressure dissipation shown in Figures 9 through 12, the horizontal coefficients of consolidation, c_h, of the phosphatic clay obtained from the piezoprobe tests were calculated and are presented in Table 6. The *in situ* vertical coefficients of consolidation, c_v, can be estimated from the horizontal coefficients of consolidation, c_h, based on the following empirical relationship proposed by Baligh, M. et al (ASCE Journal of Geotechnical Engineering, Vol. 112, No. 7, July, 1986): $c_v = 0.05 \times c_h$, and are also presented in Table 6.

The *in situ* vertical coefficients of consolidation from the piezoprobe measurement at PC-1L and the piezoprobe measurements at the top of the phosphatic clay layer at PC-1K and PC-3E indicated an average c_v value of 1.7×10^{-4} cm^2/sec, which is close to the design vertical coefficient of consolidation. However, the *in situ* vertical coefficients of consolidation from the piezoprobe measurements at mid-depth and bottom of the phosphatic clay layer at PC-1K and PC-3E had an average c_v value of 3.1×10^{-5} cm^2/sec. The c_v values of the phosphatic clay layer at PC-4F averaged 2.8×10^{-5} cm^2/sec for the three measurements at different depths.

Although the vertical coefficients of consolidation documented at the middle and bottom of PC-1K and PC-3E were lower than the original design value of 1.5×10^{-4} cm/sec, the piezoprobe measurements in 2003 and 2004 at nearby test sites had vertical coefficients of consolidation that were consistent with the design value. Because the Phase I area has just been recently loaded and no significant excess pore water pressure was observed in the phosphatic clay within the Phase III area, the lower vertical coefficients of consolidation documented in 2005 should not be an issue at this time. At PC-4F, because low vertical coefficients of consolidation were also documented at the nearby test site in 2004, Ardaman recommends performance of additional field tests to measure the undrained shear strength of the clay or any excess pore water pressure in the phosphatic clay prior to placement of the next lift of refuse in the Phase IV area.

Settlement plate data at the location of Pump Station B in the Phase VI area, as provided by Hillsborough County, are plotted in Figure 13. At this location, the initial thickness of the phosphatic clay was approximately 13 feet. As shown in Figure 13, the phosphatic clay has undergone a settlement of about 4 feet over a period of 5 years. Assuming that an average degree of consolidation of 95% has been reached under double drainage condition with an average consolidating thickness of 11 feet, the backalculated c_v from the settlement observations is 2.0×10^{-4} cm^2/sec, which is consistent with the design value.

Comparisons of Piezometric Heads

The piezometric elevations in the materials directly above and below the phosphatic clay layer, as documented from the piezocone soundings, are summarized in Table 7. The piezometric heads within the phosphatic clay layer are also shown on the same table for comparison.

The piezometric head within the phosphatic clay will be highest after loading of a new refuse lift and will decrease gradually as excess pore water pressure dissipates. If the piezometric head within the phosphatic clay is higher than the piezometric head on top of the phosphatic clay, there will be no downward migration of leachate. Once the excess pore water pressure from landfill loading dissipates, the flow direction through the phosphatic clay will be a function of the piezometric head difference across the phosphatic clay. If the piezometric elevation in the natural soils below the phosphatic clay is higher than the piezometric elevation on top of the phosphatic clay, upward flow will occur. Conversely, if the piezometric elevation in the natural soils is lower than the piezometric elevation on top of the phosphatic clay, leachate will migrate downward, at a rate governed by the piezometric head difference, and the hydraulic conductivity and thickness of the phosphatic clay deposit.

As shown in Table 7, the existing maximum piezometric heads within the phosphatic clay layer are higher than the piezometric heads in the materials above and below the phosphatic clay at the PC-1K, PC-1L, and PC-4F test site locations. Accordingly, under existing condition, there should be no downward leachate migration or upward groundwater flow through the phosphatic clay layer at these locations. At the PC-3E test site location, the piezometric elevation on top of the phosphatic clay layer is slightly higher than the maximum piezometric head within the phosphatic clay and the piezometric head in the material below the phosphatic clay. This condition will result in downward leachate flow. However, the flow is not expected to be significant considering the thickness of the phosphatic clay layer (8 feet), the relatively small hydraulic head (< 4 feet), and the low hydraulic conductivity of the phosphatic clay material (< 1×10^{-8} cm/sec).

Electric Dutch Cone Sounding in Phase VI Area

For this year, SCS requested Ardaman to perform an electric Dutch cone sounding at a test site designated PC-6F in the Phase VI area for the sole purpose of determining the elevation at the top of the phosphatic clay. Results of the Dutch cone sounding test are presented in Figure 14. As shown in the figure, results are presented in the form of tip resistance (i.e., the resistance to penetration at the cone tip), sleeve resistance (i.e., the resistance to penetration of the friction sleeve), friction ratio (i.e., the ratio of sleeve resistance to tip resistance), soil type (i.e., soil classification), and approximate standard penetration test blow count values (i.e., SPT N values) versus depth. As shown in Table 2, the top of the phosphatic clay was encountered at a depth of 52.0 feet. The elevation of ground surface at the test location was at +167.31 feet (NGVD), and the top of the phosphatic clay was at elevation +115.3 feet (NGVD).

Summary of Observations

The following key observations were made from the 2005 annual monitoring data based on the field work completed:

- The refuse surface elevations increased by 17 and 13 feet compared to March 2004 at test locations PC-1L and PC-4F, respectively. At test location PC-3E, the existing grade remained unchanged. At test location PC-1K, the refuse elevation was about the same as test location PC-1H in 2003.

- The top elevations of the phosphatic clay were as expected and generally consistent with the data obtained in 2004.

- The thicknesses of the phosphatic clay were also generally consistent with the data obtained in 2004. The phosphatic clay thickness at PC-1K, PC-1L, and PC-3E were found to be higher by 1.2, 0.4 and 0.3 feet, respectively, compared to the thicknesses estimated in 2004. At PC-4F, the clay thickness was 2.9 feet less than that observed in PC-4E in 2004. The observed decrease in phosphatic clay layer thickness at PC-4F from March 2004 to March 2005 could be attributed to compression of the phosphatic clay layer by refuse loading. However, it could also be a result of variation of phosphatic clay thickness between the test sites in 2004 and 2005.

- A considerable amount of excess pore pressure was documented within the phosphatic clay layer at PC-1L, PC-1K, and especially PC-4F. Because these areas have been loaded recently, the excess pore pressure was not unexpected. There were minimal excess pore pressure documented within the phosphatic clay at PC-3E.

- The piezometric heads above the phosphatic clay at the PC-1K, PC-1L, PC-3E, and PC-4F test site locations were measured to be 8.8, 7.2, 6.6 and 6.9 feet, respectively. On the average, these measurements were about 3 feet higher than the readings obtained in 2004.

- The piezometric elevations below the phosphatic clay were observed to be at approximately +118 to +122 feet (NGVD). These elevations are similar to those observed in 2003 and 2004.

Recommendation

High excess pore water pressures at PC-4F were recorded but are not unexpected due to recent refuse placement in this area. However, because of the lower than expected coefficients of consolidation documented at different depths of the phosphatic clay layer at PC-4F, additional field tests should be performed to measure the undrained shear strength of the clay or any excess pore water pressure in the clay prior to placement of the next lift of refuse. For all other areas, the 7-year waiting period between placement of successive refuse lifts remain valid.

Closure

This report has been prepared for the exclusive use of SCS and the Hillsborough County Solid Waste Department for specific application to annual monitoring of the phosphatic clay liner at the Southeast Landfill in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made.

Ardaman appreciates the opportunity to assist you on this project. Please contact us if you have any questions concerning this report or need additional information.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Shawkat Ali

Shawkat Ali, Ph.D., P.E.
Project Engineer

Francis K. Cheung, P.E.
Senior Project Manager
Florida License No. 36382

05/27/05

Enclosures

Table 1

Test Site Locations and Elevations

Test Site	Area	State Plan Coordinates		Approx Ground Surface Elevations (feet)	
		Northing	Easting	NGVD29	NGVD88
PC-1K	Phase I	1,250,443.55	595,886.47	+163.53	+162.62
PC-1L	Phase I	1,249,916.34	597,283.83	+188.66	+187.75
PC-3E	Phase III	1,251,089.80	597,409.63	+154.67	+153.76
PC-4F	Phase IV	1,250,656.68	596,423.09	+178.15	+177.24
PC-6F	Phase VI	1,250,983.97	596,262.97	+167.31	+166.40

Table 2

Top and Bottom Elevations of Phosphatic Clay

Area	Test Site	Date	Approx Ground Surface Elevation (ft, NGVD)	Top of Clay		Bottom of Clay		Clay Thickness (ft)
				Depth (ft, BLS)	Elevation (ft, NGVD)	Depth (ft, BLS)	Elevation (ft, NGVD)	
Phase I	PC-1K	03/14/05	+163.53	52.8	+110.7	60.2	+103.3	7.4
	PC-1L	03/16/05	+188.66	71.8	+116.9	75.8	+112.9	4.0
Phase III	PC-3E	03/11/05	+154.67	36.0	+118.7	44.3	+110.3	8.3
Phase IV	PC-4F	03/09/05	+178.15	64.5	+113.7	71.4	+106.8	6.9
Phase VI	PC-6F	03/03/05	+167.31	52.0	+115.3	--	--	--

Table 3

Piezometric Levels on Top of Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Piezometric Head on Top of Phosphatic Clay (ft)
Phase I	PC-1K	04/14/05	+163.53	+119.5	+110.73	8.8
	PC-1L	04/12/05	+188.66	+124.2	+116.9	7.2
Phase III	PC-3E	04/14/05	+154.67	+125.3	+118.7	6.6
Phase IV	PC-4F	04/14/05	+178.15	+119.5	+113.7	6.9

Table 4

Piezometric Elevations Below Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)
Phase I	PC-1K	03/14/05	+163.53	+121.7
	PC-1L	04/18/05	+188.66	+118.3
Phase III	PC-3E	04/25/05	+154.67	+121.8
Phase IV	PC-4F	03/09/05	+178.15	+118.4

Table 5

Pore Pressures Within Phosphatic Clay

Area	Test Site	Ground Surface Elevation (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Bottom of Clay Elevation (ft, NGVD)	Piezoprobe Designation	Piezoprobe Tip Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Stabilized Pore Pressure at Piezoprobe Tip After Dissipation (ft of H_2O)	Piezometric Elevation at Piezoprobe Tip Level (ft, NGVD)	Piezometric Elevation on Top of Clay (ft, NGVD)	Piezometric Elevation Below Clay (ft, NGVD)	Excess Pore Pressure at Piezoprobe Tip Level (ft of H_2O)
Phase I	PC-1K	+163.53	+110.7	+103.3	PC-1K	54.2 56.3 58.3	+109.3 +107.2 +105.2	21.1 28.2 26.7	+130.4 +135.4 +132.0	+119.5	+121.7	10.4 14.9 10.8
	PC-1L	+188.66	+116.9	+112.9	PC-1L	73.0	+115.7	13.8	+129.5	+124.2*	+118.2	7.1
Phase III	PC-3E	+154.67	+118.7	+121.2	PC-3E	38.0 40.0 42.0	+116.7 +114.7 +112.7	8.0 10.2 11.87	+124.7 +124.9 +124.5	+125.3	+121.8	0.2 1.3 1.8
Phase IV	PC-4F	+1178.15	+113.7	+106.8	PC-4E	66.3 68.0 69.8	+111.9 +110.2 +108.4	26.7 37.8 42.2	+138.6 +148.0 +150.6	+119.5	+118.5	19.4 29.0 31.9

Table 6

Computed Coefficients of Consolidation from Piezoprobe Tests

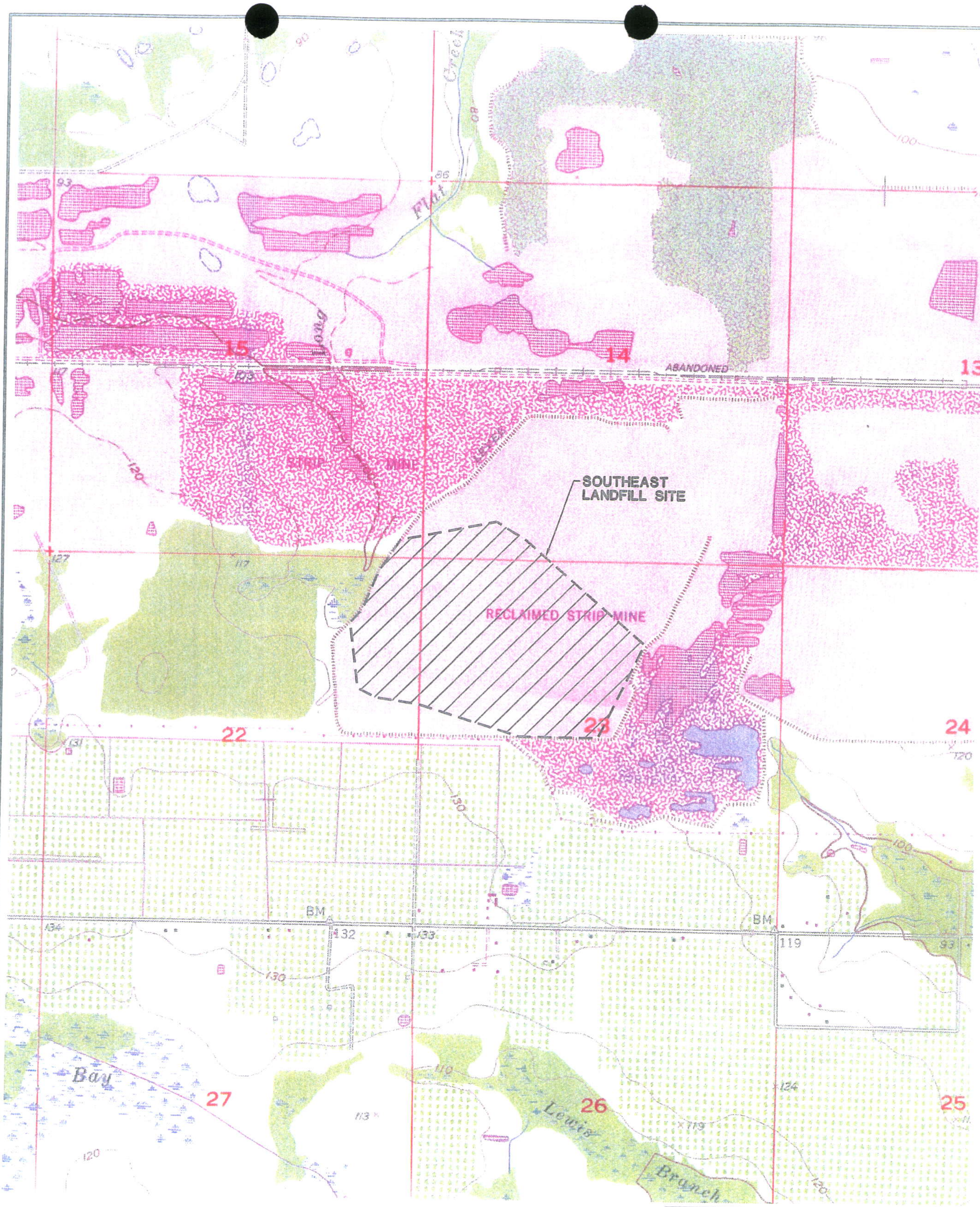
Area	Test Site	Piezoprobe Designation	Piezoprobe Tip Depth Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Horizontal Coefficient of Consolidation, c_h (cm^2/sec)	Vertical Coefficient of Consolidation, c_v* (cm^2/sec)
Phase I	PC-1K	PC-1K	54.2 56.3 58.3	+109.3 +107.2 +105.2	3.0×10^{-3} 6.6×10^{-4} 5.8×10^{-4}	1.5×10^{-4} 3.2×10^{-5} 2.9×10^{-5}
	PC-1L	PC-1L	73.0	+115.7	2.6×10^{-3}	1.3×10^{-4}
Phase III	PC-3E	PC-3E	38.0 40..0 42.0	+116.7 +114.7 +112.7	4.9×10^{-3} 7.8×10^{-4} 4.8×10^{-4}	2.4×10^{-4} 3.8×10^{-5} 2.3×10^{-5}
Phase IV	PC-4F	PC-4F	66.3 68.0 69.8	+111.9 +110.2 +108.4	9.2×10^{-4} 3.4×10^{-4} 4.5×10^{-4}	4.5×10^{-5} 1.7×10^{-5} 2.2×10^{-5}

* c_v using empirical relationship recommended by Baligh et al., 1986.

Table 7

Comparisons of Piezometric Elevations

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Existing Maximum Piezometric Elevation Within Clay (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)	Location of Existing Maximum Head	
Phase I	PC-1K	04/14/05	+163.53	+119.5	+135.5	+121.7	Within Clay	2.2
	PC-1L	04/12/05	+188.66	+124.2	+129.5	+118.3	Within Clay	5.9
Phase III	PC-3E	04/14/05	+154.67	+125.3	+124.9	+121.8	Above Clay	3.5 ↓
Phase IV	PC-4F	04/14/05	+178.15	+119.5	+150.6	+118.4	Within Clay	1.1



N

0 1000 2000

SCALE: — 1"=2000'

TOWNSHIP 31 SOUTH
RANGE 21 EAST
SECTIONS 14, 15, 22 AND 23

OBTAINED FROM U.S.G.S. QUAD MAP:
LITHIA, FLORIDA 1955
(PHOTOREVISED 1987)

SITE LOCATION MAP		
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
DRAWN BY: BTW	CHECKED BY: SA	DATE: 05/16/05
FILE NO. 05-010	APPROVED BY: FKC	FIGURE: 1

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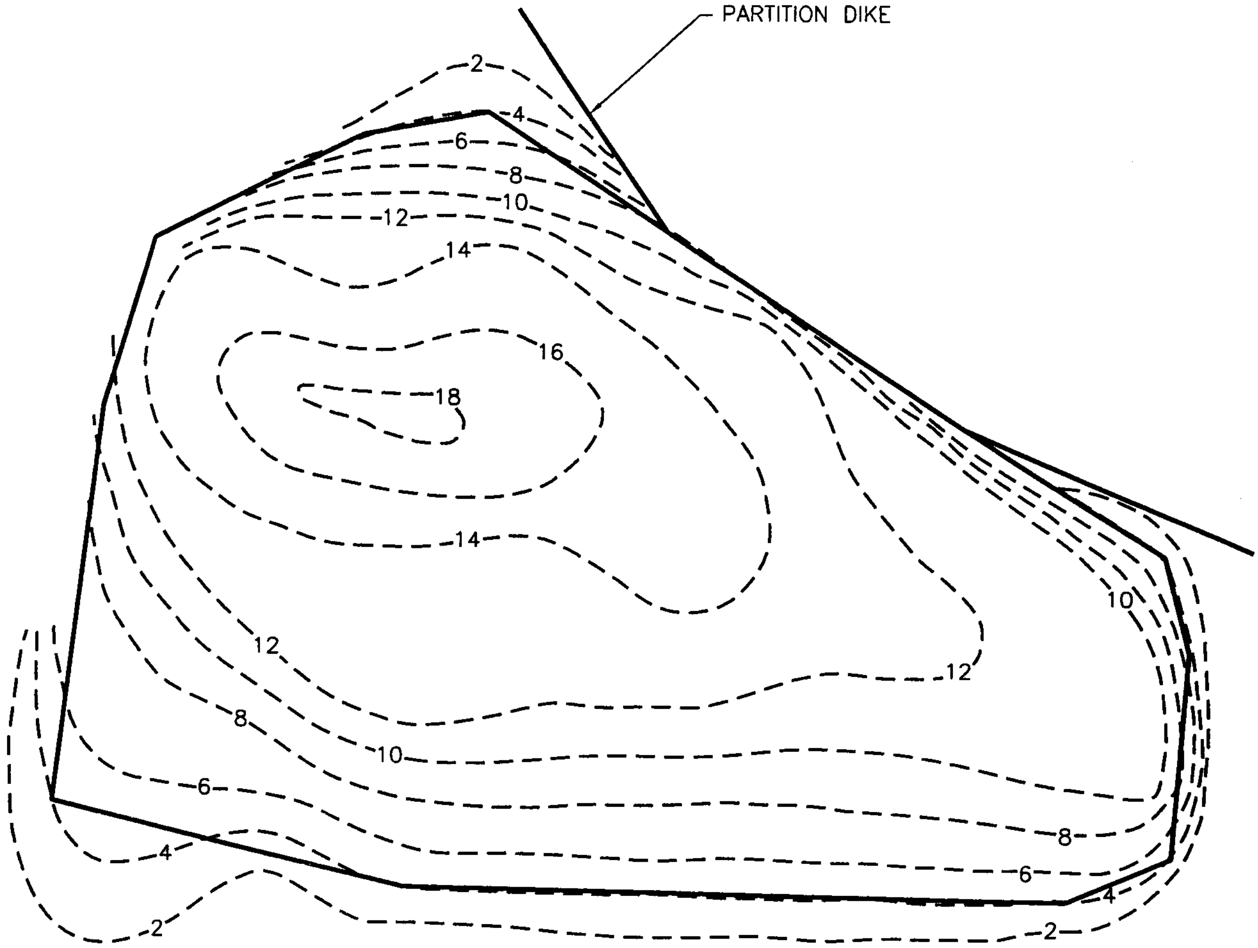
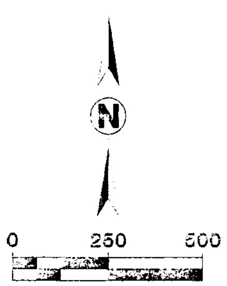


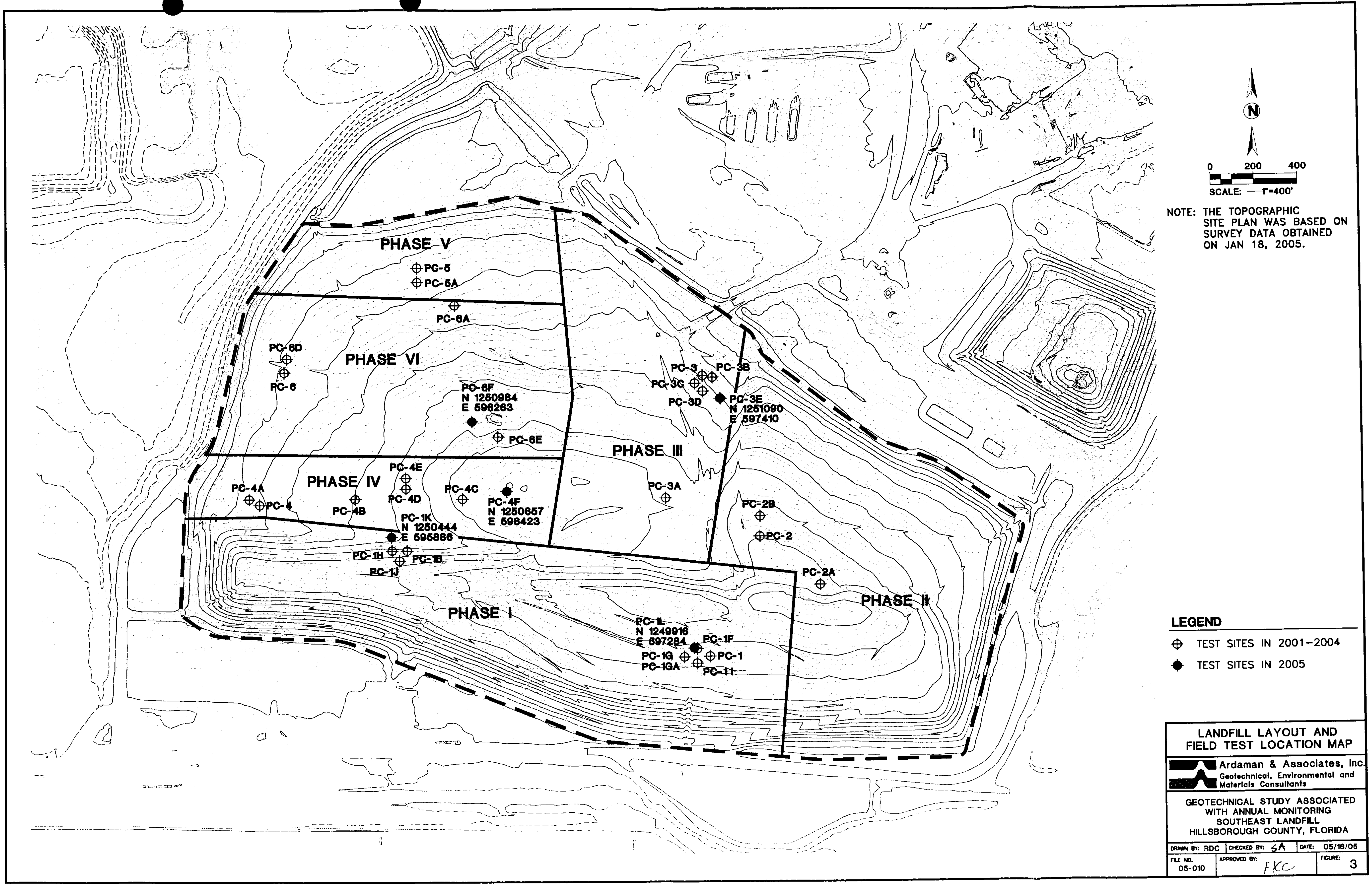


LEGEND

10 — CONTOURS OF CLAY THICKNESS IN FEET

NOTE: REPRODUCED FROM ARDAMAN & ASSOCIATES' 1981-1983 STUDY

THICKNESS OF PHOSPHATIC CLAY BEFORE LANDFILL CONSTRUCTION			
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants			
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA			
DRAWN BY: BTW	CHECKED BY: SA	DATE: 05/16/05	
FILE NO. 05-010	APPROVED BY: FLCC	FIGURE: 2	



PHASE V
PC-5
PC-5A
PC-6A
PHASE VI
PC-6D
PC-6
PC-6F
N 1250984
E 596263
PC-6E
PHASE IV
PC-4E
PC-4A
PC-4
PC-4B
PC-4D
PC-4C
PC-4F
N 1250657
E 596423
PC-1K
N 1250444
E 595886
PC-1H
PC-1B
PC-1J
PHASE III
PC-3
PC-3B
PC-3C
PC-3D
PC-3E
N 1251090
E 597410
PC-3A
PC-2B
PC-2
PC-2A
PHASE II
PHASE I
PC-1
N 1249916
E 597284
PC-1F
PC-1G
PC-1
PC-1GA
PC-1I
N
0 200 400
SCALE: 1"=400'
NOTE: THE TOPOGRAPHIC SITE PLAN WAS BASED ON SURVEY DATA OBTAINED ON JAN 18, 2005.
LEGEND
TEST SITES IN 2001-2004
TEST SITES IN 2005
LANDFILL LAYOUT AND FIELD TEST LOCATION MAP
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA
DRAWN BY: RDC
CHECKED BY: SA
DATE: 05/16/05
FILE NO. 05-010
APPROVED BY: FKC
FIGURE: 3
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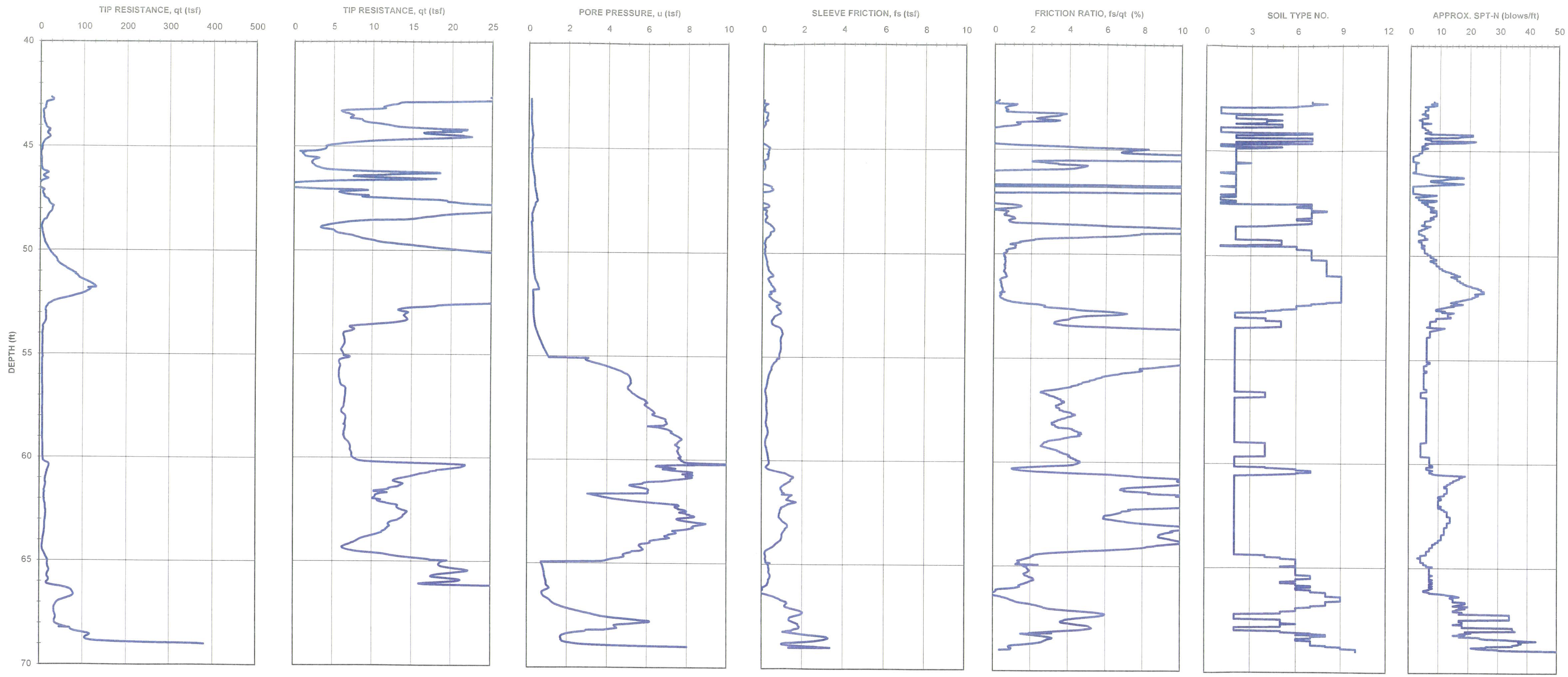


Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson etal., 1986

TEST SITE: PC-1K

SOUNDING DATE 3/14/05

SURFACE ELEVATION (FT, NGVD) 163.53

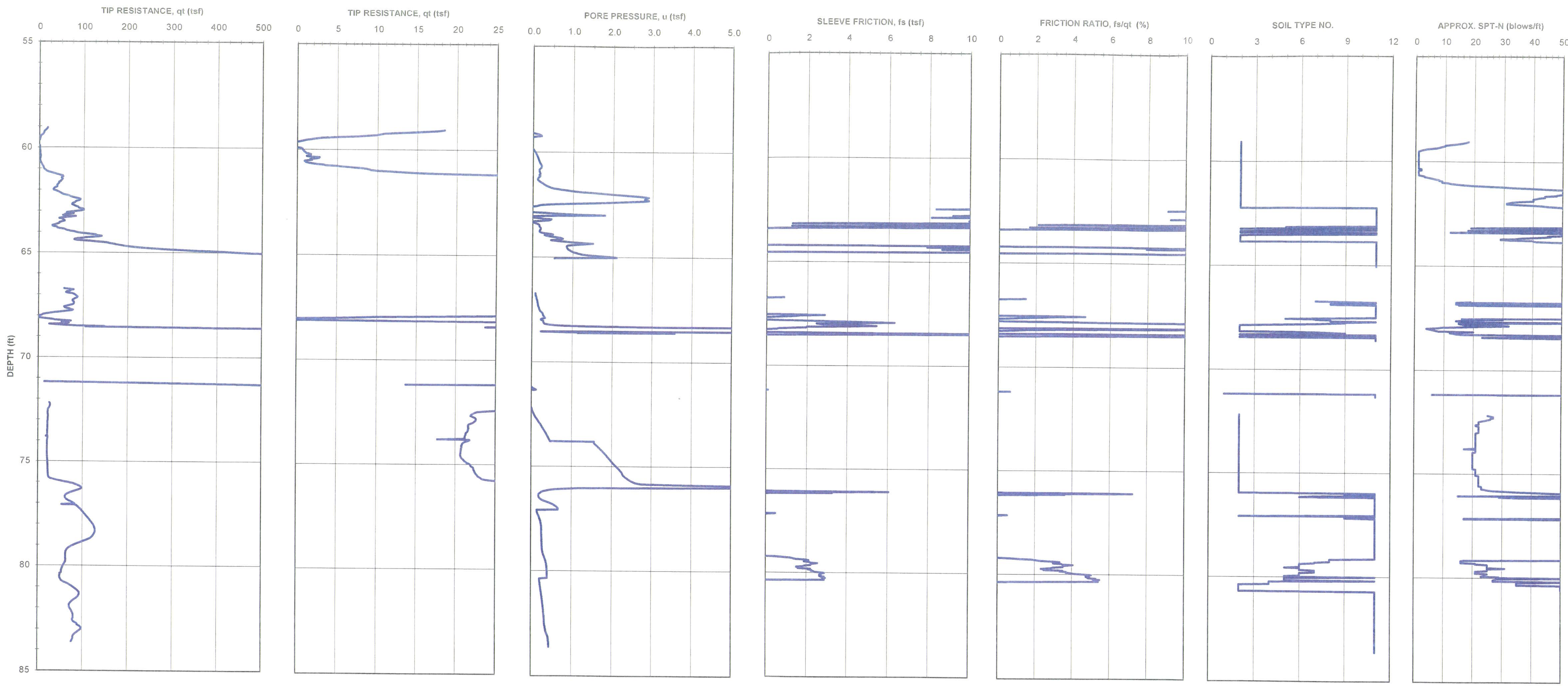
COORDINATE LOCATION (FT) N 1,250,443.55
E 595,886.47

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING

SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY	SA	CHECKED BY	SA	DATE	05-16-05
FILE NO	05-010	APPROVED BY	FKC	FIGURE	4



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

TEST SITE: PC-1L

SOUNDING DATE 3/16/05

SURFACE ELEVATION (FT, NGVD) 188.66

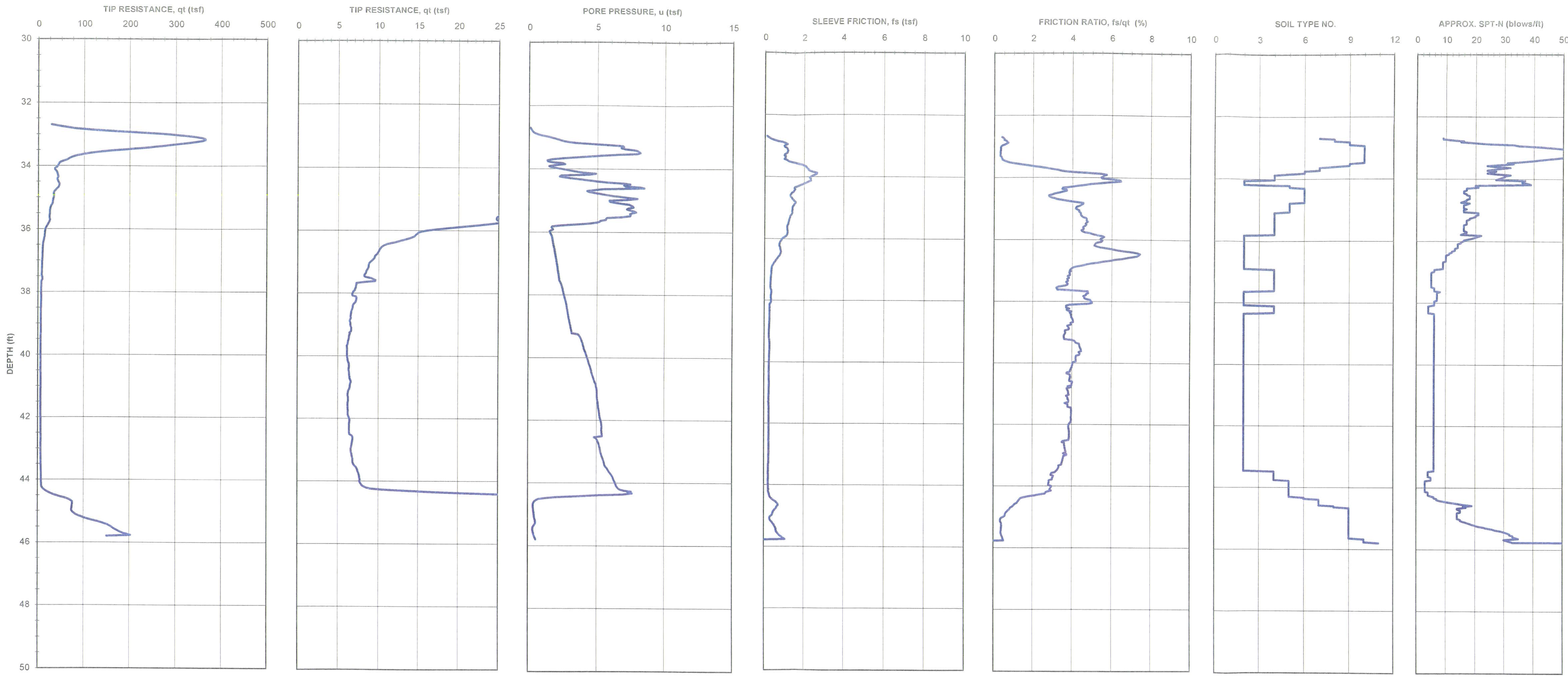
COORDINATE LOCATION (FT) N 1,249,916.34
E 597,283.83

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING

SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY SA	CHECKED BY SA	DATE 05-16-05
FILE NO. 05-010	APPROVED BY FFC	FIGURE 5



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

TEST SITE: PC-3E

SOUNDING DATE 3/11/05

SURFACE ELEVATION (FT, NGVD) 154.67

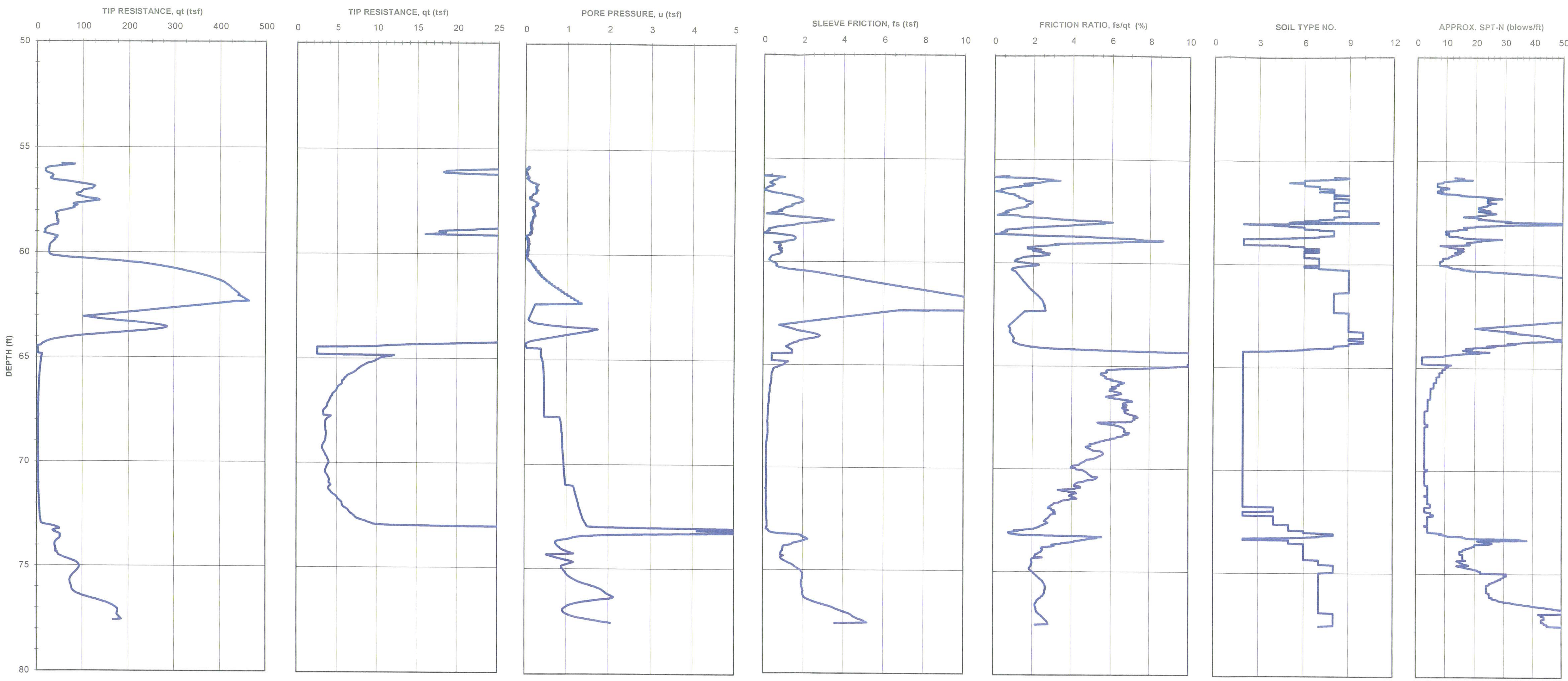
COORDINATE LOCATION (FT) N 1,251,089.80
E 597,409.63

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING

SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY	SA	CHECKED BY	SA	DATE	05-16-05
FILE NO.	05-010	APPROVED BY	FICC	FIGURE	6



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil Classification by Robertson et al., 1986

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

TEST SITE: PC-4F

SOUNDING DATE 3/9/05

SURFACE ELEVATION (FT, NGVD) 178.15

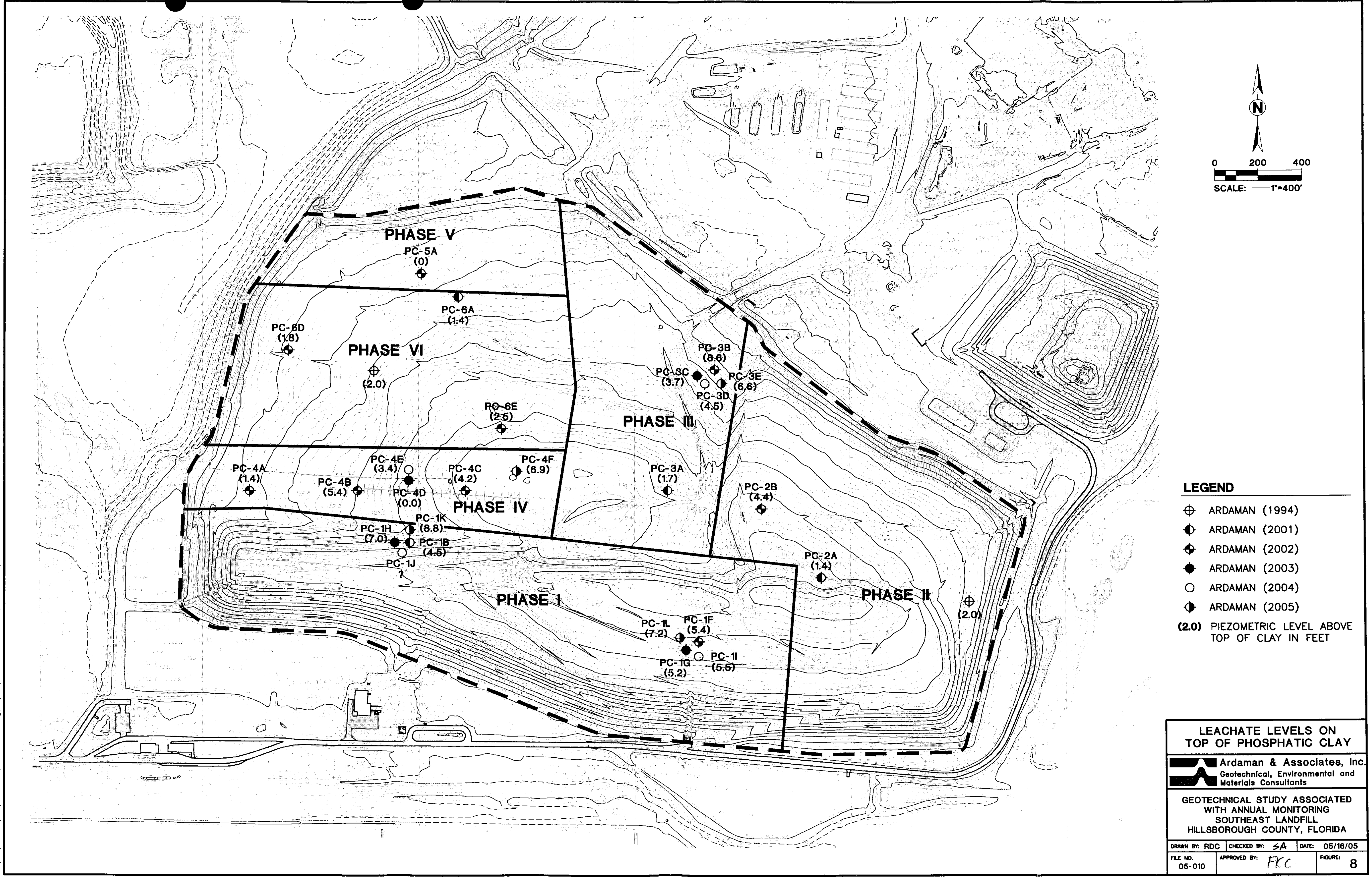
COORDINATE LOCATION (FT) N 1,250,656.68
E 596,423.09

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING

SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY	SA	CHECKED BY	SA	DATE	05-16-05
FILE NO.	05-010	APPROVED BY	FKC	FIGURE	7



LEACHATE LEVELS ON TOP OF PHOSPHATIC CLAY

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: RDC	CHECKED BY: SA	DATE: 05/18/05
FILE NO. 05-010	APPROVED BY: FKC	FIGURE: 8

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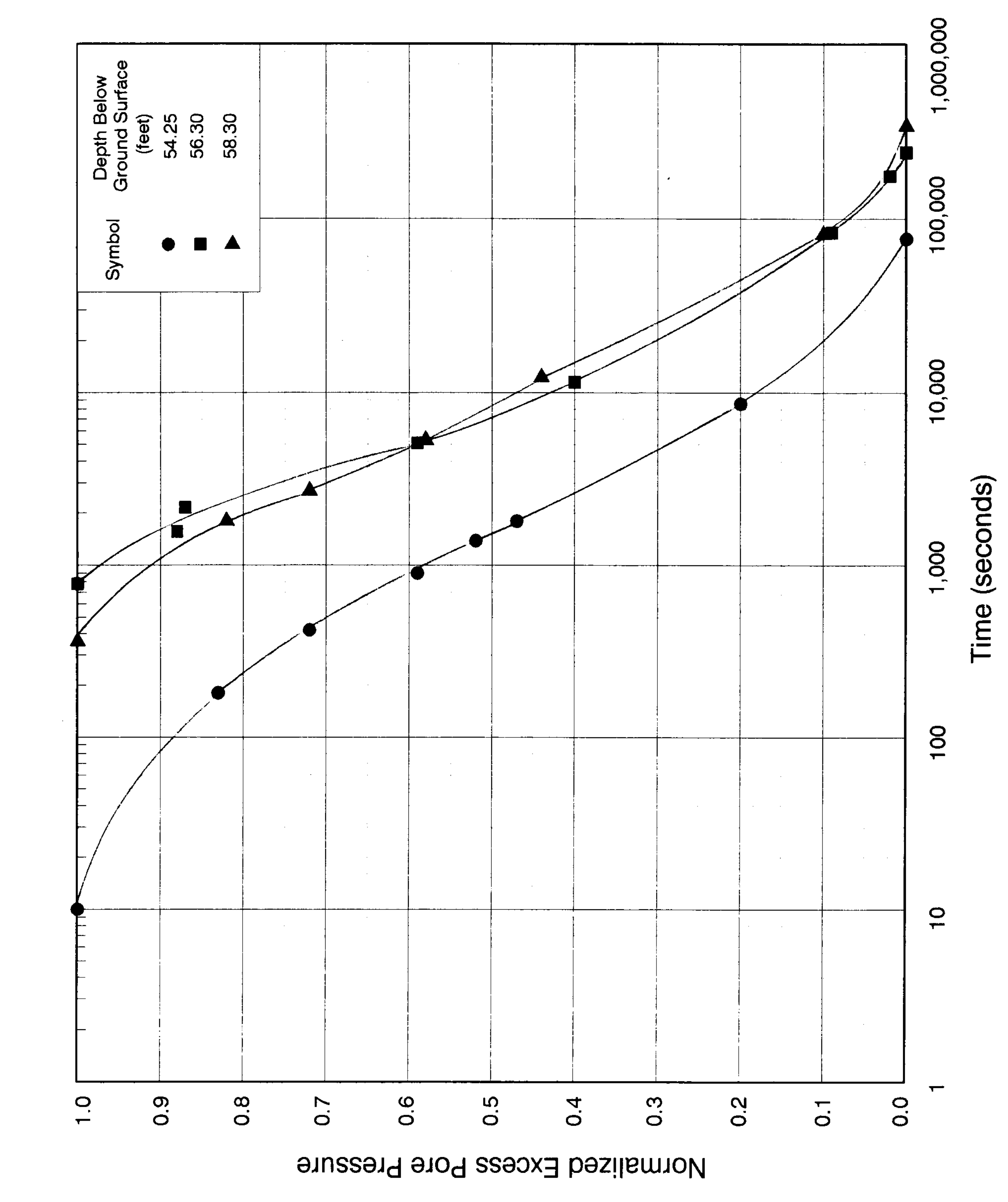
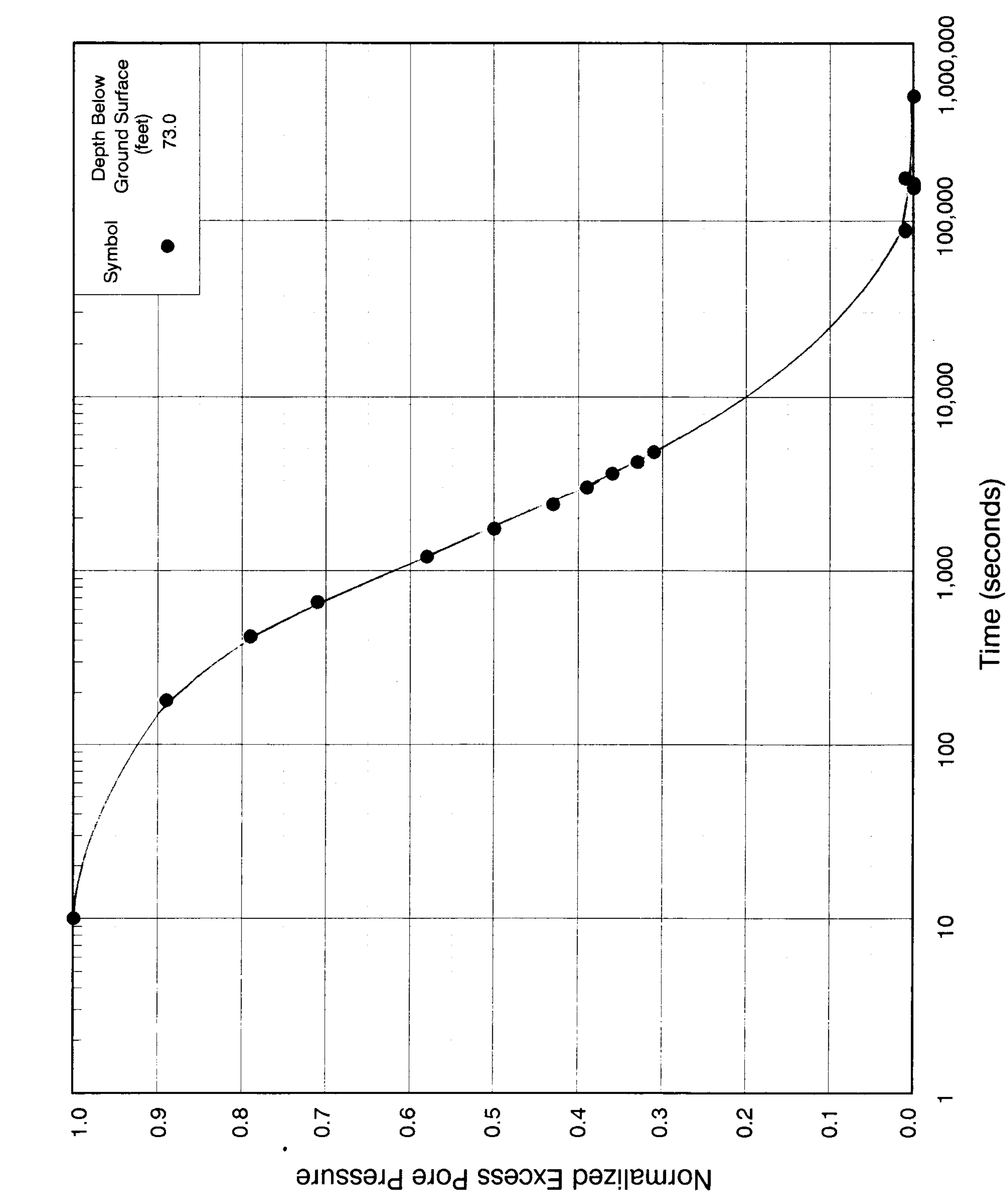


EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE AT TEST LOCATION PC-1K

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 05-16-03
FILE NO.: 05-010	APPROVED BY: FKC	FIGURE: 9



Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

EXCESS PORE PRESSURE DISSIPATION PIEZOPROBE AT TEST LOCATION PC-1L

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

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FILE NO.: 05-010	APPROVED BY: FICC	FIGURE: 10

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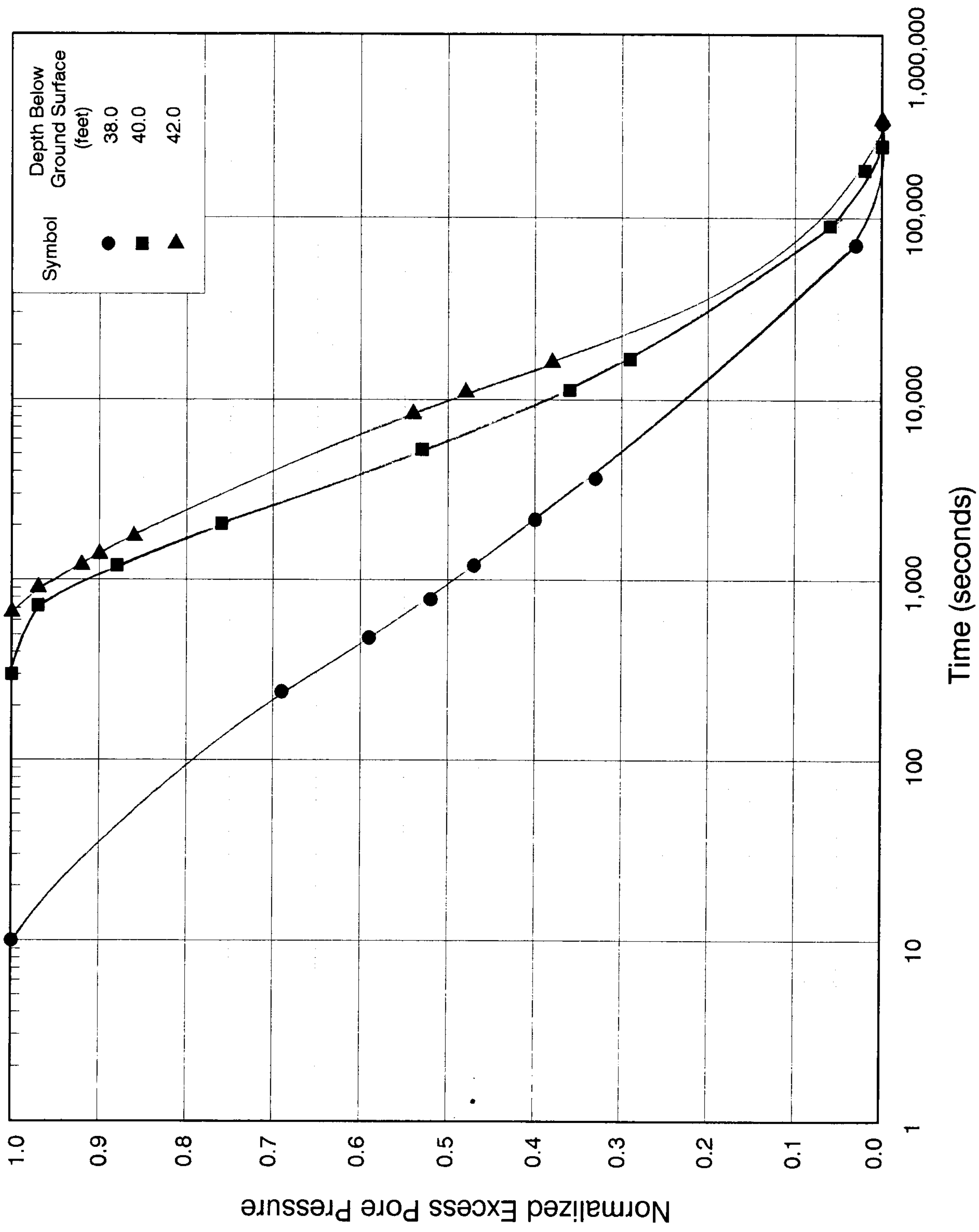
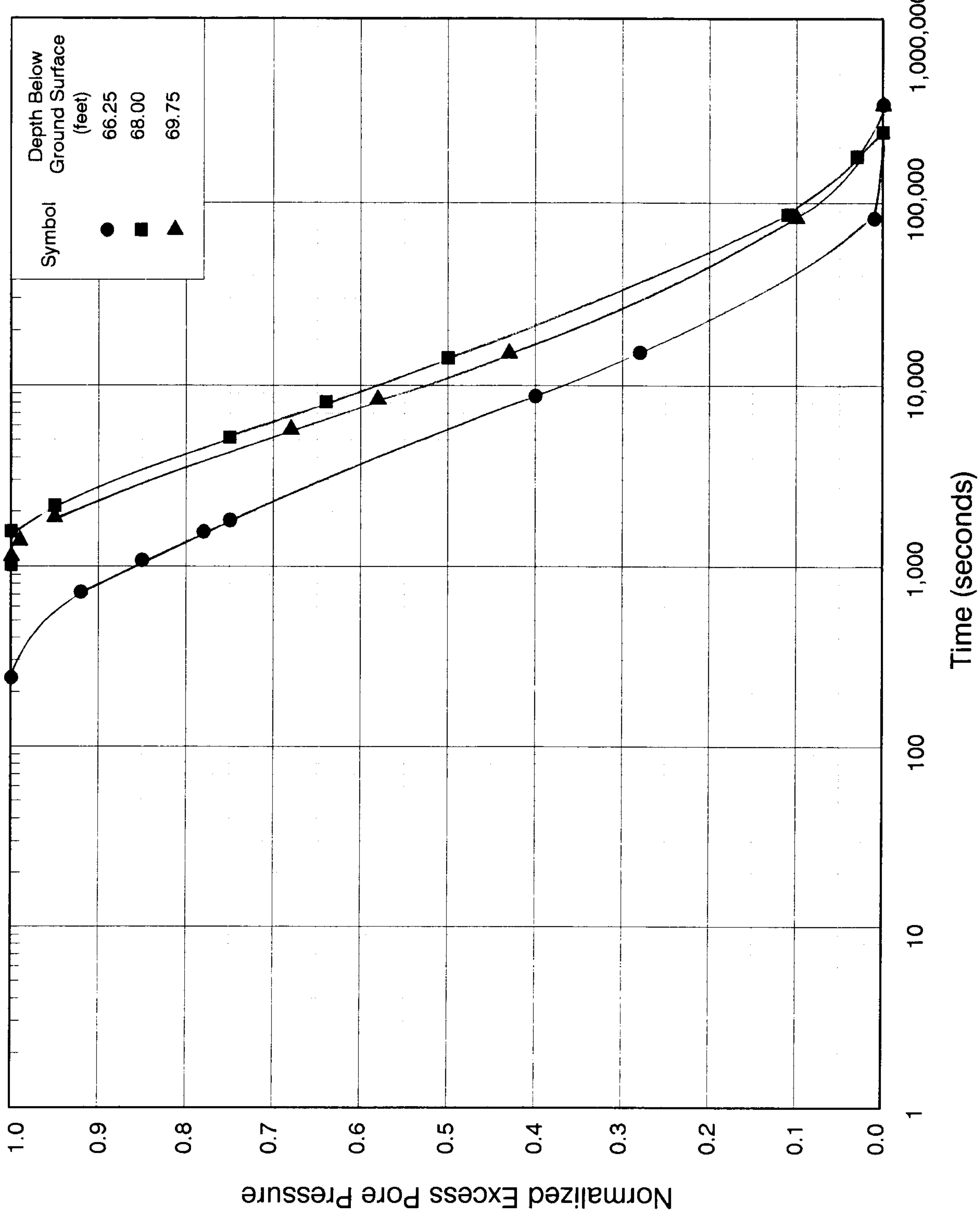


Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

EXCESS PORE PRESSURE DISSIPATION PIEZOPROBE AT TEST LOCATION PC-3E

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE 05-16-03
FILE NO.: 05-010	APPROVED BY:	FIGURE: 11

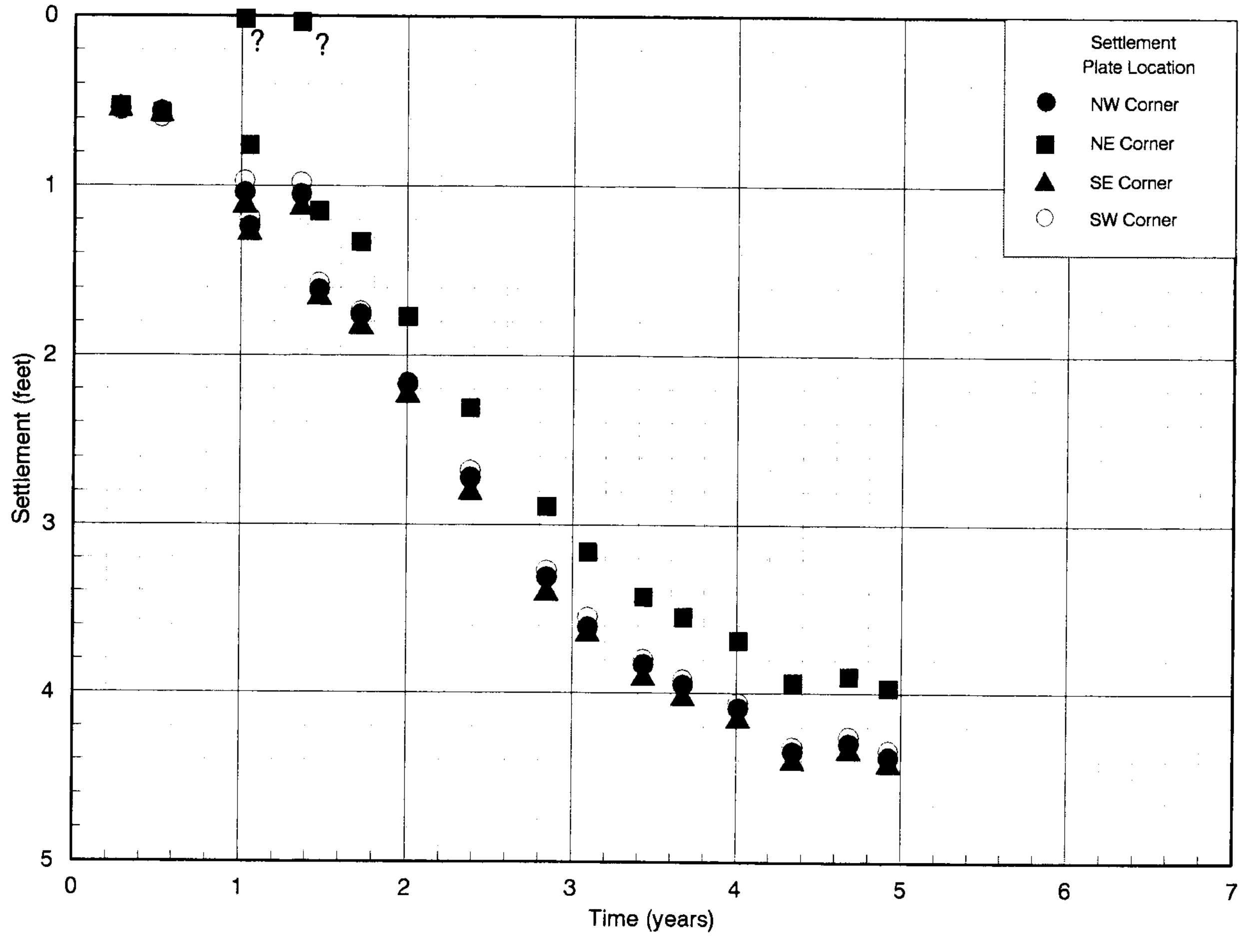


EXCESS PORE PRESSURE DISSIPATION PIEZOPROBE AT TEST LOCATION PC-4F

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 05-16-03
FILE NO.: 05-010	APPROVED BY: FKG	FIGURE: 12



SETTLEMENT VERSUS TIME

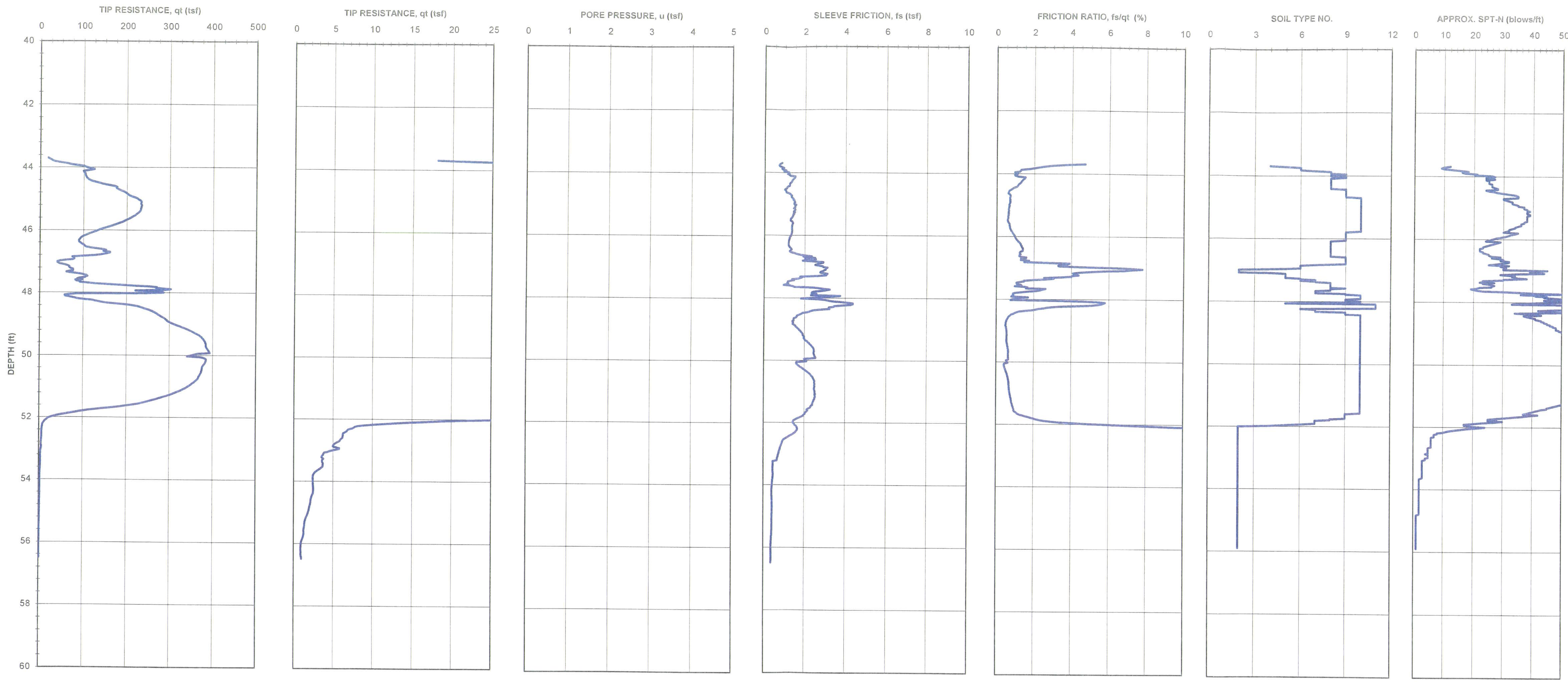
SETTLEMENT OF TOP OF PHOSPHATIC CLAY AT PUMP STATION B SUMP

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 05-16-03
FILE NO.: 05-010	APPROVED BY: PCC	FIGURE: 13

timesett.drw



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

TEST SITE: PC-6F

SOUNDING DATE 3/3/05

SURFACE ELEVATION (FT, NGVD) 167.31

COORDINATE LOCATION (FT) N 1,250,983.97
E 96,262.97

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING

SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY	SA	CHECKED BY	SA	DATE	05-16-05
FILE NO.	05-010	APPROVED BY	FKC	FIGURE	14

Environmental Consultants

3012 U.S. Highway 301 N
Suite 700
Tampa, FL 33619-2242

813 621-0080
FAX 813 623-6757

SCS ENGINEERS

April 12, 2005
File No. 09200020.15

Ms. Susan J. Pelz, P.E.
Florida Department of Environmental Protection
3804 Coconut Palm Drive
Tampa, Florida 33619

Subject: Clay Evaluation Report
Southeast County Landfill, Hillsborough County
Permit Number 35435-006-S0; Specific Conditions 16(f)

Dear Ms. Pelz:

On behalf of the Hillsborough County Solid Waste Management Department (SWMD), SCS Engineers (SCS) is requesting an extension of time before submitting the final report on the clay evaluation in Phase I through VI of the Southeast County Landfill, Hillsborough County, Florida. The clay evaluation is an annual report that is outlined in Specific Condition 16(f) of the above referenced permit.

Currently, Ardaman and Associates (Ardaman) has completed the drilling through the landfill and has identified the top and bottom of the waste phosphatic clays. After initial review of pore pressure measurements within the drainage sand layer above the clays and review of the top of clay elevations, some data readings were inconsistent. Ardaman has re-mobilized to the landfill, as well as the surveyor, to collect some additional data to confirm or modify the previous readings, in addition to collecting final pore pressures within the clay. Pore pressure readings are dependent upon the rate of dissipation within the sands and clay layers.

SCS requests an extension of time to allow additional data to be collected and analyzed prior to submitting to the FDEP. SCS anticipates that the finalized report can be submitted to FDEP by May 31, 2005.

Please let us know if this request is approved. In addition, SCS is available if you have any questions or need additional information.

Very truly yours,

Joseph H. O'Neill, P.E.
Project Manager
SCS ENGINEERS

C. Ed Wilt
for Raymond J. Dever, P.E., DEE
Vice President
SCS ENGINEERS

cc: Patty V. Berry, SWMD
Larry Ruiz, SWMD

JHO/RJD:jho

100494

Environmental Consultants

3012 U.S. Highway 301 N
Suite 700
Tampa, FL 33619-2242

813 621-0080
FAX 813 623-6757

SCS ENGINEERS

April 15, 2004
File No. 09200020.14

D.E.P.
APR 1 5 2004
Southwest District Tampa

Mr. Kim B. Ford, P.E.
Florida Department of Environmental Protection
Southwest District
3804 Coconut Palm Drive
Tampa, Florida 33619

Subject: Southeast County Landfill Phosphatic Clay Annual Evaluation
Hillsborough County, Florida - Permit No. 35435-006-SO

Dear Mr. Ford:

On behalf of the Hillsborough County Solid Waste Department, SCS Engineers (SCS) is submitting the potentiometric level measurements made in March 2004 at the Southeast County Landfill (SCLF) as required by the Permit Specific Condition No. 16.f. As stated in the attached report by Ardaman and Associates, Inc. (Ardaman), under existing conditions, the piezocone soundings show that an upward gradient exists at the locations PC-1I, PC-1J, and PC-4E. Therefore, an effective downward head over the liner less than 12 inches is being maintained at these locations.

At the location of PC-3D, a downward potentiometric head of 2.5 feet was measured. SCS concurs with Ardaman's assessment that this condition is not significant considering that the phosphatic clay layer at this location is 8 feet thick and has a permeability of less than $1x10^{-8}$ cm/sec. Based on the data obtained by Ardaman, SCS recommends no further action at this time and to continue with the annual evaluation as required by Specific Condition No. 16.f.

Please call should you have any questions or require additional information.

Sincerely,

Larry E. Ruiz

Raymond J. Dever

Larry E. Ruiz, Assoc. AIA
Project Manager
SCS ENGINEERS

Raymond J. Dever, P.E., DEE
Vice President
SCS ENGINEERS

LER/RJD:lr

cc: Patricia V. Berry, SWMD
Paul Schipfer, EPC

Attachment

Geotechnical Study Associated with 2004 Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County

April 15, 2004

FILE

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Geotechnical, Environmental and
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April 15, 2004
File Number 04-018

SCS Engineers
3012 US Highway 301 North
Suite 700
Tampa, FL 33619

Attention: Mr. Larry E. Ruiz

Subject: Geotechnical Study Associated with 2004 Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County

Gentlemen:

As requested by SCS Engineers (SCS), Ardaman & Associates, Inc., (Ardaman) has completed a geotechnical study associated with annual monitoring of the phosphatic clay liner beneath the Southeast Landfill in Hillsborough County. The annual monitoring program was mandated by the Florida Department of Environmental Protection (FDEP) under Specific Condition No. 16f of the Landfill Operation Permit No. 35435-006-SO issued on June 25, 2002, which requires performance of piezocone soundings and measurements of pore water pressures in the vicinity of the following four test sites where a number of piezocone soundings and pore pressure measurements had previously been performed by Ardaman and Madrid Engineering Group, Inc., (Madrid) in 2001/2002: (i) PC-1B in the Phase I area; (ii) PC-4B/PC-4C in the Phase IV area; (iii) PC-3/PC-3B in the Phase III area; and (iv) PC-1F in the Phase I area. Specifically, the permit condition requires documentation and interpretation of the following data:

- Piezometric elevations on top of the phosphatic clay.
- Elevations at the top and bottom of the phosphatic clay.
- Pore water pressures near the top, middle, and bottom of the phosphatic clay.
- Piezometric elevations in the natural soils below the phosphatic clay.

Evaluation of the phosphatic clay liner in 2003 was documented in an Ardaman report titled "Geotechnical Study Associated with Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County", dated April 10, 2003. This report contains the results of the piezocone soundings and pore pressure measurements obtained by Ardaman in March 2004, and presents our interpretation of the field testing data.

Site Location

The Southeast Landfill is located within Sections 14, 15, 22, and 23 of Township 31 South, Range 21 East, in Hillsborough County, Florida. More specifically, the landfill site is located between

Picnic and Pinecrest, about 2 miles west of State Road 39 and about 0.5 miles north of County Road 672. The approximate site location, as superimposed on a reproduction of the United States Geological Survey (USGS) quadrangle map of Lithia, Florida (1955, photorevised 1987), is shown in Figure 1.

Project History

The Southeast Landfill is constructed directly above a waste clay settling area at a former phosphate mine known as Lonesome Phosphate Mine or Boyette Mine. The settling area, also known as Settling Area No. 1, was built on natural ground within a perimeter dike constructed of sand borrowed from surrounding areas. Waste phosphatic clay was deposited within the settling area for a number of years during the mining operation.

A comprehensive geotechnical study was conducted by Ardaman between 1981 and 1983 to characterize the phosphatic clay deposit and to evaluate the feasibility of constructing a landfill within the waste clay settling area. Results from that study were documented in an Ardaman report titled "Hydrogeological Investigation, Southeast County Landfill, Hillsborough County, Florida", dated February 22, 1983. Based on the data and analyses documented in that report, Ardaman concluded that a landfill could be constructed directly on top of the phosphatic clay. However, to maintain an adequate factor of safety against slope failure, the waste disposal area was divided into different phases, and each phase had to be filled in lifts such that filling above a previous lift would occur only when the underlying phosphatic clay had consolidated under the weight of the previous refuse lift and experienced sufficient increase in shear strength to support any additional load. In areas where the clay thickness was greater than 14 feet, it was recommended that the clay should be pre-loaded prior to placement of the first lift of refuse. A diagram that shows the original thickness of the phosphatic clay within the settling area, as reproduced from the 1983 Ardaman report, is shown in Figure 2. As shown, the phosphatic clay deposit had an original thickness that varied between 4 and 18 feet.

Another comprehensive geotechnical study was completed by Ardaman in 1994 in association with operation permit renewal for the Southeast Landfill. Results from that study were documented in an Ardaman report titled "Geotechnical Investigation at Southeast Landfill, Hillsborough County, Florida", dated March 7, 1994. The strength and consolidation properties of the phosphatic clay obtained from that study were in good agreement with those used in the original stability analyses and affirmed the recommended filling schedule.

In support of the last operation permit renewal application in 2002, SCS retained Madrid and Ardaman to perform supplemental studies to confirm the engineering properties of the phosphatic clay, and to determine whether the material had been consolidating and gaining strength as predicted and whether the 7-year waiting period for placements of successive refuse lifts in the landfill should be modified. Results from the latest study were presented in an Ardaman report titled "Geotechnical Study Associated with Operation Permit Renewal for Hillsborough County Southeast Landfill", dated March 4, 2002.

The original geotechnical investigation completed in 1983 and the follow-up studies completed in 1994 and 2002 recommended that each lift of refuse should have a thickness no greater than 20 feet and that a minimum waiting period of 7 years should be provided between placements of successive refuse lifts. These requirements were derived based on stability analyses using an undrained shear strength to effective vertical stress ratio of 0.21 and a coefficient of consolidation of 1.5×10^{-4} cm^2/sec for the waste phosphatic clay. The undrained shear strength to effective vertical stress ratio determines the magnitude of strength increase in the phosphatic clay, whereas the coefficient of consolidation governs the rate of strength increase.

Field Test Program

Current operation at the Southeast Landfill divides the waste disposal area into six phases designated Phases I through VI, as shown on a topographic site plan in Figure 3. The topographic site plan was generated from survey data obtained on May 17, 2003. As part of our scope of work for the annual monitoring program stipulated in Specific Condition No. 16f of the FDEP Permit No. 35435-006-SO issued on June 25, 2002, Ardaman performed piezocone soundings and pore water pressure measurements at four test sites within the Phase I, III, and IV areas where a number of field tests and measurements had previously been performed by Madrid and Ardaman in 2001/2002.

Four test sites, designated PC-1I, PC-1J, PC-3D, and PC-4E, were selected by SCS for performance of piezocone soundings and installation of piezoprobes. The approximate locations of these test sites are shown in Figure 3 along with the test site locations selected in the 2001/2002 studies performed by Madrid and Ardaman as well as the test site locations selected for the 2003 annual monitoring program. As shown in Figure 3, two of the four test sites were located in the Phase I area (i.e., PC-1I and PC-1J), one test site was located within the Phase III area (i.e., PC-3D), and the remaining test site was located within the Phase IV area (i.e., PC-4E). PC-1I was located in close proximity to the previous PC-1, PC-1F, and PC-1G test site locations, and PC-1J was selected adjacent to the previous PC-1B and PC-1H test site locations. PC-3D was located near the previous PC-3, PC-3B, and PC-3C test site locations. PC-4E was selected adjacent to the PC-4D test site location used in the 2003 annual monitoring program. The current field work and testing were undertaken by Ardaman in March 2004.

The surveyed coordinates and ground surface elevations at the current test site locations, as provided by Heidt & Associates, Inc., are summarized in Table 1. The elevations were surveyed using both the NGVD29 and NGVD88 datums. Although Hillsborough County uses the NGVD88 datum for elevation data and the survey stakes in the field were labeled based on the NGVD88 datum, the elevation data used in the previous geotechnical studies were based on the NGVD29 datum. To be consistent, the elevations based on the NGVD29 datum are used in this report.

Piezocone Penetration Tests

The piezocone consists of a conical point attached to a steel rod and a friction sleeve. The test is performed by pushing the assembly into the soil at a constant rate of penetration. Resistance to penetration at the cone tip and on the friction sleeve are measured by load cells placed within the assembly, and the pore pressure in the soil is measured using a pressure transducer connected to the porous element placed near the cone tip. Prior to pushing of the piezocone through the waste phosphatic clay, a hollow stem auger was used to create a borehole through the refuse.

Results of the four piezocone penetration tests (i.e., PC-1I, PC-1J, PC-3D, and PC-4E) performed at the four test site locations are presented in Figures 4 through 7 respectively. As shown in the figures, results are presented in the form of tip resistance (i.e., the resistance to penetration at the cone tip), sleeve resistance (i.e., the resistance to penetration of the friction sleeve), pore pressure (i.e., the total pore water pressure including the pore pressure generated due to penetration of the cone), friction ratio (i.e., the ratio of sleeve resistance to tip resistance), soil type (i.e., soil classification), and approximate standard penetration test blow count values (i.e., SPT N values) versus depth.

Since sandy soils typically exist above and below the phosphatic clay, the depth and thickness of the phosphatic clay layer could be inferred by examining the variations of tip resistance and pore pressure with depth. The tip resistance and the pore pressure in a clayey soil are expected to be lower and higher, respectively, than those in a sandy soil. Higher friction ratios are generally indicative of clayey soil types, whereas lower ratios generally indicate the presence of silty and sandy soils. Sudden changes in tip resistance, pore pressure, and friction ratio are expected to occur at the interface between the drainage sand layer and the underlying phosphatic clay as well as the interface between the phosphatic clay and the underlying natural sandy soils.

Thickness of Refuse

Based on results of the auger borings and piezocone soundings, it was estimated that the thicknesses of the refuse at the four test site locations ranged from approximately 35 to 65 feet. The refuse at the PC-3D test site in the Phase III area had a thickness of approximately 35 feet. The refuse at the PC-1I test site in the Phase I area had an estimated thickness of 50 feet, and that at the PC-1J test site had an estimated thickness of 65 feet. It is estimated that test site PC-4E had a refuse thickness slightly greater than 50 feet. The refuse thicknesses at the PC-1I, PC-3D, and PC-4E test site locations have remained approximately the same since March 2003. The refuse thickness at the PC-1J test site location has increased by approximately 15 feet.

Filling Schedule

According to SCS Engineers, the current filling in the Phase I area began in March 2003 and progresses from west to east toward the Phase II area, with filling at the PC-1J test site location occurring around June 2003. On March 1, 2004 (i.e., approximately one year after the current filling in the Phase I area began), when our field crew began work at PC-1I, refuse was being placed in the area immediately west of this test site location. Prior to the current filling, the previous refuse lift in the Phase I area was completed in August 1997.

Filling of the Phase III area began in December 1990 and ended in June 1994. In the Phase IV area, no single lift of refuse was placed since May 1995. However, some refuse was placed on top of the Phase IV area from the overlap of a refuse lift placed in the adjacent Phase V and VI areas that was completed in March 2003.

Elevations and Thicknesses of Phosphatic Clay

Prior to landfill construction, the surface of the waste phosphatic clay within the former settling area was documented to have typical elevations in the range of +121 to +123 feet (NGVD), and the bottom of the phosphatic clay reportedly occurred at typical elevations ranging from +103 to +117 feet (NGVD). As indicated previously, the original thickness of the phosphatic clay ranged from 4 to 18 feet.

Based on results of the piezocone penetration tests, the top and bottom elevations of the waste phosphatic clay as well as the phosphatic clay thickness encountered at the four test sites are summarized in Table 2. As shown, the top elevations of the phosphatic clay ranged from a low of +110.5 feet (NGVD) at PC-1J to a high of +119.1 feet (NGVD) at PC-3D. The bottom elevations of the phosphatic clay layer ranged from a low of +101.9 feet (NGVD) at PC-4E to a high of +114.6 feet (NGVD) at PC-1I.

At the location of PC-1I, the top and bottom of the phosphatic clay were encountered at approximately +118.2 and +114.6 feet (NGVD), respectively, for a clay thickness of about 3.6 feet. This thickness was approximately the same as the clay thickness (3.3 feet) documented at the nearby PC-1G test site location in 2003. Refuse was last placed at this location around August 1997. When our field crew began work at PC-1I on March 1, 2004, refuse was being placed in the area immediately west of the PC-1I test site location.

Based on the piezocone sounding performed at the location of PC-1J, the phosphatic clay had top and bottom elevations of +110.5 and +104.3 feet (NGVD), respectively, for a phosphatic clay thickness of 6.2 feet, which is almost identical to the thickness (6.3 feet) documented at the nearby PC-1H test site location in 2003. As indicated previously, approximately 15 feet of refuse was added at this location around June 2003.

The piezocone sounding performed at the location of PC-3D revealed the top elevation of the phosphatic clay at +119.1 feet (NGVD) and the bottom elevation at +111.1 feet (NGVD), for a clay thickness of 8.0 feet, which is identical to the thickness documented at the nearby PC-3C test site location in 2003. As indicated previously, no refuse lift has been placed in the Phase III area since June 1994.

Based on the piezocone sounding performed at the location of PC-4E, the top and bottom elevations of the phosphatic clay were documented at +111.7 and +101.9 feet (NGVD), for a clay thickness of 9.8 feet, which is 0.5 feet less than the thickness (10.3 feet) documented at the nearby PC-4D test site location in 2003. As indicated previously, no single lift of refuse was placed in the Phase IV area since May 1995. However, some refuse was placed on top of the Phase IV area from the overlap of a refuse lift placed in the adjacent Phase V and VI areas that was completed in March 2003.

In summary, the phosphatic clay elevations and thicknesses documented at the four test site locations in 2004 were generally close to the measurements obtained in 2003. Although approximately 15 feet of refuse has been added at the location of PC-1J since June 2003, no significant compression of the phosphatic clay layer was documented at the time of our field exploration.

Piezometric Elevations on Top of Phosphatic Clay

The piezometric heads on top of the phosphatic clay could be inferred from the piezocone penetration test results. As the piezocone was pushed through the drainage sand layer on top of the phosphatic clay, it was held stationary at selected depths to allow the excess pore water pressure generated as a result of pushing of the piezocone to stabilize. Because of the relatively high permeability of the sand, any excess pore pressure should dissipate in a short duration. The pore pressures were monitored for several minutes to make sure that the final readings represented the stabilized pore pressures at the selected depths.

Based on the piezocone soundings performed at the four test sites, the piezometric heads on top of the phosphatic clay are summarized in Table 3 and are further displayed in Figure 8. Piezometric heads documented from previous studies are also shown on the same figure for comparisons.

As shown in Table 3 and Figure 8, results of the piezocone soundings indicated that the piezometric heads on top of the phosphatic clay at the four test site locations ranged from 3.4 to 26 feet. The highest piezometric elevation of +137 feet (NGVD) was observed at the PC-1J test site location (i.e., 26 feet above the top of the phosphatic clay). The piezometric heads at the PC-1I, PC-3D, and PC-4E test site locations were measured to be 5.5, 4.5, and 3.4 feet, respectively.

The measured piezometric heads on top of the phosphatic clay in 2004 are generally consistent with the previous data obtained adjacent to the PC-1I and PC-3D test site locations. At the PC-4E test site location, the piezometric head on top of phosphatic clay in 2004 was measured at 3.4 feet compared to 0 foot in 2003. The piezometric head was unexpectedly and significantly higher than previous measurements around the PC-1J test site location. The magnitude of piezometric head increase is consistent with the head induced by approximately 15 feet of refuse that has been placed at this location since June 2003. Therefore, it appears that the observed piezometric head increase on top of the phosphatic clay at PC-1J is associated with loading from the current lift of refuse and not a result of rise in leachate level within the landfill.

Piezometric Elevations Below Phosphatic Clay

Based on the piezocone sounding results, the piezometric elevations in the natural soils below the phosphatic clay are summarized in Table 4. As shown, the piezometric elevations were documented at approximately +117 to +119 feet (NGVD) at the PC-1I, PC-3D, and PC-4E test site locations. However, a piezometric elevation of approximately +137 feet (NGVD) was observed at the PC-1J test site location. In 2003, the piezometric elevations below the phosphatic clay at all four test site locations were between approximately +118 and +120 feet (NGVD).

At the location of PC-1J, the piezometric elevation measured in the material immediately below the phosphatic clay is identical to the piezometric elevation documented in the material immediately above the phosphatic clay. Therefore, it appears that the pore water in the material directly beneath the phosphatic clay may also have been pressurized by loading from the current refuse lift in the Phase I area. In previous explorations, the piezometric elevation below the phosphatic clay at this location was documented to be below +118 feet (NGVD). The high piezometric head is expected to dissipate with time.

Piezoprobe Tests Within Phosphatic Clay

The piezoprobe tests were performed by installing piezoprobes to pre-selected depths and holding them stationary until the excess pore pressure generated from probe penetration completely dissipated, and the measured pore pressure reached the actual pore pressure before probe penetration.

The dissipation of excess pore pressures generated due to probe penetrations are presented in Figures 9 to 12 in the form of normalized excess pore pressure (i.e., the ratio of excess pore water pressure at any time to the initial excess pore water pressure immediately after piezoprobe penetration) versus time. As shown in the figures, all pore pressures reached equilibrium conditions at the end of the monitoring periods. The rate of dissipation of excess pore pressure generated by probe penetration can be used to estimate the *in situ* coefficient of consolidation of the phosphatic clay.

At the locations of PC-3D and PC-4E with approximately 8 and 10 feet of phosphatic clay, respectively, piezoprobe tests were performed at three different depths to measure the pore pressures near the top, middle, and bottom of the phosphatic clay layer. Because of the limited phosphatic clay thickness, one piezoprobe was installed at the PC-1I test site and two piezoprobes were installed at the PC-1J test site. Results from the piezoprobe tests are summarized in Table 5.

At the location of PC-1I, one piezoprobe test was performed with the piezoprobe tip elevation at +116.4 feet (NGVD). The piezometric elevation at that depth was documented to be +125.9 feet (NGVD), corresponding to an excess pore water pressure that is equivalent to approximately 4.8 feet of water. The excess water pressure could have been generated by the newly placed refuse immediately west of the PC-1J test site location or by the heavy construction equipment working in the area.

At the location of PC-1J, the equilibrium piezometric elevations for the two piezoprobes installed with tip elevations at +107.3 and +105.3 feet (NGVD) were documented to be approximately +135.5 and +132.6 feet (NGVD), respectively. These piezometric heads within the phosphatic clay were very close to the piezometric heads documented by the piezocone soundings in the materials immediately above and below the phosphatic clay, which further supports the hypothesis that the piezometric heads measured above and below the phosphatic clay could have been induced by loading from the current refuse lift. The excess pore water pressure within the phosphatic clay layer at this location is estimated to be on the order of 20 feet.

At the location of PC-3D, three piezoprobe tests were performed within the phosphatic clay layer with the piezoprobe tip elevations at +117.1, +115.1, and +113.1 feet (NGVD). The excess pore water pressures documented by the piezoprobes were equivalent to 0 to 3.4 feet of water. A 20-foot thick refuse lift can induce an excess pore water pressure equivalent to 25 feet of water. Therefore, the remaining excess pore water pressure within the phosphatic clay layer at the PC-3D test site location is relatively minimal.

At the location of PC-4E, three piezoprobe tests were performed within the phosphatic clay layer with the piezoprobe tip elevations at +109.4, +106.9, and +103.9 feet (NGVD). The excess pore water pressures documented by the piezoprobes were equivalent to 18 to 39 feet of water, which were slightly higher than the values recorded in 2003. As indicated previously, some refuse was placed on top of the Phase IV area from the overlap of a refuse lift placed in the adjacent Phase V and VI areas that was completed in March 2003.

Based on the rates of excess pore pressure dissipation shown in Figures 9 through 12, the horizontal coefficients of consolidation of the phosphatic clay were calculated and are presented in Table 6. The *in situ* vertical coefficient of consolidation, c_v, can be estimated from the horizontal coefficients of consolidation obtained from the piezoprobe tests, c_h, using the empirical relationship proposed by Baligh, M. et al (ASCE Journal of Geotechnical Engineering, Vol. 112, No. 7, July, 1986), where $c_v = 0.05 \times c_h$. The *in situ* vertical coefficients of consolidation from the piezoprobe measurements at PC-1I, PC-1J, and PC-3D are generally consistent, and average 2.3×10^{-4} cm²/sec. However, the *in situ* vertical coefficients of consolidation from the piezoprobe measurements at PC-4E were considerably lower, with an average value of 3.1×10^{-5} cm²/sec. This may explain the slow rate of excess pore water pressure dissipation observed at this location.

The filling schedule at the Southeast Landfill was originally based on a design coefficient of consolidation of 1.5×10^{-4} cm²/sec. At this time, we recommend the 7-year waiting period between placement of refuse lifts be maintained. However, prior to placement of the next refuse lift in the Phase IV area, additional studies should be performed to determine the pore water pressure and to assess the *in situ* undrained shear strength of the phosphatic clay.

Comparisons of Piezometric Heads

The piezometric elevations in the materials directly above and below the phosphatic clay layer, as documented from the piezocone soundings, are summarized in Table 7. The piezometric heads within the phosphatic clay layer are also shown on the same table for comparison.

The piezometric head within the phosphatic clay will be highest after loading of a new refuse lift and will decrease gradually as excess pore water pressure dissipates. If the piezometric head within the phosphatic clay is higher than the piezometric head on top of the phosphatic clay, there will be no downward migration of leachate. Once the excess pore water pressure from landfill loading dissipates, the flow direction through the phosphatic clay will be a function of the piezometric head difference across the phosphatic clay. If the piezometric elevation in the natural soils below the phosphatic clay is higher than the piezometric elevation on top of the phosphatic clay, upward flow will occur. Conversely, if the piezometric elevation in the natural soils is lower than the piezometric elevation on top of the phosphatic clay, leachate will migrate downward, at a rate governed by the piezometric head difference, and the hydraulic conductivity and thickness of the phosphatic clay deposit.

As shown in Table 7, the existing maximum piezometric heads within the phosphatic clay layer are higher than the piezometric heads in the materials above and below the phosphatic clay at the PC-1I, PC-1J, and PC-4E test site locations. Accordingly, under existing condition, there should be no downward leachate migration or upward groundwater flow through the phosphatic clay layer at these locations. At the PC-3D test site location, the piezometric elevation on top of the phosphatic clay layer is slightly higher than the maximum piezometric head within the phosphatic clay and the piezometric head in the material below the phosphatic clay. This condition will result in downward leachate flow. However, the flow is not expected to be significant considering the thickness of the phosphatic clay layer (8 feet), the relatively small hydraulic head (< 3 feet), and the low hydraulic conductivity of the phosphatic clay material (< 1×10^{-8} cm/sec).

Once the excess pore water pressure within the phosphatic clay dissipates, there will be downward heads of approximately 4.9 and 7.9 feet at the locations of PC-1I and PC-3D, respectively. The head difference across the phosphatic clay layer at the PC-1J test site location could not be determined from the current data. At the location of PC-4E, an upward head of 1.7 feet is expected to occur after complete dissipation of any excess pore water pressure. Based on the monitoring data obtained in 2003, there was an upward head across the phosphatic clay layer at both the PC-1J and PC-4E locations upon complete dissipation of excess pore water pressure within the phosphatic clay.

Summary of Observations

The following key observations were made from the 2004 annual monitoring data:

- Except at the PC-1J test site location, the top of refuse elevations remained approximately the same as in 2003. At the PC-1J test site, the existing grade has been raised by approximately 15 feet of refuse since June 2003.

- The top elevations of the phosphatic clay were as expected and generally consistent with the data obtained in 2003.

- The thicknesses of the phosphatic clay were also consistent with the data obtained in 2003.

- No significant compression of the phosphatic clay layer was observed at PC-1J from the current refuse lift that has been placed over this location since June 2003, which is consistent with the high pore water pressure measured immediately above, within, and immediately below the clay.

- At the PC-1I, PC-3D, and PC-4E test site locations, the piezometric heads above the phosphatic clay (i.e., the leachate levels) were estimated to be in the range of 3 to 6 feet, and were generally in agreement with the data obtained in 2003. The high piezometric head observed immediately above the phosphatic clay at the PC-1J test site location appears to have been caused by current landfill loading.

Closure

This report has been prepared for the exclusive use of SCS and the Hillsborough County Solid Waste Department for specific application to annual monitoring of the phosphatic clay liner at the Southeast Landfill in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made.

Ardaman appreciates the opportunity to assist you on this project. Please contact us if you have any questions concerning this report or need additional information.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Dinh T. Nguyen, Ph.D.
Assistant Project Engineer

Francis K. Cheung, P.E.
Senior Project Manager
Florida Registration No. 36382
04/15/04

Enclosures

Table 1

Test Site Locations and Elevations

Test Site	Area	State Plan Coordinates		Approx Ground Surface Elevations (feet)	
		Northing	Easting	NGVD29	NGVD88
PC-1I	Phase I	1,249,845.22	597,297.95	+171.99	+171.08
PC-1J	Phase I	1,250,331.03	595,922.98	+178.27	+177.36
PC-3D	Phase III	1,251,124.14	597,329.97	+157.59	+156.68
PC-4E	Phase IV	1,250,719.93	595,954.04	+165.43	+164.52

Table 2

Top and Bottom Elevations of Phosphatic Clay

Area	Test Site	Date	Approx Ground Surface Elevation (ft, NGVD)	Top of Clay		Bottom of Clay		Clay Thickness (ft)
				Depth (ft, BLS)	Elevation (ft, NGVD)	Depth (ft, BLS)	Elevation (ft, NGVD)	
Phase I	PC-1I	03/01/04	+171.99	53.8	+118.2	57.4	+114.6	3.6
	PC-1J	03/03/04	+178.27	67.8	+110.5	74.0	+104.3	6.2
Phase III	PC-3D	03/02/04	+157.59	38.5	+119.1	46.5	+111.1	8.0
Phase IV	PC-4E	03/03/04	+165.43	53.7	+111.7	63.5	+101.9	9.8

Table 3

Piezometric Levels on Top of Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Piezometric Head on Top of Phosphatic Clay (ft)
Phase I	PC-1I	03/01/04	+171.99	+123.6	+118.11	5.5
	PC-1J	03/03/04	+178.27	+136.6*	+110.47	26.1*
Phase III	PC-3D	03/02/04	+157.59	+125.4	+119.09	4.5**
Phase IV	PC-4E	03/03/04	+165.43	+115.1	+111.73	3.4

* The high piezometric elevation/head is believed to be a result of landfill loading and not a result of actual leachate level within the landfill.

** Based on tape measurement, the leachate level was documented to be approximately 4.5 feet above the top of the phosphatic clay. The piezocone data indicates the head immediately above the phosphatic clay to be approximately 6.2 feet.

Table 4

Piezometric Elevations Below Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)
Phase I	PC-1I	03/01/04	+171.99	+118.7
	PC-1J	03/03/04	+178.27	+136.6*
Phase III	PC-3D	03/02/04	+157.59	+117.5
Phase IV	PC-4E	03/03/04	+165.43	+116.9

* The high piezometric elevation is believed to be a result of landfill loading and not representative of natural piezometric head in the material below the phosphatic clay. In previous explorations, the piezometric elevation below the phosphatic clay at this location was documented to be below +118 feet (NGVD).

Table 5

Pore Pressures Within Phosphatic Clay

Area	Test Site	Ground Surface Elevation (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Bottom of Clay Elevation (ft, NGVD)	Piezoprobe Designation	Piezoprobe Tip Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Stabilized Pore Pressure at Piezoprobe Tip After Dissipation (ft of H_2O)	Piezometric Elevation at Piezoprobe Tip Level (ft, NGVD)	Piezometric Elevation on Top of Clay (ft, NGVD)	Piezometric Elevation Below Clay (ft, NGVD)	Excess Pore Pressure at Piezoprobe Tip Level (ft of H_2O)
Phase I	PC-1I	+171.99	+118.2	+114.6	PC-1IA	55.6	+116.4	9.5	+125.9	+123.6	+118.7	4.8
	PC-1J	+178.27	+110.5	+104.3	PC-1JA	71.0 73.0	+107.3 +105.3	29.0 31.0	+135.5 +132.6	+136.6*	+136.6**	20.0*** 20.0***
Phase III	PC-3D	+157.59	+119.1	+111.1	PC-3DA	40.5 42.5 44.5	+117.1 +115.1 +113.1	8.5 9.5 10.0	+123.3 +122.7 +122.9	+125.4	+117.5	0 1.3 3.4
Phase IV	PC-4E	+165.43	+111.7	+101.9	PC-4EA	56.0 58.5 61.5	+109.4 +106.9 +103.9	27.5 48.0 30.7	+136.9 +154.9 +134.6	+115.2	+116.9	21.3 38.9 18.0

* The high piezometric elevation/head is believed to be a result of landfill loading and not a result of actual leachate level within the landfill.

** The high piezometric elevation is believed to be a result of landfill loading and not representative of natural piezometric head in the material below the phosphatic clay. In previous explorations, the piezometric elevation below the phosphatic clay at this location was documented to be below +118 feet (NGVD).

*** Estimated value based on an equilibrium piezometric elevation of approximately +117 feet (NGVD).

Table 6

Computed Coefficients of Consolidation from Piezoprobe Tests

Area	Test Site	Piezoprobe Designation	Piezoprobe Tip Depth Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Horizontal Coefficient of Consolidation, c_h (cm^2/sec)	Vertical Coefficient of Consolidation, c_v* (cm^2/sec)
Phase I	PC-1I	PC-1IA	55.6	+116.4	1.06×10^{-2}	2.27×10^{-4}
	PC-1J	PC-1JA	71.0 73.0	+107.3 +105.3	3.18×10^{-3} 4.55×10^{-3}	1.59×10^{-4} 2.27×10^{-4}
Phase III	PC-3D	PC-3DA	40.5 42.5 44.5	+117.1 +115.1 +113.1	7.96×10^{-3} 3.70×10^{-3} 4.19×10^{-3}	3.98×10^{-4} 1.85×10^{-4} 2.09×10^{-4}
Phase IV	PC-4E	PC-4EA	56.0 58.5 61.5	+109.4 +106.9 +103.9	7.96×10^{-4} 6.12×10^{-4} 1.12×10^{-3}	3.18×10^{-5} 2.89×10^{-5} 3.18×10^{-5}

* c_v using empirical relationship recommended by Baligh et al., 1986.

Table 7

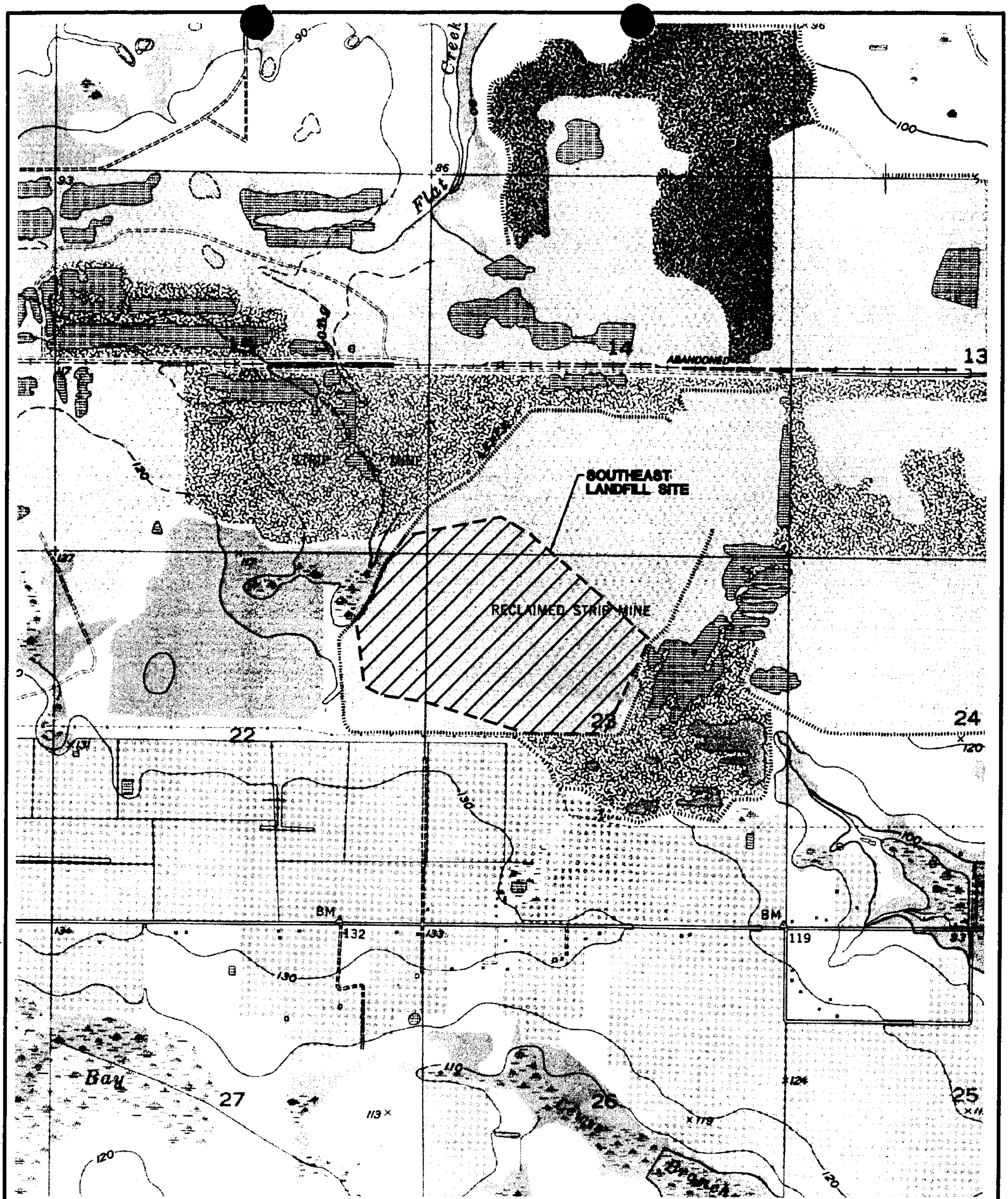
Comparisons of Piezometric Elevations

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Existing Maximum Piezometric Elevation Within Clay (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)	Location of Existing Maximum Head	Head Difference Across Clay After Dissipation of Excess Pore Water Pressure (ft)
Phase I	PC-1I	03/01/04	+171.99	+123.6	+125.9	+118.7	Within Clay	4.9 (downward)
	PC-1J	03/03/04	+178.27	+136.6*	+139.0	+136.6**	Within Clay	***
Phase III	PC-3D	03/02/04	+157.59	+125.4	+122.9	+117.5	Above Clay	7.9 (downward)
Phase IV	PC-4E	03/03/04	+165.43	+115.2	+154.9	+116.9	Within Clay	1.7 (upward)

* The high piezometric elevation/head is believed to be a result of landfill loading and not a result of actual leachate level within the landfill.

** The high piezometric elevation is believed to be a result of landfill loading and not representative of natural piezometric head in the material below the phosphatic clay. In previous explorations, the piezometric elevation below the phosphatic clay at this location was documented to be below +118 feet (NGVD).

*** Head difference across the phosphatic clay layer could not be determined from the current data. Based on the monitoring data obtained in 2003, there was an 1.1-foot upward head across the phosphatic clay layer after complete dissipation of excess pore water pressure.



TOWNSHIP 31 SOUTH
RANGE 21 EAST
SECTIONS 14, 15, 22 AND 23

OBTAINED FROM U.S.G.S. QUAD MAP:
LITHIA, FLORIDA 1955
(PHOTOREVISED 1987)

N

0 1000 2000

SCALE: — 1"=2000'

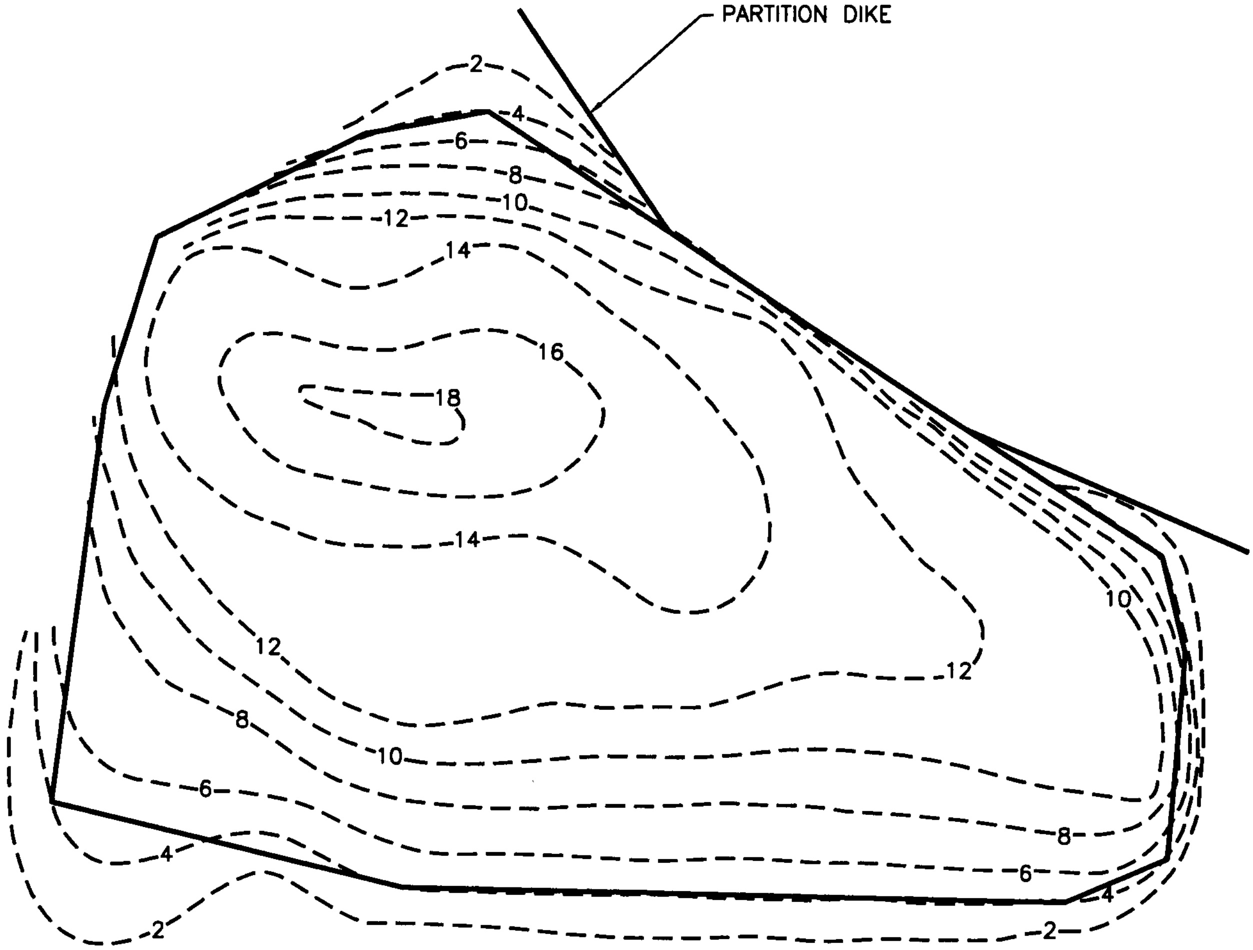
SITE LOCATION MAP

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED
WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: BTW	CHECKED BY: NTD	DATE: 03/31/03
FILE NO. 01-122	APPROVED BY: FKC	FIGURE: 1

T:\Corporate\04\04-018\04018-01.dwg, 04/07/2004 04:27:25 PM, Revised By: RDC



LEGEND

10 CONTOURS OF CLAY THICKNESS IN FEET

NOTE: REPRODUCED FROM ARDAMAN & ASSOCIATES' 1981-1983 STUDY

T:\Corporate\04\04-018\04018-02.dwg, 04/07/2004 04:27:02 PM, Revised By: RDC

THICKNESS OF PHOSPHATIC CLAY BEFORE LANDFILL CONSTRUCTION		
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
DRAWN BY: BTW	CHECKED BY: NTD	DATE: 03/30/04
FILE NO. 04-018	APPROVED BY: FKC	FIGURE: 2

T:\Corporate\04\04-018\404018-03.dwg, 04/07/2004 04:26:26 PM, Revised By: RDC

N

0 200 400

SCALE: 1"=400'

NOTE: THE TOPOGRAPHIC SITE PLAN WAS BASED ON SURVEY DATA OBTAINED ON MAY 17, 2003.

LEGEND

⊕ TEST SITES IN 2001–2003

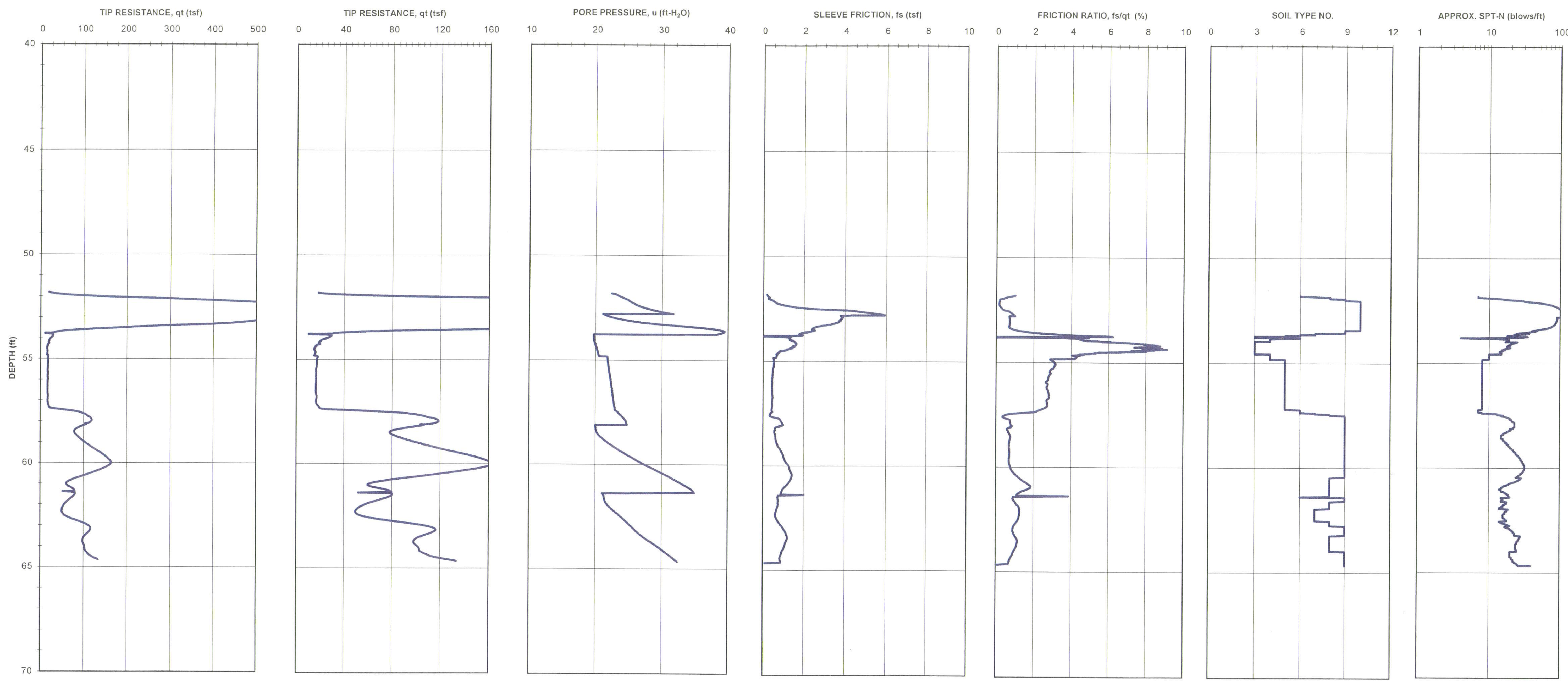
◆ TEST SITES IN 2004

LANDFILL LAYOUT AND FIELD TEST LOCATION MAP

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: RDC	CHECKED BY: NTD	DATE: 03/28/03	
FILE NO. 03-018	APPROVED BY: FKC	FIGURE: 3	



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson etal., 1986

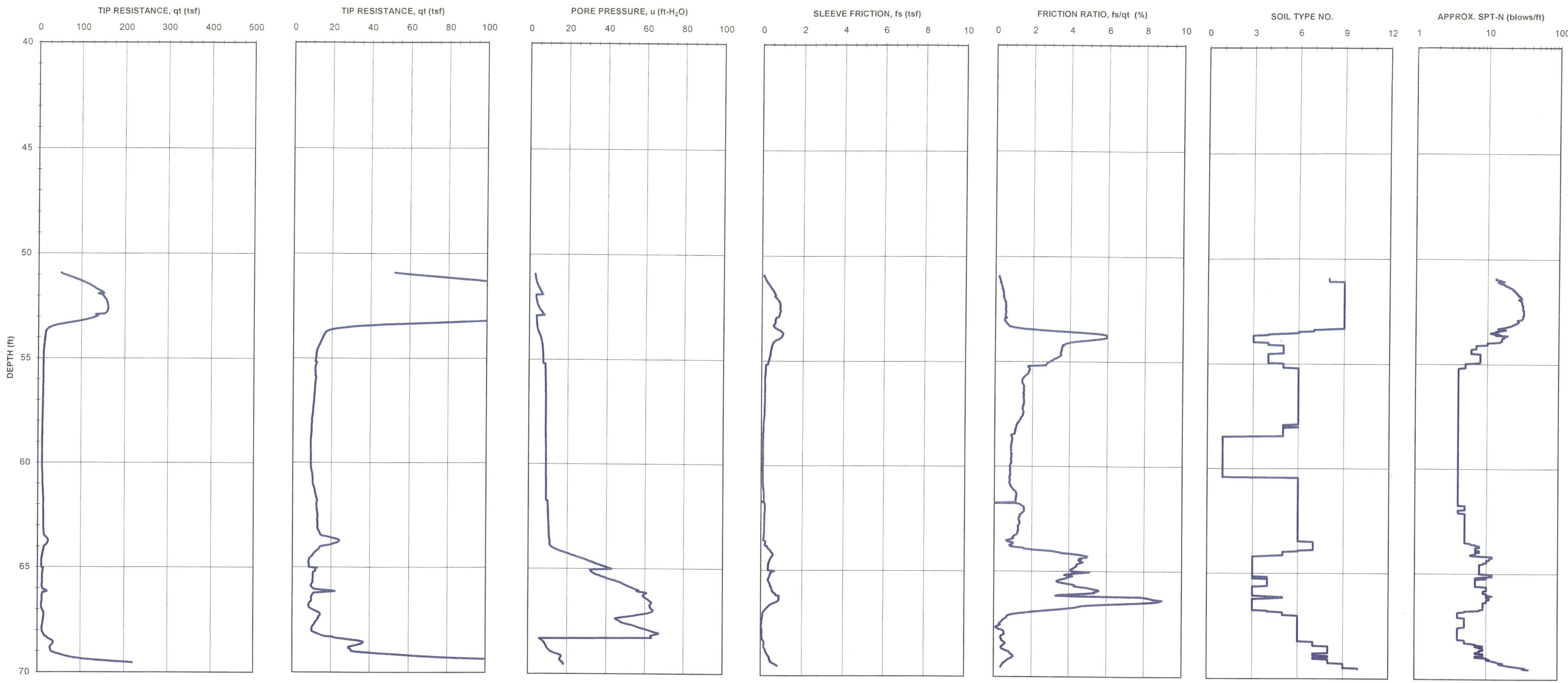
TEST SITE: PC-1I

SOUNDING DATE: 3/1/04
SURFACE ELEVATION (FT, NGVD): 171.99
COORDINATE LOCATION (FT) N 1,249,845.04
E 597,298.09

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED
WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY:	CHECK BY: NTD	DATE: 3/30/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 4



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson etal., 1986

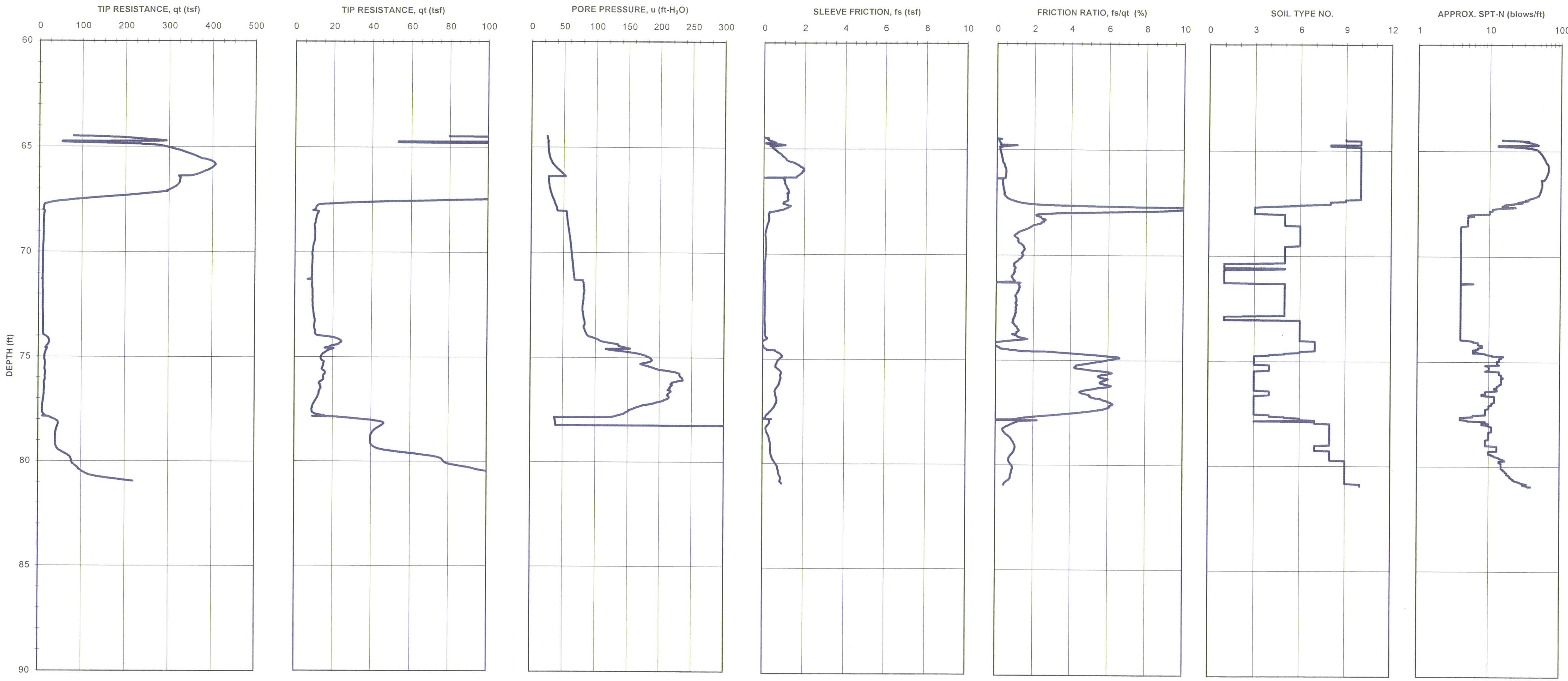
TEST SITE: PC-4E

SOUNDING DATE: 3/3/04
SURFACE ELEVATION (FT, NGVD): 165.33
COORDINATE LOCATION (FT) N 1,250,720.42
E 595,954.13

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED
WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY:	CHECK BY: MTD	DATE: 3/30/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 7



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson etal., 1986

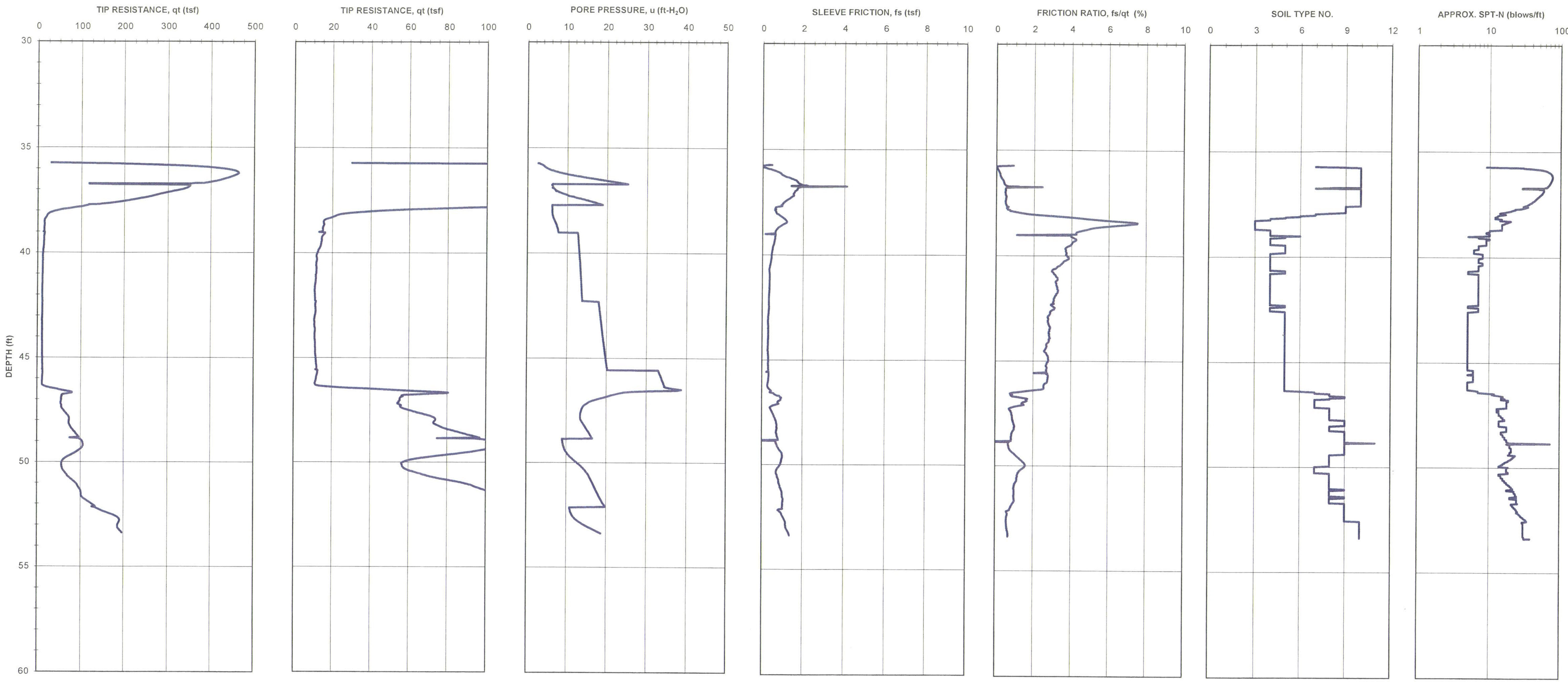
TEST SITE: PC-1J

SOUNDING DATE: 3/3/04
SURFACE ELEVATION (FT, NGVD): 178.27
COORDINATE LOCATION (FT) N 1,250,330.87
E 595,922.79

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY:	CHECK BY: JTD	DATE: 3/30/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 5



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil Classification by Robertson etal., 1986

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

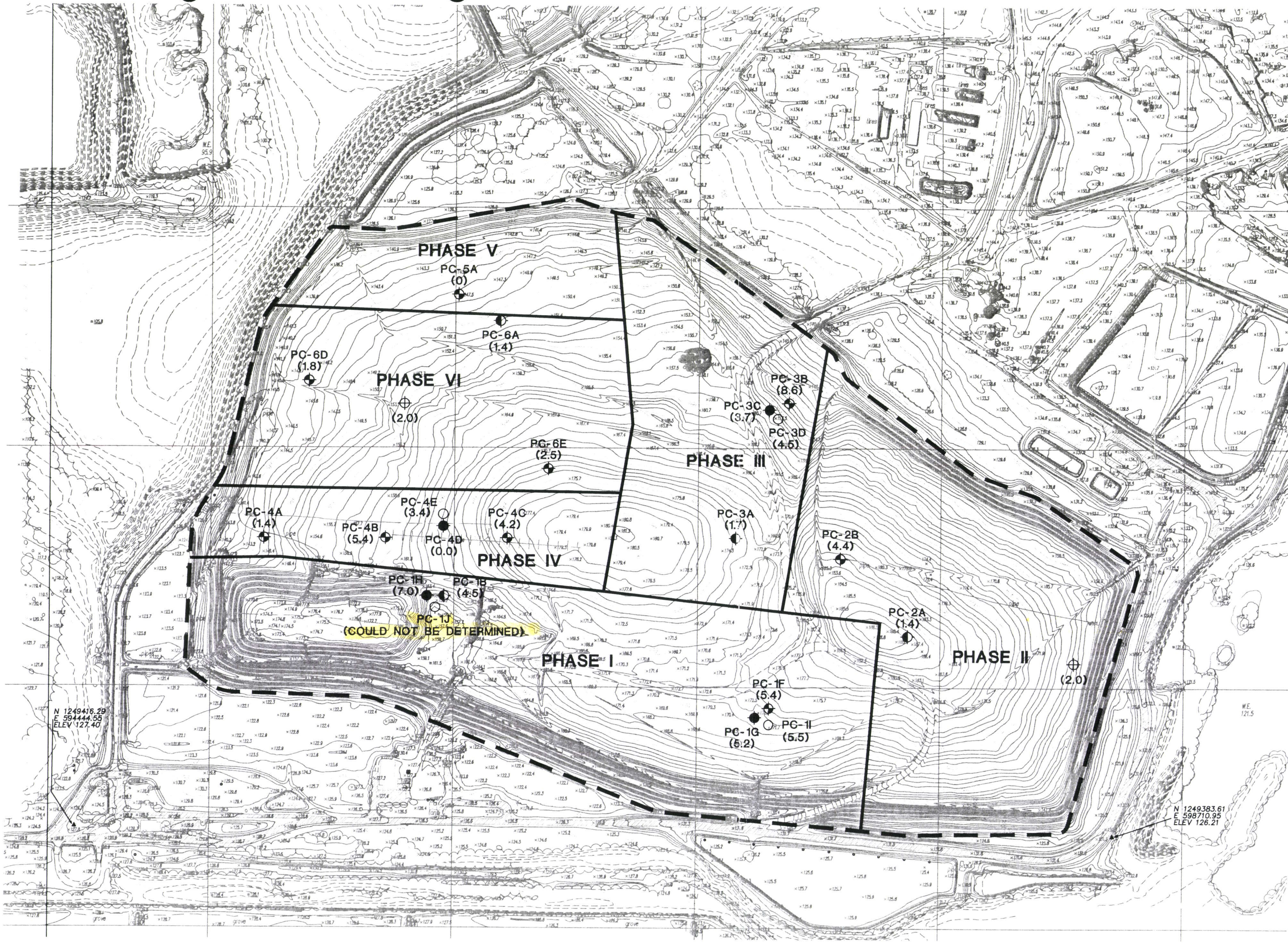
TEST SITE: PC-3D

SOUNDING DATE: 3/2/04
SURFACE ELEVATION (FT, NGVD): 157.59
COORDINATE LOCATION (FT) N 1,251,123.66
E 597,329.65

Ardaman & Associates, Inc.
Piezocone Test Results

GEOTECHNICAL STUDY ASSOCIATED
WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FL

DRAWN BY:	CHECK BY: NTD	DATE: 3/30/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 6



D.E.P.
APR 1 5 2004
Southwest District Tampa

LEGEND

- ARDAMAN (1994)
- ARDAMAN (2001)
- ARDAMAN (2002)
- ARDAMAN (2003)
- ARDAMAN (2004)

(2.0) PIEZOMETRIC LEVEL ABOVE TOP OF CLAY IN FEET

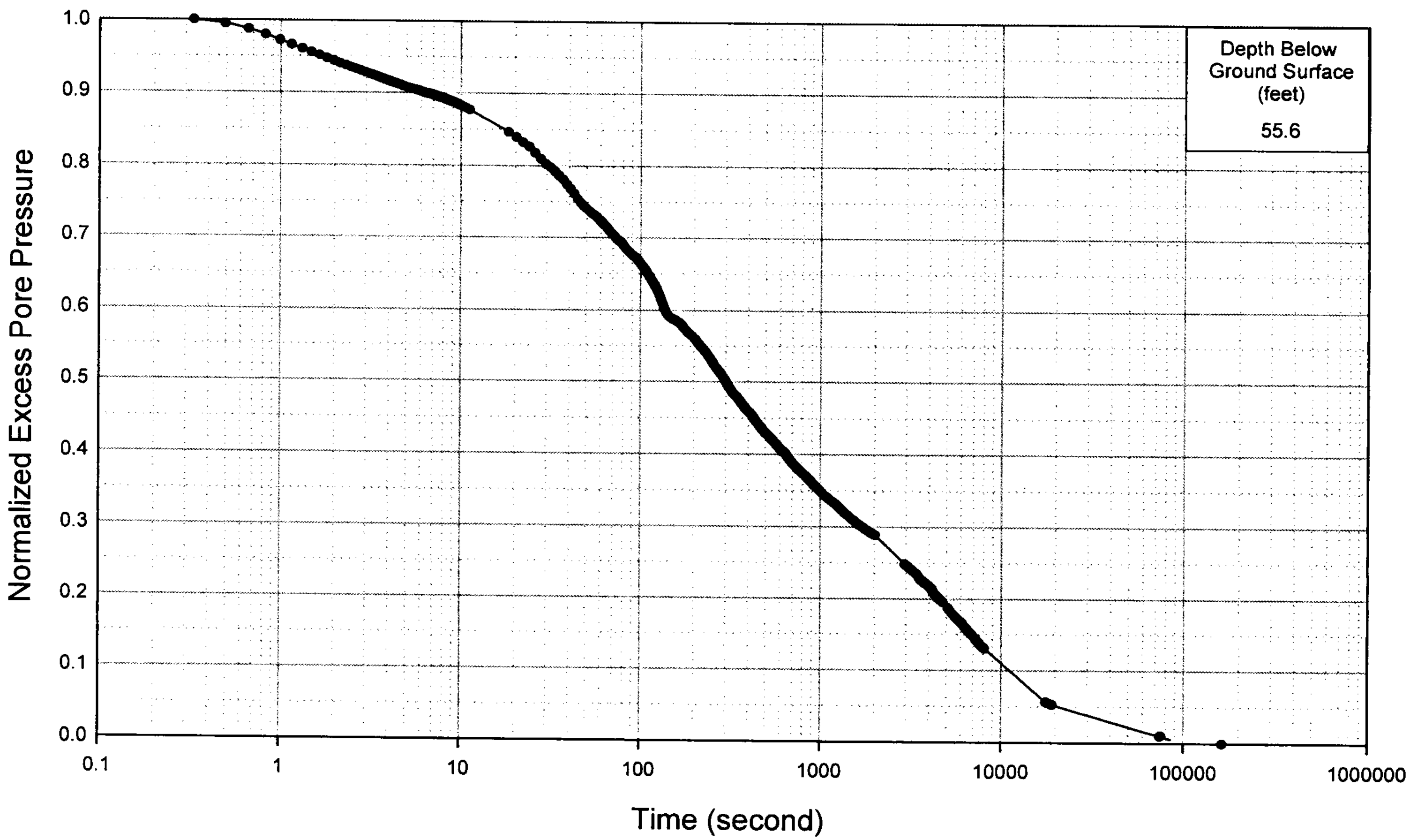
LEACHATE LEVELS ON TOP OF PHOSPHATIC CLAY

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

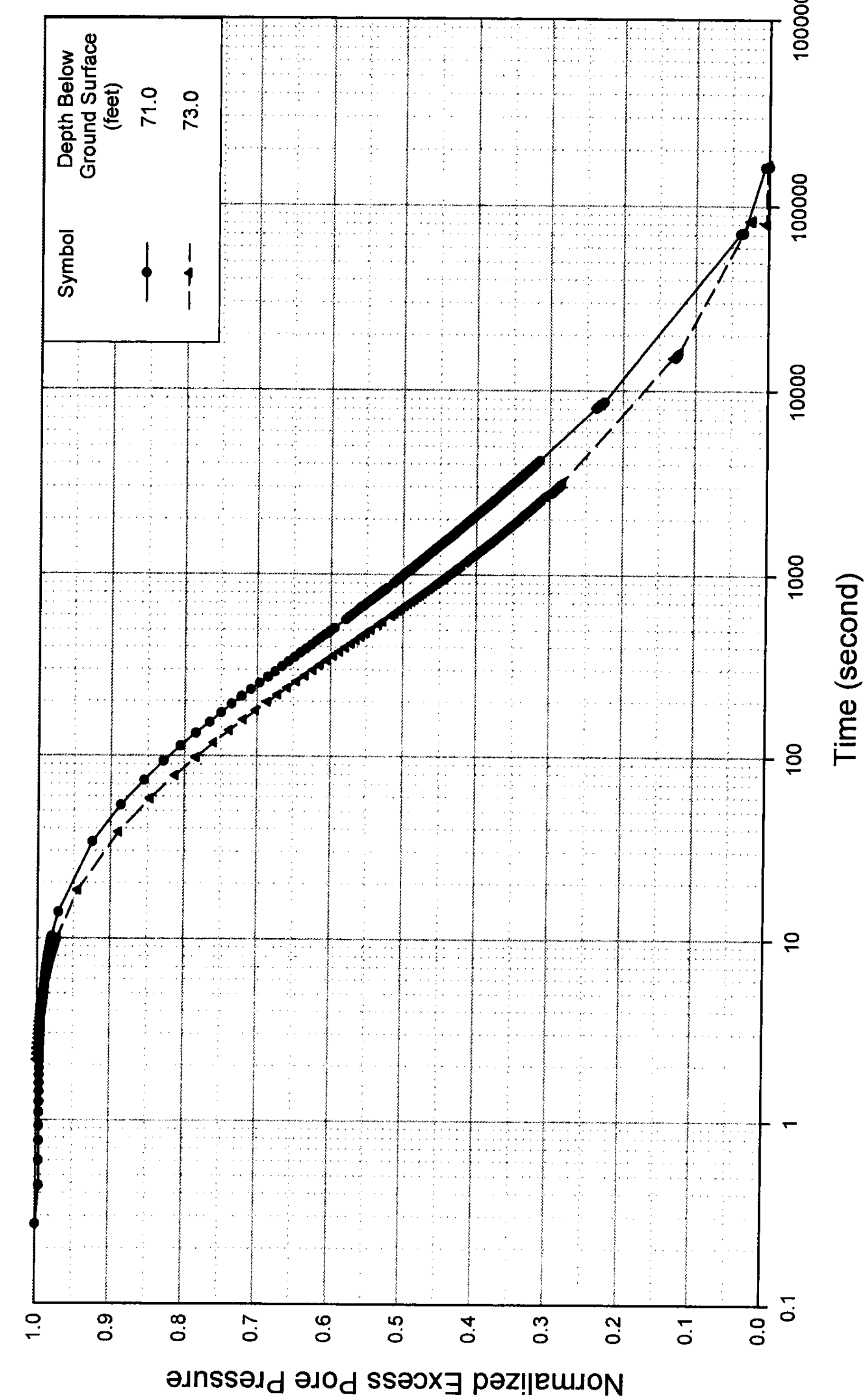
DRAWN BY: RDC	CHECKED BY: NTD	DATE: 03/30/04
FILE NO. 04-018	APPROVED BY: FKC	FIGURE: 8

This figure revised 8/8/08



EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE PC1-I

Ardaman & Associates, Inc. Piezoprobe Test Results		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILSBOROUGH COUNTY, FL		
DRAWN BY: JJ	CHECKED BY: NTD	DATE: 04/06/04
FILE NO.: 04-018	APPROVED BY: FICC	FIGURE: 9

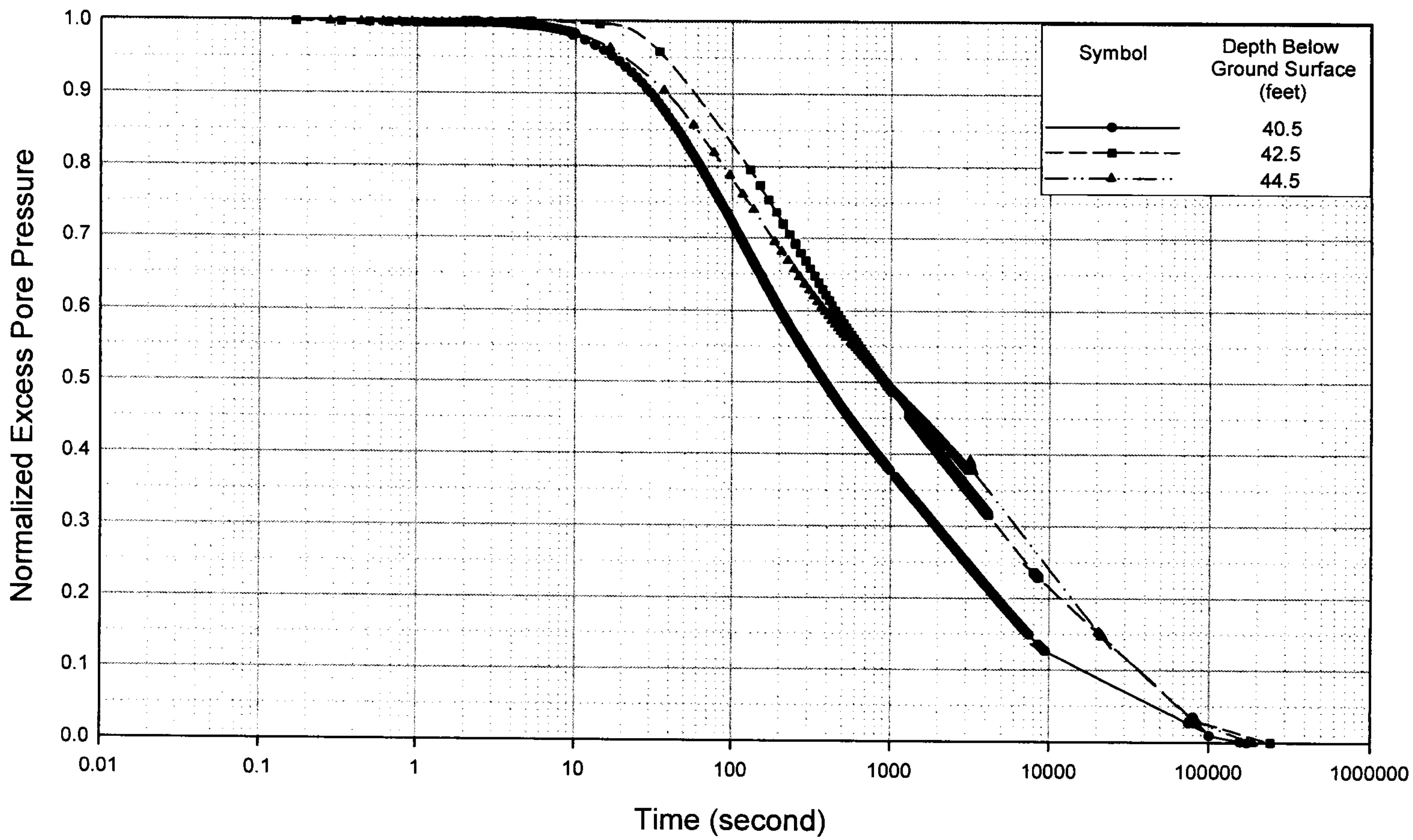


EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE PC1-J

Ardaman & Associates, Inc.
Piezoprobe Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILSBOROUGH COUNTY, FL

DRAWN BY: JJ	CHECKED BY: NTD	DATE: 04/06/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 10

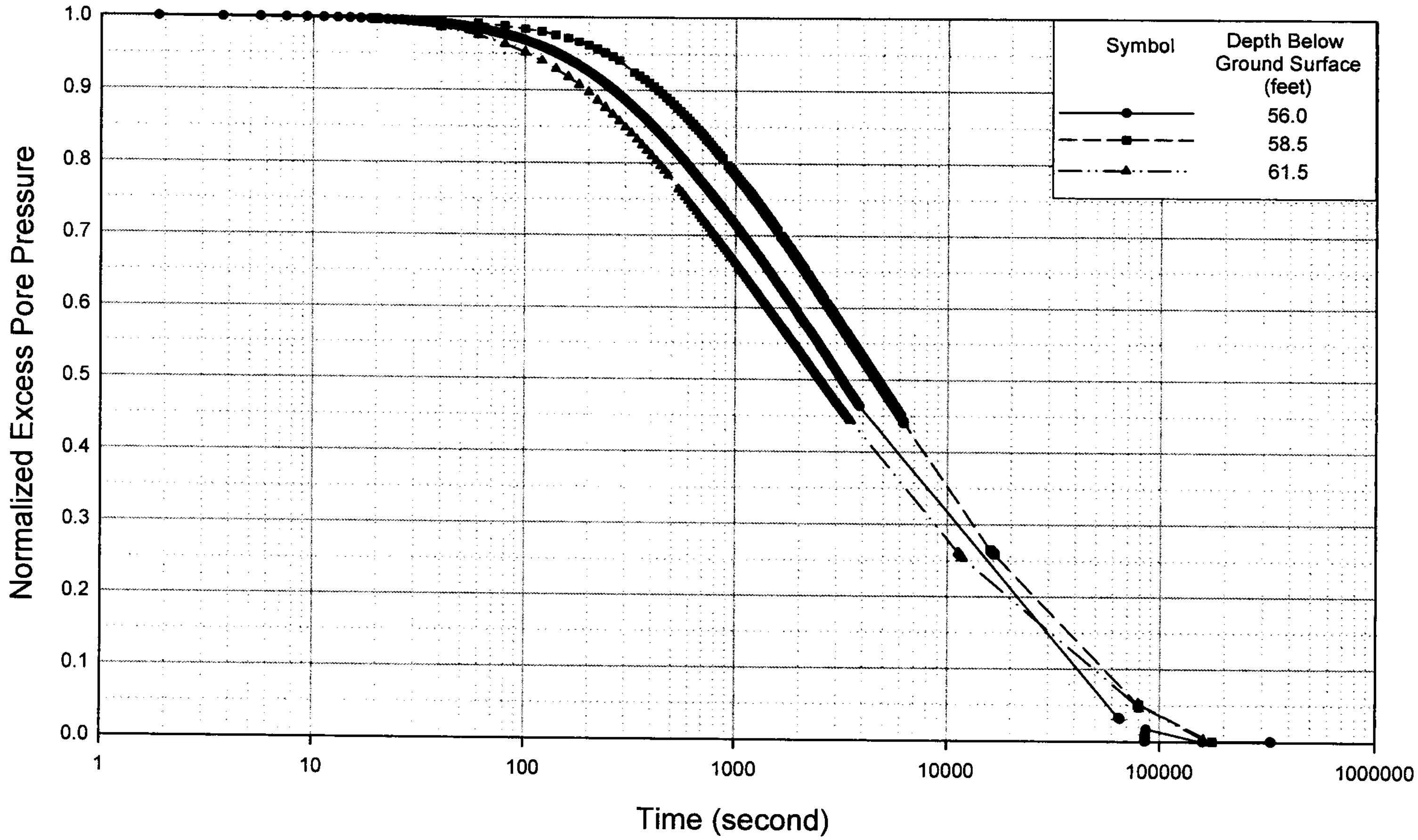


EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE PC-3D

Ardaman & Associates, Inc.
Piezoprobe Test Results

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILSBOROUGH COUNTY, FL

DRAWN BY: JJ	CHECKED BY: NTD	DATE: 04/06/04
FILE NO.: 04-018	APPROVED BY: FKC	FIGURE: 11



EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE PC-4E

Ardaman & Associates, Inc. Piezoprobe Test Results	
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILSBOROUGH COUNTY, FL	
DRAWN BY: JJ	CHECKED BY: NTD
DATE: 04/06/04	
FILE NO.: 04-018	APPROVED BY: FKC
FIGURE: 12	

100494

Environmental Consultants

3012 U.S. Highway 301 N
Suite 700
Tampa, FL 33619-2242

813 621-0080
FAX 813 623-6757

SCS ENGINEERS

April 15, 2003
File No. 09200020.13

Susan – Any Comments ?

Mr. Kim B. Ford, P.E.
Florida Department of Environmental Protection
Southwest District
3804 Coconut Palm Drive
Tampa, Florida 33619

D.E.P.
APR 15 2003
Southwest District Tampa

Subject: Southeast County Landfill Operations Permit ~~Modification~~
Hillsborough County, Florida
Permit No. 35435-006-SO

IS NOT PART OF MOD. PER LARRY R. 4/16/03

Dear Mr. Ford:

On behalf of the Hillsborough County Solid Waste Department, SCS Engineers (SCS) is submitting the potentiometric level measurements at the Southeast County Landfill (SCLF) as required by the Permit Specific Condition No. 16.f. As stated in the attached report by Ardaman and Associates, Inc. (Ardaman), under existing conditions, the piezocone soundings show that an upward gradient exists at the locations measured. Therefore, an effective downward head over the liner less than 12 inches is being maintained at the SCLF. Based on the data obtained by Ardaman, SCS recommends no further action at this time.

Please call should you have any questions or require additional information.

Sincerely,

Larry E. Ruiz

Larry E. Ruiz, Assoc. AIA
Project Manager

RBGard

Robert B. Gardner, P.E., DEE
Senior Vice President
SCS ENGINEERS

LER/RBG:lr

cc: Patricia V. Berry, SWMD
Paul Schipfer, EPC

Attachment

D.E.P.
APR 1 5 2003
Southwest District Tampa

Geotechnical Study Associated with Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County

April 10, 2003

FILE

Ardaman & Associates, Inc.

OFFICES

Orlando, 8008 S. Orange Avenue, Orlando, Florida 32809, Phone (407) 855-3860
Bartow, 1525 Centennial Drive, Bartow, Florida 33830, Phone (863) 533-0858
Cocoa, 1300 N. Cocoa Blvd., Cocoa, Florida 32922, Phone (321) 632-2503
Fort Lauderdale, 3665 Park Central Boulevard North, Pompano Beach, Florida 33064, Phone (954) 969-8788
Fort Myers, 9970 Bavaria Road, Fort Myers, Florida 33913, Phone (941) 768-6600
Miami, 2608 W. 84th Street, Hialeah, Florida 33016, Phone (305) 825-2683
Port Charlotte, 740 Tamiami Trail, Unit 3, Port Charlotte, Florida 33954, Phone (941) 624-3393
Port St. Lucie, 460 Concourse Place NW, Unit 1, Port St. Lucie, Florida 34986, Phone (772) 878-0072
Sarasota, 2500 Bee Ridge Road, Sarasota, Florida 34239, Phone (941) 922-3526
Tallahassee, 3175 West Tharpe Street, Tallahassee, Florida 32303, Phone (850) 576-6131
Tampa, 3925 Coconut Palm Drive, Suite 115, Tampa, Florida 33619, Phone (813) 620-3389
West Palm Beach, 2511 Westgate Avenue, Suite 10, West Palm Beach, Florida 33409, Phone (561) 687-8200

MEMBERS:
A.S.F.E.
American Concrete Institute
American Society for Testing and Materials
Florida Institute of Consulting Engineers

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

April 10, 2003
File Number 03-018

SCS Engineers
3012 US Highway 301 North
Suite 700
Tampa, FL 33619

Attention: Mr. Larry E. Ruiz

Subject: Geotechnical Study Associated with Annual Monitoring of Phosphatic Clay Liner Beneath the Southeast Landfill in Hillsborough County

Gentlemen:

As requested by SCS Engineers (SCS), Ardaman & Associates, Inc., (Ardaman) has completed a geotechnical study associated with annual monitoring of the phosphatic clay liner beneath the Southeast Landfill in Hillsborough County. The annual monitoring program was mandated by the Florida Department of Environmental Protection (FDEP) under Specific Condition No. 16f of the Landfill Operation Permit No. 35435-006-SO issued on June 25, 2002. The program requires performance of piezocone soundings and measurements of pore water pressures in the vicinity of the following four test sites where a number of piezocone soundings and pore pressure measurements had previously been performed by Ardaman and Madrid Engineering Group, Inc., (Madrid) in 2001/2002: (i) PC-1B in the Phase I area; (ii) PC-4B/PC-4C in the Phase IV area; (iii) PC-3/PC-3B in the Phase III area; and (iv) PC-1F in the Phase I area. Specifically, the permit condition requires documentation and interpretation of the following data:

- Piezometric elevations on top of the phosphatic clay.
- Elevations at the top and bottom of the phosphatic clay.
- Pore water pressures near the top, middle, and bottom of the phosphatic clay.
- Piezometric elevations in the natural soils below the phosphatic clay.

This report documents the results from the piezocone soundings and pore pressure measurements, and presents our interpretation of the field testing data. The field work and testing were undertaken by Ardaman in February and March of 2003.

Site Location

The Southeast Landfill is located within Sections 14, 15, 22, and 23 of Township 31 South, Range 21 East, in Hillsborough County, Florida. More specifically, the landfill site is located between Picnic and Pinecrest, about 2 miles west of State Road 39 and about 0.5 miles north of County Road 672. The approximate site location, as superimposed on a reproduction of the United States Geological Survey (USGS) quadrangle map of Lithia, Florida (1955, photorevised 1987), is shown in Figure 1.

8008 S. Orange Avenue (32809), Post Office Box 593003, Orlando, Florida 32859-3003 Phone (407) 855-3860 FAX (407) 859-8121
Offices in: Bartow, Cocoa, Fort Lauderdale, Fort Myers, Miami, Orlando, Port Charlotte, Port St. Lucie, Sarasota, Tallahassee, Tampa, W. Palm Beach

Project History

The Southeast Landfill is constructed directly above a waste clay settling area at a former phosphate mine known as Lonesome Phosphate Mine or Boyette Mine. The settling area, also known as Settling Area No. 1, was built on natural ground within a perimeter dike constructed of sand borrowed from surrounding areas. Waste phosphatic clay was deposited within the settling area for a number of years during the mining operation.

A comprehensive geotechnical study was conducted by Ardaman between 1981 and 1983 to characterize the phosphatic clay deposit and to evaluate the feasibility of constructing a landfill within the waste clay settling area. Results from that study were documented in an Ardaman report titled "Hydrogeological Investigation, Southeast County Landfill, Hillsborough County, Florida", dated February 22, 1983. Based on the data and analyses documented in that report, Ardaman concluded that a landfill could be constructed directly on top of the phosphatic clay. However, to maintain an adequate factor of safety against slope failure, the waste disposal area was divided into different phases, and each phase had to be filled in lifts such that filling above a previous lift would occur only when the underlying phosphatic clay had consolidated under the weight of the previous refuse lift and experienced sufficient increase in shear strength to support any additional load. In areas where the clay thickness was greater than 14 feet, it was recommended that the clay should be pre-loaded prior to placement of the first lift of refuse. A diagram that shows the original thickness of the phosphatic clay within the settling area, as reproduced from the 1983 Ardaman report, is shown in Figure 2. As shown, the phosphatic clay deposit had an original thickness that varied between 4 and 18 feet.

Another comprehensive geotechnical study was completed by Ardaman in 1994 in association with operation permit renewal for the Southeast Landfill. Results from that study were documented in an Ardaman report titled "Geotechnical Investigation at Southeast Landfill, Hillsborough County, Florida", dated March 7, 1994. The strength and consolidation properties of the phosphatic clay obtained from that study were in good agreement with those used in the original stability analyses and affirmed the recommended filling schedule.

In support of the last operation permit renewal application in 2002, SCS retained Madrid and Ardaman to perform supplemental studies to confirm the engineering properties of the phosphatic clay, and to determine whether the material had been consolidating and gaining strength as predicted and whether the 7-year waiting period for placements of successive refuse lifts in the landfill should be modified. Results from the latest study were presented in an Ardaman report titled "Geotechnical Study Associated with Operation Permit Renewal for Hillsborough County Southeast Landfill", dated March 4, 2002.

The original geotechnical investigation completed in 1983 and the follow-up studies completed in 1994 and 2002 recommended that each lift of refuse should have a thickness no greater than 20 feet and that a minimum waiting period of 7 years should be provided between placements of successive refuse lifts. These requirements were derived based on stability analyses using an undrained shear strength to effective vertical stress ratio of 0.21 and a coefficient of consolidation of 1.5×10^{-4} cm^2/sec for the waste phosphatic clay. The undrained shear strength to effective vertical stress ratio determines the magnitude of strength increase in the phosphatic clay, whereas the coefficient of consolidation governs the rate of strength increase.

Field Test Program

Current operation at the Southeast Landfill divides the waste disposal area into six phases designated Phases I through VI, as shown on a topographic site plan in Figure 3. The topographic site plan was generated from survey data obtained on January 10, 2001.

As part of our scope of work for the annual monitoring program stipulated in Specific Condition No. 16f of the FDEP Permit No. 35435-006-SO issued on June 25, 2002, Ardaman performed piezocone soundings and pore water pressure measurements in the vicinity of the following four test sites where a number of field tests and measurements had previously been performed by Madrid and Ardaman in 2001/2002: (i) PC-1B in the Phase I area; (ii) PC-4B/PC-4C in the Phase IV area; (iii) PC-3/PC-3B in the Phase III area; and (iv) PC-1F in the Phase I area. Specifically, the permit condition requires documentation and interpretation of the following data:

- Piezometric elevations on top of the phosphatic clay.
- Elevations at the top and bottom of the phosphatic clay.
- Pore water pressures near the top, middle, and bottom of the phosphatic clay.
- Piezometric elevations in the natural soils below the phosphatic clay.

Four test sites, designated PC-1G, PC-1H, PC-3C, and PC-4D, were selected by SCS for performance of piezocone soundings and installation of piezoprobes. The approximate locations of these test sites are shown in Figure 3 along with the test site locations selected in the 2001/2002 studies performed by Madrid and Ardaman. An additional piezocone sounding, designated PC-1GA, was performed 7 feet east of PC-1G to confirm the piezocone sounding results at PC-1G. As shown in Figure 3, two of the four test sites were located in the Phase I area, one test site was located within the Phase III area, and the remaining test site was located within the Phase IV area. PC-1G and PC-1GA were located in close proximity to the previous PC-1 and PC-1F test site locations, and PC-1H was selected adjacent to the previous PC-1B test site location. PC-3C was located near the previous PC-3 and PC-3B test site locations. PC-4D was selected at a location between the previous PC-4B and PC-4C locations. The field work and testing were undertaken by Ardaman in February and March of 2003.

The surveyed coordinates and ground surface elevations at the current test site locations, as provided by Heidt & Associates, Inc., are summarized in Table 1. The elevations were surveyed using both the NGVD29 and NGVD88 datums. Although Hillsborough County currently uses the NGVD88 datum for elevation data, we understand that the elevation data used in the previous geotechnical studies were based on the NGVD29 datum. To be consistent, the surveyed elevations based on the NGVD29 datum are used for interpretation of the current field data.

Piezocone Penetration Tests

The piezocone consists of a conical point attached to a steel rod and a friction sleeve. The test is performed by pushing the assembly into the soil at a constant rate of penetration. Resistance to penetration at the cone tip and on the friction sleeve are measured by load cells placed within the assembly, and the pore pressure in the soil is measured using a pressure transducer connected to the porous element placed near the cone tip. Prior to pushing of the piezocone through the waste phosphatic clay, a hollow stem auger was used to create a borehole through the refuse.

Results of the five piezocone penetration tests (i.e., PC-1G, PC-1GA, PC-1H, PC-3C, and PC-4D) performed by Ardaman at the four test site locations are presented in Figures 4 through 8, respectively. As shown in the figures, results are presented in the form of tip resistance (i.e., the resistance to penetration at the cone tip), sleeve resistance (i.e., the resistance to penetration of the friction sleeve), pore pressure (i.e., the total pore water pressure including the pore pressure generated due to penetration of the cone), friction ratio (i.e., the ratio of sleeve resistance to tip resistance), soil type (i.e., soil classification), and approximate standard penetration test blow count values (i.e., SPT N values) versus depth.

Since sandy soils typically exist above and below the phosphatic clay, the depth and thickness of the phosphatic clay layer could be inferred by examining the variations of tip resistance and pore pressure with depth. The tip resistance and the pore pressure in a clayey soil are expected to be lower and higher, respectively, than those in a sandy soil. Higher friction ratios are generally indicative of clayey soil types, whereas lower ratios generally indicate the presence of silty and sandy soils. Sudden changes in tip resistance, pore pressure, and friction ratio are expected to occur at the interface between the sand tailings (i.e., the drainage sand layer) and the underlying phosphatic clay as well as the interface between the phosphatic clay and the underlying natural sandy soils.

Thickness of Refuse

Based on results of the auger borings and piezocone soundings performed by Ardaman, the thicknesses of the refuse at the test site locations varied from approximately 35 to 50 feet. The refuse at the PC-3C test site in the Phase III area had a thickness of approximately 35 feet. The refuse at the PC-1G/PC-1GA and PC-1H test sites in the Phase I area had an estimated thickness of 50 to 55 feet, and that at the PC-4D test site in the Phase IV area had a thickness of slightly greater than 50 feet.

The refuse thicknesses near the PC-1G/PC-1GA and PC-3C test site locations have remained approximately the same since 2001/2002. The refuse thickness near the PC-1H test site location appears to have increased by approximately 8 feet, and that near the PC-4D test site location has increased by close to 25 feet.

Filling Schedule

According to SCS, filling of the Phase I area occurred from May 1995 through August 1997, and filling of the Phase III area began in December 1990 and ended in June 1994. Filling in the Phase 4 area was completed as recently as March 2003.

Elevations and Thicknesses of Phosphatic Clay

Prior to landfill construction, the surface of the waste phosphatic clay within the former settling area was documented to have typical elevations in the range of +121 to +123 feet (NGVD). The bottom of the phosphatic clay reportedly occurred at typical elevations ranging from +103 to +117 feet (NGVD). As indicated previously, the original thickness of the phosphatic clay ranged from 4 to 18 feet.

Based on results of the piezocone penetration tests, the top and bottom elevations of the waste phosphatic clay as well as the phosphatic clay thickness encountered at the four test sites are summarized in Table 2. As shown, the top elevations of the phosphatic clay ranged from a low of +109.6 feet (NGVD) at PC-1H to a high of +119.1 feet (NGVD) at PC-3C. The bottom elevations of the phosphatic clay layer ranged from a low of +102.5 feet (NGVD) at PC-4D to a high of +113.1 feet (NGVD) at PC-1GA.

At the location of PC-1G, the top elevation of the phosphatic clay was at slightly above +116 (NGVD), and the bottom elevation was at approximately +113 feet (NGVD), for a clay thickness of slightly greater than 3 feet. The contour map in Figure 2 shows a phosphatic clay thickness of approximately 10 feet in the general area of PC-1G prior to landfill construction. Based on the piezocone sounding performed at the nearby PC-1 in the early part of 2001, Madrid reported top and bottom elevations of +116.5 and +105.5 feet (NGVD), respectively, for the phosphatic clay (i.e., for a clay thickness of 11 feet). Based on the piezocone sounding performed at the nearby PC-1F by Ardaman in the early part of 2002, the phosphatic clay was encountered at a top elevation of +117.5 feet (NGVD). The piezocone sounding at PC-1F did not penetrate through the phosphatic clay and, thus, the clay thickness could not be determined.

Although the top elevation of the phosphatic clay documented at PC-1G is in general agreement with previous results, the phosphatic clay deposit documented from the current piezocone sounding was significantly thinner. Accordingly, Ardaman performed another piezocone sounding at an adjacent test site, designated PC-1GA, located at approximately 7 feet east of PC-1G. At this location, the top and bottom elevations of the phosphatic clay were documented at +116.2 and +113.1 feet (NGVD) and the phosphatic clay thickness was computed to be 3.1 feet, which corroborate the results obtained from PC-1G. The 7 to 8 feet of material directly below the phosphatic clay had slightly higher tip resistance and allowed much more rapid dissipation of excess pore water pressure generated from advancement of the piezocone. This test site may be located within a portion of the settling area where pockets of sand tailings and phosphatic clay mixture exist.

Based on the piezocone sounding performed at PC-1H, the phosphatic clay had top and bottom elevations of +109.6 and +103.3 feet (NGVD), for a phosphatic clay thickness of 6.3 feet. These data are very consistent with the piezocone sounding data obtained at PC-1B by Ardaman in the later part of 2001, which showed top and bottom elevations of +110.0 and +103.5 feet (NGVD), respectively, and a thickness of 6.5 feet for the phosphatic clay layer.

The piezocone sounding performed at the location of PC-3C revealed the top elevation of the phosphatic clay at +119.1 feet (NGVD) and the bottom elevation at +111.1 feet (NGVD), for a clay thickness of 8.0 feet. PC-3C is located near PC-3 that was investigated by Madrid in the early part of 2001 and PC-3B that was investigated by Ardaman in the early part of 2002. At PC-3, Madrid reported top and bottom elevations of +119.5 and +110.5 feet (NGVD) and a thickness of 9.0 feet for the phosphatic clay. At PC-3B that was terminated at the top of the phosphatic clay, Ardaman encountered the phosphatic clay at a top elevation of +119.4 feet (NGVD). Accordingly, the current data are consistent with previous results.

Based on the piezocone sounding performed at PC-4D, the top and bottom elevations of the phosphatic clay were documented at +112.8 and +102.5 feet (NGVD), for a clay thickness of 10.3 feet. As shown in Figure 3, PC-4D is located between PC-4B and PC-4C that were investigated by Ardaman in the early part of 2002. The piezocone soundings at both PC-4B and PC-4C were terminated at the top of the phosphatic clay layer, which occurred at elevations of +113.8 and +114.8 feet (NGVD), respectively. The slightly lower top elevation was probably a result of settlement of the phosphatic clay from landfill loading in the Phase IV area.

Piezometric Elevations on Top of Phosphatic Clay

The piezometric elevations on top of the phosphatic clay could be inferred from the piezocone penetration test results. As the piezocone was pushed through the drainage sand layer on top of the phosphatic clay, it was held stationary at selected depths and the excess pore water pressure generated as a result of pushing of the piezocone was allowed to stabilize. Because of the relatively high permeability of the sand, the excess pore pressure dissipated in a very short duration. The pore pressures were monitored for several minutes to make sure that the final readings represented the stabilized pore pressures at those depths.

Based on the piezocone soundings performed at the four test sites, the piezometric elevations and heads on top of the phosphatic clay are summarized in Table 3 and are further displayed in Figure 9. Piezometric heads documented from previous studies are also shown on the same figure for comparison.

Results of piezocone soundings performed by Ardaman for this annual monitoring program indicated that the piezometric heads at the four test site locations ranged from 0 to 7 feet with an average piezometric head of approximately 4 feet on top of the phosphatic clay. Based on the current data, the piezometric heads were greatest in the Phase I area (5.2 feet at PC-1G and 7.0 feet at PC-1H). The piezometric level was 3.7 feet at PC-3C in the northeastern part of the Phase III area. No piezometric head on top of the phosphatic clay was documented at PC-4D in the Phase IV area.

In comparison to the previous data, the piezometric head on top of the phosphatic clay has decreased slightly in the eastern part of the Phase I area, but has increased by 2.5 feet in the western part. The piezometric heads in the Phase III and IV areas are much lower than previous readings. The piezometric heads on top of the phosphatic clay are expected to vary, depending on rainfall and other factors.

Piezometric Elevations Below Phosphatic Clay

Based on the piezocone sounding results, the piezometric elevations in the natural soils below the phosphatic clay are summarized in Table 4. As shown, the piezometric elevations in the natural soils varied from approximately +118 at PC-1H, PC-3C, and PC-4D to approximately +123 feet (NGVD) at PC-1GA. Based on these elevations, it appears that groundwater flow beneath the Southeast Landfill was in the northwesterly direction.

Piezoprobe Tests Within Phosphatic Clay

The piezoprobe tests were performed by installing piezoprobes to pre-selected depths and holding them stationary until the excess pore pressure generated from probe penetration completely dissipated, and the measured pore pressure reached the actual pore pressure before probe penetration.

The dissipation of excess pore pressures generated due to probe penetrations are presented in Figures 10 to 13 in the form of normalized excess pore pressure (i.e., the ratio of excess pore water pressure at any time to the initial excess pore water pressure immediately after piezoprobe penetration) versus time. As shown in the figures, all pore pressures reached equilibrium conditions at the end of the monitoring periods. The rate of dissipation of excess pore pressure generated by probe penetration can be used to estimate the *in situ* coefficient of consolidation of the phosphatic clay.

At the locations of PC-3C and PC-4D with approximately 8 and 10 feet of phosphatic clay, respectively, piezoprobe tests were performed at three different depths to measure the pore pressures near the top, middle, and bottom of the phosphatic clay layer. Because of the limited phosphatic clay thickness, one piezoprobe was installed at each of the PC-1H and PC-1G test sites. Results from the piezoprobe tests are summarized in Table 5.

At the location of PC-1GA, one piezoprobe test was performed at the piezoprobe tip elevation of +115.7 feet (NGVD). The piezometric elevation at that depth was +125.7 feet (NGVD), and the excess pore pressure was computed to be approximately 4 feet of water. At the location of PC-1H, the piezometric elevation at the piezoprobe tip elevation of +106.1 feet (NGVD) was documented to be +127.1 feet (NGVD), and the excess pore water pressure was computed to be approximately 10 feet. At the location of PC-3C, three piezoprobe test were performed at piezoprobe tip elevations of +118.1, +115.1 and +112.6 feet (NGVD). The excess pore pressure in the phosphatic clay at this test site location was computed to be approximately 3 feet of water. At the location of PC-4D, the piezoprobe tests were performed with tip elevations at +111.2, +107.9 and 103.6 feet (NGVD). The excess pore pressures were equivalent to approximately 30 feet of water near the upper and middle portions of the phosphatic clay layer, and approximately 11 feet of water near the bottom of the phosphatic clay.

Considering an average total unit weight of 80 lbs/ft^3 for the refuse and daily covers, the initial excess pore water pressure generated from a 20-foot thick lift of refuse was computed to be approximately 26 feet. Therefore, it appears that the excess pore water pressures generated from landfill loading in the Phase III area and the eastern part of the Phase I area have substantially dissipated. However, some excess pore water pressure remains in the western portion of the Phase I area, and dissipation of excess pore water pressure in the Phase IV area does not appear to have begun. These observations are generally consistent with the filling schedule. As indicated previously, filling of the Phase I area occurred from May 1995 through August 1997, and filling of the Phase III area began in December 1990 and ended in June 1994. Filling in the Phase 4 area was completed as recently as March 2003.

Based on the rates of excess pore pressure dissipation shown in Figures 10 to 13, the piezoprobe horizontal coefficients of consolidation of the phosphatic clay were estimated and are presented in Table 6. The *in situ* vertical coefficient of consolidation, c_v, can be estimated from the horizontal coefficients of consolidation obtained from the piezoprobe tests, c_h, using the empirical relationship proposed by Baligh, M. et al (ASCE Journal of Geotechnical Engineering, Vol. 112, No. 7, July, 1986), where $c_v = 0.05 \times c_h$. The average *in situ* vertical coefficient of consolidation from the piezoprobe measurements is 1.2×10^{-4} cm²/sec. The filling schedule at the Southeast Landfill was originally based on a design coefficient of consolidation of 1.5×10^{-4} cm²/sec. Therefore, the recommended waiting period between placement of refuse lifts remains applicable.

Comparisons of Piezometric Heads

The piezometric elevations on top of the phosphatic clay and in the natural soils below the landfill, as documented from the piezocone soundings, are summarized in Table 7. The piezometric heads within the phosphatic clay layer on the dates of our field measurements are also shown on the same table for comparison.

The piezometric head within the phosphatic clay will be highest after loading of a new refuse lift and will decrease gradually as excess pore water pressure dissipates. If the piezometric head within the phosphatic clay is higher than the piezometric head on top of the phosphatic clay, there will be no downward migration of leachate. Once the excess pore water pressure from landfill loading dissipates, the flow direction through the phosphatic clay will be a function of the piezometric head difference across the phosphatic clay. If the piezometric elevation in the natural soils below the phosphatic clay is higher than the piezometric elevation on top of the phosphatic clay, upward flow will occur. Conversely, if the piezometric elevation in the natural soils is lower than the piezometric elevation on top of the phosphatic clay, leachate will migrate downward, at a rate governed by the piezometric head difference, and the hydraulic conductivity and thickness of the phosphatic clay deposit.

As shown in Table 7, the existing piezometric heads within the phosphatic clay layer are higher than the piezometric heads on top of and below the phosphatic clay at all four test site locations. Accordingly, under existing condition, there should be no downward leachate migration or upward groundwater flow through the phosphatic clay layer.

Once the excess pore water pressure within the phosphatic clay dissipates, there will be an upward head of approximately 1 to 2 feet at the locations of PC-1GA and PC-1H in the Phase I area. Accordingly, downward migration of leachate cannot occur at these test site locations. Similarly, there will be upward flow at the location of PC-4D where no leachate was encountered and the piezometric elevation in the natural soils below the phosphatic clay is at least at least 5.4 feet higher than the top elevation of the phosphatic clay. At PC-3C in the Phase III area, there would be an approximately 5-foot downward head difference between the piezometric elevation on top of the phosphatic clay and that in the underlying natural soils after dissipation of the excess pore water pressure. Nevertheless, downward leakage through the phosphatic clay is not expected to be significant because there is approximately 8 feet of low-permeability phosphatic clay at this location.

Closure

This report has been prepared for the exclusive use of SCS and the Hillsborough County Solid Waste Department for specific application to annual monitoring of the phosphatic clay liner at the

Southeast Landfill in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made.

Ardaman appreciates the opportunity to assist you on this project. Please contact us if you have any questions concerning this report or need additional information.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Shawkat Ali, Ph.D., P.E.
Project Engineer

Francis K. Cheung, P.E.
Senior Project Manager
Florida Registration No. 36382

04/10/03

Enclosures

Table 1

Test Site Locations and Elevations

Test Site	Area	State Plan Coordinates		Approx Ground Surface Elevations (feet)	
		Northing	Easting	NGVD29	NGVD88
PC-1G	Phase I	1,249,863.45	597,248.58	+171.70	+170.79
PC-1GA	Phase I	1,249,863.45	597,255.58	+171.70	+170.79
PC-1H	Phase I	1,250,379.18	595,948.51	+163.13	+162.21
PC-3C	Phase III	1,251,138.57	597,324.78	+157.10	+156.19
PC-4D	Phase IV	1,250,671.26	595,967.14	+167.29	+166.38

Table 2

Top and Bottom Elevations of Phosphatic Clay

Area	Test Site	Date	Approx Ground Surface Elevation (ft, NGVD)	Top of Clay		Bottom of Clay		Clay Thickness (ft)
				Depth (ft, BLS)	Elevation (ft, NGVD)	Depth (ft, BLS)	Elevation (ft, NGVD)	
Phase I	PC-1G	02/27/03	+171.7	55.4	+116.3	58.7	+113.0	3.3
	PC-1GA	02/28/03	+171.7	55.5	+116.2	58.6	+113.1	3.1
	PC-1H	02/26/03	+163.1	53.5	+109.6	59.8	+103.3	6.3
Phase III	PC-3C	02/28/03	+157.1	38.0	+119.1	46.0	+111.1	8.0
Phase IV	PC-4D	02/26/03	+167.3	54.5	+112.8	64.8	+102.5	10.3

Table 3

Piezometric Levels on Top of Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Piezometric Head on Top of Phosphatic Clay (ft)
Phase I	PC-1G	02/27/03	+171.7	-	+116.3	-
	PC-1GA	02/28/03	+171.7	+121.4	+116.2	5.2
	PC-1H	02/26/03	+163.1	+116.6	+109.6	7.0
Phase III	PC-3C	02/28/03	+157.1	+122.8	+119.1	3.7
Phase IV	PC-4D	02/26/03	+167.3	< +112.8	+112.8	0.0

Table 4

Piezometric Elevations Below Phosphatic Clay

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)
Phase I	PC-1G	02/27/03	+171.7	+120.1
	PC-1GA	02/28/03	+171.7	+123.1
	PC-1H	02/26/03	+163.1	+117.7
Phase III	PC-3C	02/28/03	+157.1	+117.7
Phase IV	PC-4D	02/26/03	+167.3	+118.2

Table 5

Pore Pressures Within Phosphatic Clay

Area	Test Site	Ground Surface Elevation (ft, NGVD)	Top of Clay Elevation (ft, NGVD)	Bottom of Clay Elevation (ft, NGVD)	Piezoprobe Designation	Piezoprobe Tip Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Stabilized Pore Pressure at Piezoprobe Tip After Dissipation (ft of H_2O)	Piezometric Elevation at Piezoprobe Tip Level (ft, NGVD)	Piezometric Elevation on Top of Clay (ft, NGVD)	Piezometric Elevation Below Clay (ft, NGVD)	Excess Pore Pressure at Piezoprobe Tip Level (ft of H_2O)
Phase I	PC-1GA	+171.7	+116.2	+113.1	P356	56.0	+115.7	10.0	+125.7	+121.4	+123.1	4.0
	PC-1H	+163.1	+109.6	+103.3	P257	57.0	+106.1	21.0	+127.1	+116.6	+117.7	10.0
Phase III	PC-3C	+157.1	+119.1	+111.1	P439	39.0 42.0 44.5	+118.1 +115.1 +112.6	7.0 7.7 9.2	+125.1 +122.8 +121.8	+122.8	+117.7	2.9 2.6 3.1
Phase IV	PC-4D	+167.3	+112.8	+102.5	P656	56.1 59.4 63.7	+111.2 +107.9 +103.6	33.6 44.9 25.4	+144.7 +152.8 +129.0	<+112.8	+118.2	31.1 37.4 11.4

Table 6

Computed Coefficients of Consolidation from Piezoprobe Tests

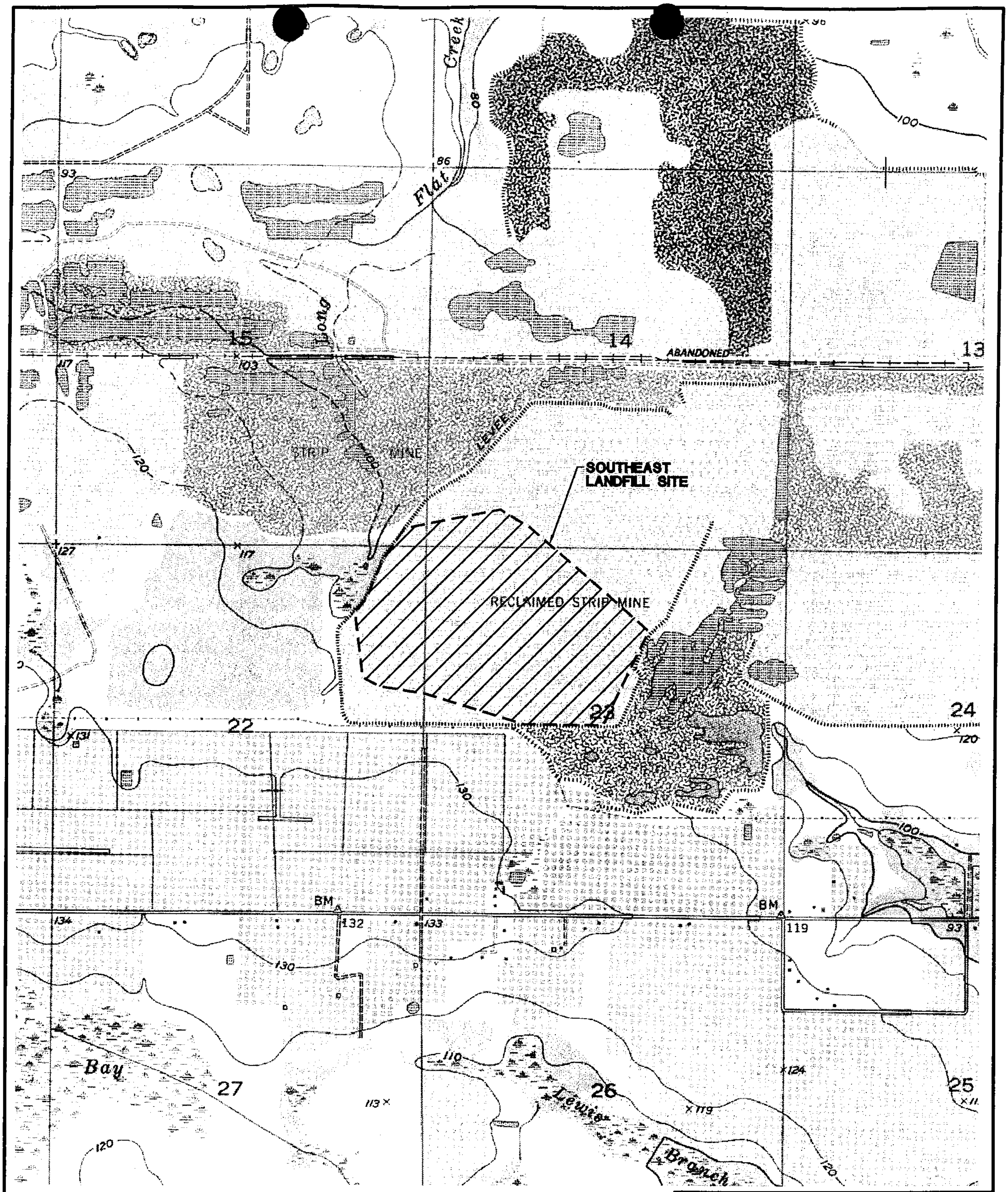
Area	Test Site	Piezoprobe Designation	Piezoprobe Tip Depth Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Horizontal Coefficient of Consolidation, c_h (cm^2/sec)	Vertical Coefficient of Consolidation, c_v* (cm^2/sec)
Phase I	PC-1GA	P356	56.0	+115.7	4.4×10^{-4}	2.2×10^{-5}
	PC-1H	P257	57.0	+106.1	3.4×10^{-3}	1.7×10^{-4}
Phase III	PC-3C	P439	39.0 42.0 44.5	+118.1 +115.1 +112.6	4.5×10^{-3} 1.6×10^{-3} 2.2×10^{-3}	2.3×10^{-4} 8.0×10^{-5} 1.1×10^{-4}
Phase IV	PC-4D	P656	56.1 59.4 63.7	+111.2 +107.9 +103.6	3.5×10^{-3} 3.2×10^{-3} 2.5×10^{-4}	1.8×10^{-4} 1.6×10^{-4} 1.3×10^{-5}

* c_v using empirical relationship recommended by Baligh et al., 1986.

Table 7

Comparisons of Piezometric Elevations

Area	Test Site	Date	Ground Surface Elevation (ft, NGVD)	Piezometric Elevation on Top of Phosphatic Clay (ft, NGVD)	Existing Maximum Piezometric Elevation Within Clay (ft, NGVD)	Piezometric Elevation Below Phosphatic Clay (ft, NGVD)	Head Difference Across Clay After Dissipation of Excess Pore Water Pressure (ft)
Phase I	PC-1G	02/27/03	+171.7	-	-	+120.1	-
	PC-1GA	02/28/03	+171.7	+121.4	+125.7	+123.1	1.7 (upward)
	PC-1H	02/26/03	+163.1	+116.6	+127.1	+117.7	1.1 (upward)
Phase III	PC-3C	02/28/03	+157.1	+122.8	+125.1	+117.7	5.1 (downward)
Phase IV	PC-4D	02/26/03	+167.3	< +112.8	+152.8	+118.2	> 5.4 (upward)



TOWNSHIP 31 SOUTH
RANGE 21 EAST
SECTIONS 14, 15, 22 AND 23

OBTAINED FROM U.S.G.S. QUAD MAP:
LITHIA, FLORIDA 1955
(PHOTOREVISED 1987)

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0 1000 2000

SCALE: — 1"=2000'

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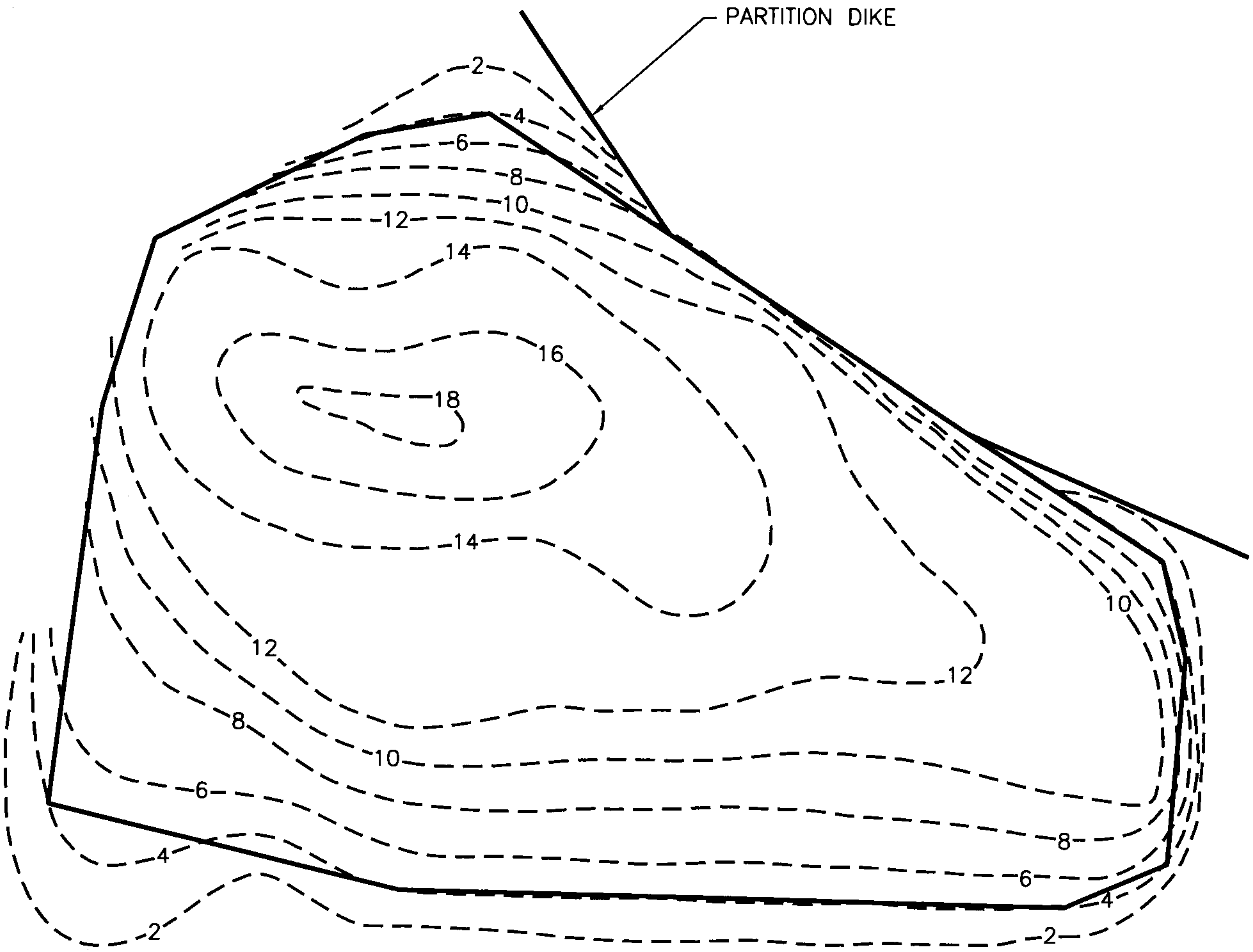
SITE LOCATION MAP

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: BTW	CHECKED BY: SA	DATE: 03/31/03
FILE NO. 01-122	APPROVED BY: FKC	FIGURE: 1



LEGEND

10 CONTOURS OF CLAY THICKNESS IN FEET

0 250 500

NOTE: REPRODUCED FROM ARDAMAN & ASSOCIATES' 1981-1983 STUDY

THICKNESS OF PHOSPHATIC CLAY BEFORE LANDFILL CONSTRUCTION

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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FILE NO. 03-018	APPROVED BY: FKC	FIGURE: 2

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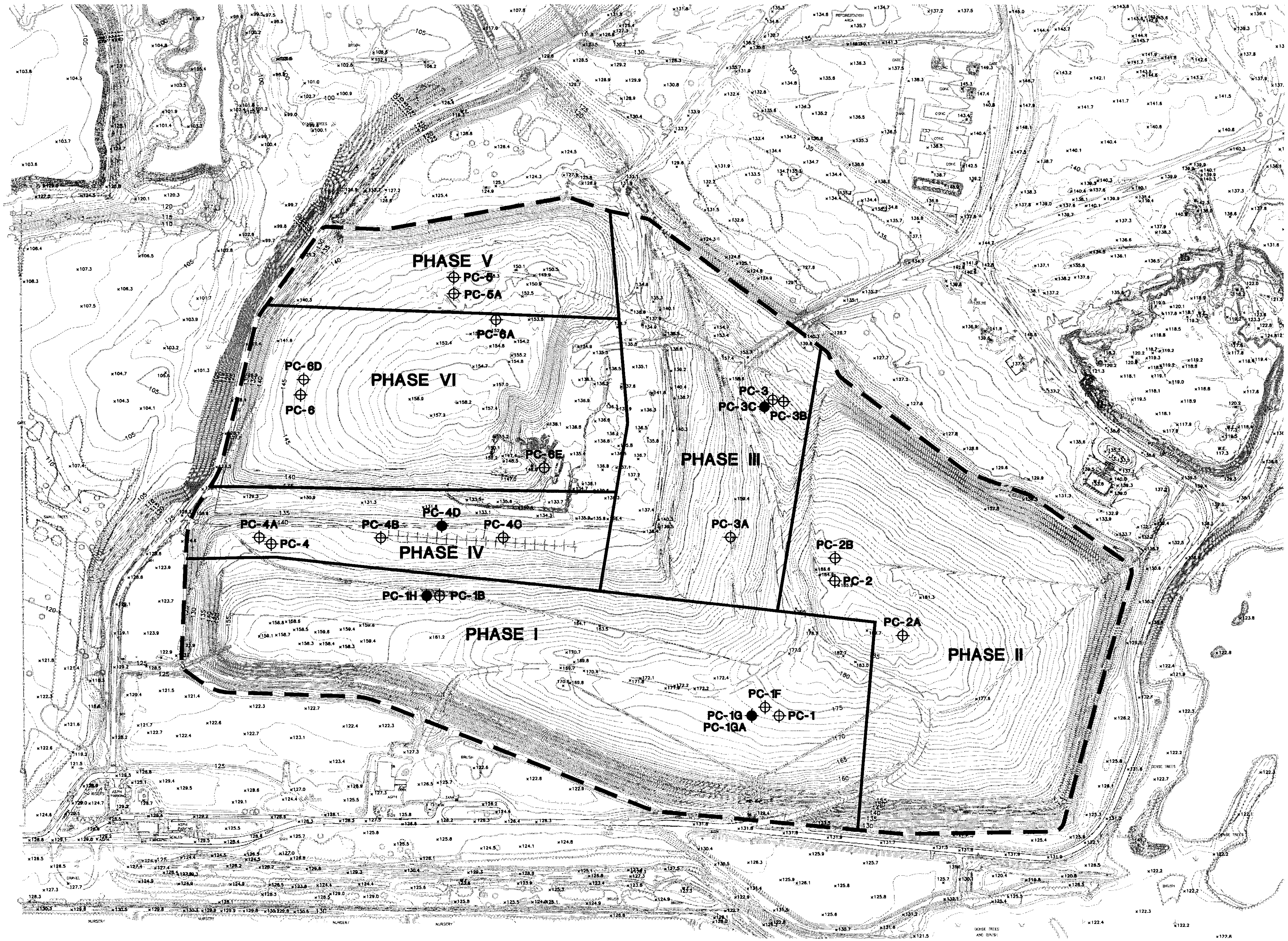

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0 200 400

SCALE: 1"=400'

NOTE: THE TOPOGRAPHIC SITE PLAN WAS BASED ON SURVEY DATA OBTAINED ON JANUARY 10, 2001.

LEGEND

⊕ TEST SITES IN 2001/2002

● TEST SITES IN 2003

LANDFILL LAYOUT AND FIELD TEST LOCATION MAP		
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
DRAWN BY: BTW	CHECKED BY: SA	DATE: 03/28/03
FILE NO. 03-018	APPROVED BY: FKC	FIGURE: 3

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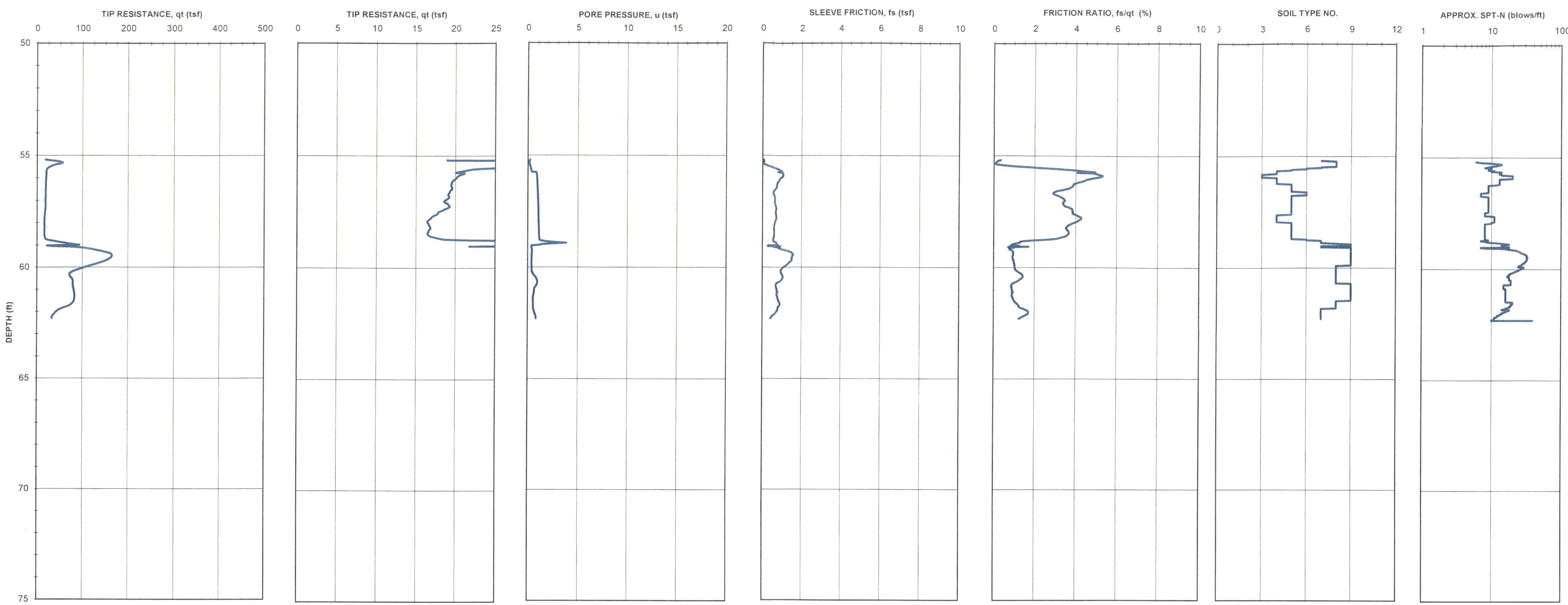


Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

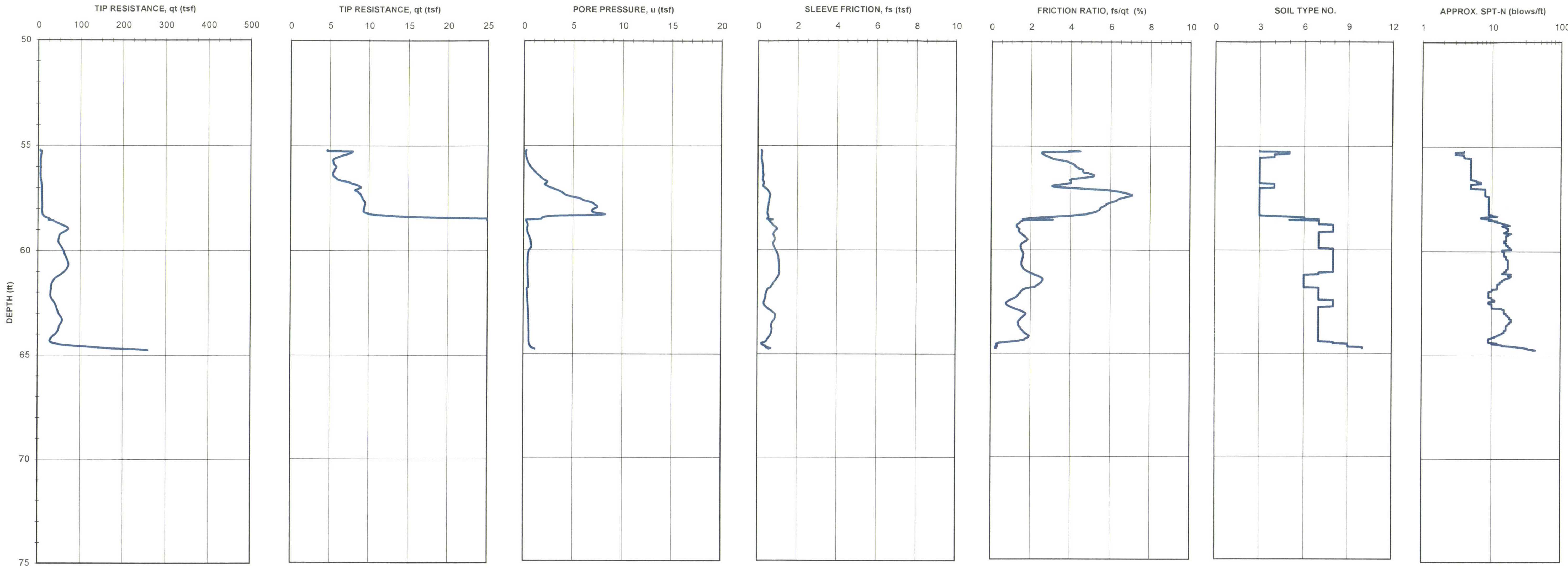
SOUNDING DATE: 2/27/2003
SURFACE ELEVATION (FT, NGVD): 171.7
COORDINATE LOCATION (FT): N 1,249, 863.5
E 597,248.6

PENETRATION TEST DATA FOR PIEZOCONE SOUNDING PC-1G

Ardaman & Associates, Inc.
Geotechnical Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: N.S	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 4



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

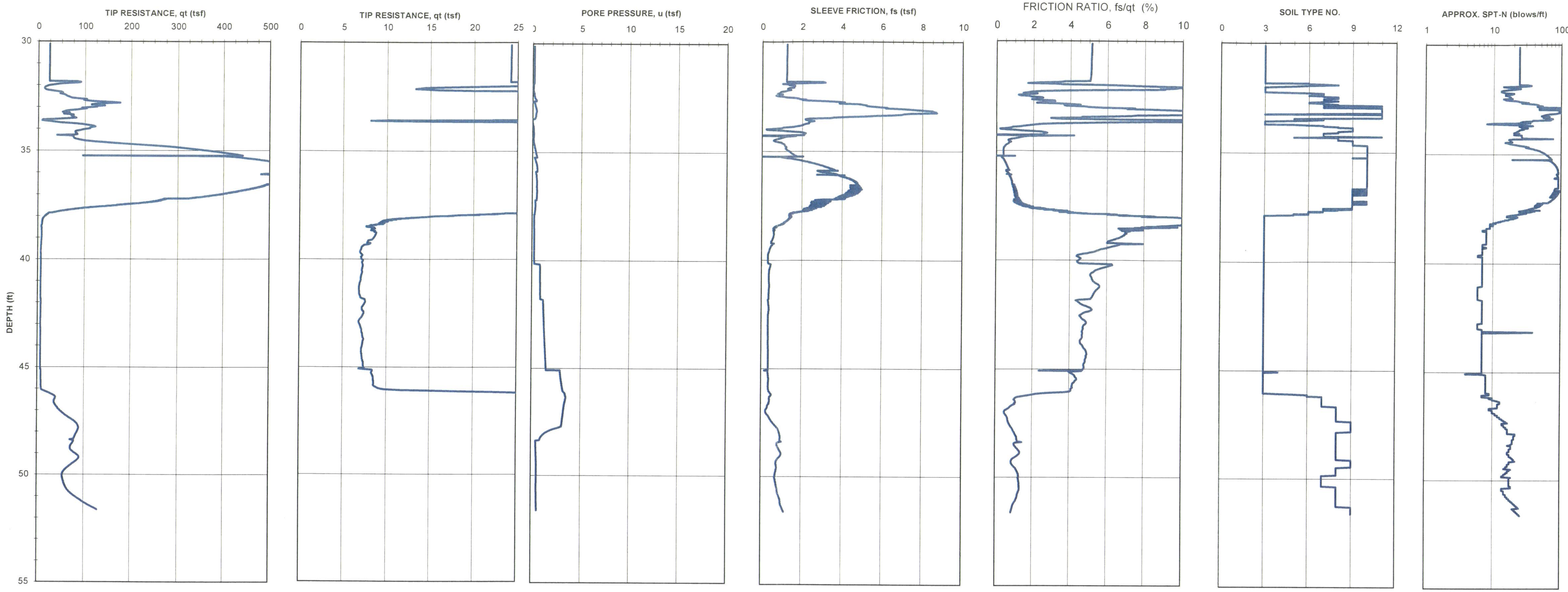
SOUNDING DATE: 2/28/2003
SURFACE ELEVATION (FT, NGVD): 171.7
COORDINATE LOCATION (FT): N 1,249, 863.5
E 597,255.6

PENETRATION TEST DATA FOR PIEZOCONE SOUNDING PC-1GA

Ardaman & Associates, Inc.
Geotechnical Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: N.S	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 5



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

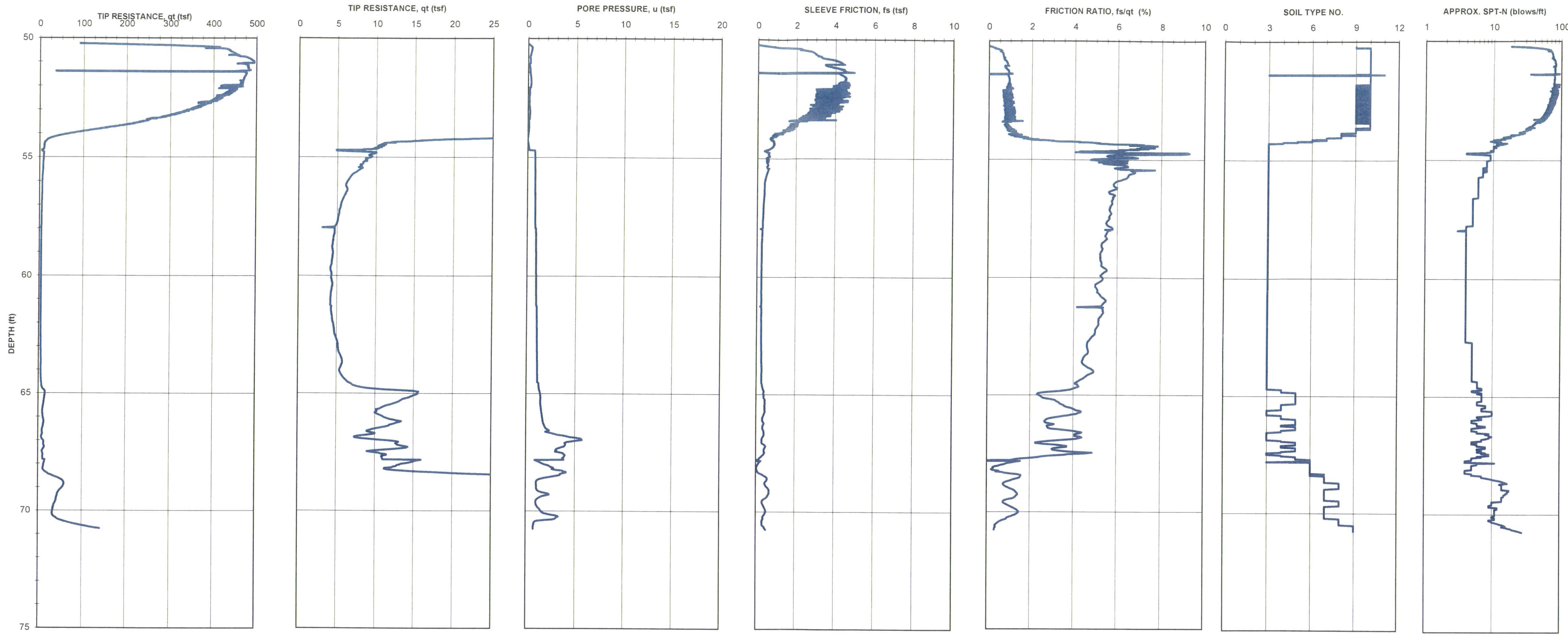
SOUNDING DATE: 2/28/2003
SURFACE ELEVATION (FT, NGVD): 157.1
COORDINATE LOCATION (FT): N 1,251, 138.6
E 597,324.8

PENETRATION TEST DATA FOR PIEZOCONE SOUNDING PC-3C

Ardaman & Associates, Inc.
Geotechnical Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: N.S	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 7



Soil I.D. #	Soil Description	UCS
1	Sensitive Fine Grained	OH/CH
2	Organic Material	OH
3	Clay	CH
4	Silty Clay to Clay	CL/MH
5	Clayey Silt to Silty Clay	MH/CL
6	Silty Sand to Sandy Silt	SC

Soil I.D. #	Soil Description	UCS
7	Sand to Sandy Silt	SP/SC
8	Sand to Silty Sand	SP
9	Sand	SP/SW
10	Gravelly Sand to Sand	SP/GW
11	Very Stiff Fine Grained	OC Clay
12	Sand to Clayey Sand	Cemented

Soil Classification by Robertson et al., 1986

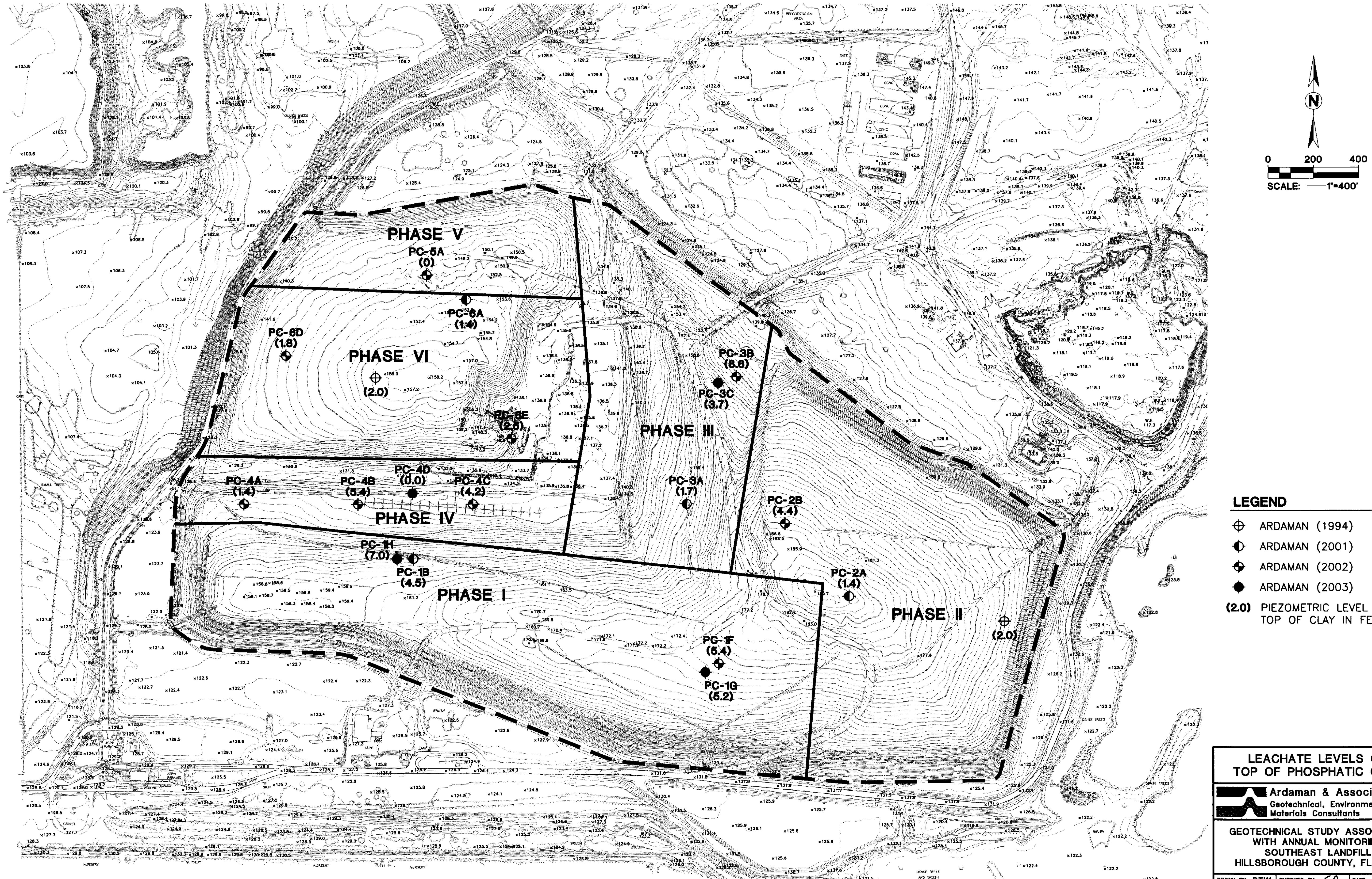
SOUNDING DATE: 2/26/2003
SURFACE ELEVATION (FT, NGVD): 167.3
COORDINATE LOCATION (FT): N 1,250, 671.3
E 595,967.1

PENETRATION TEST DATA FOR PIEZOCONE SOUNDING PC-4D

Ardaman & Associates, Inc.
Geotechnical Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: NS	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 8



LEGEND

- ARDAMAN (1994)
- ARDAMAN (2001)
- ARDAMAN (2002)
- ARDAMAN (2003)
- **(2.0)** PIEZOMETRIC LEVEL ABOVE TOP OF CLAY IN FEET

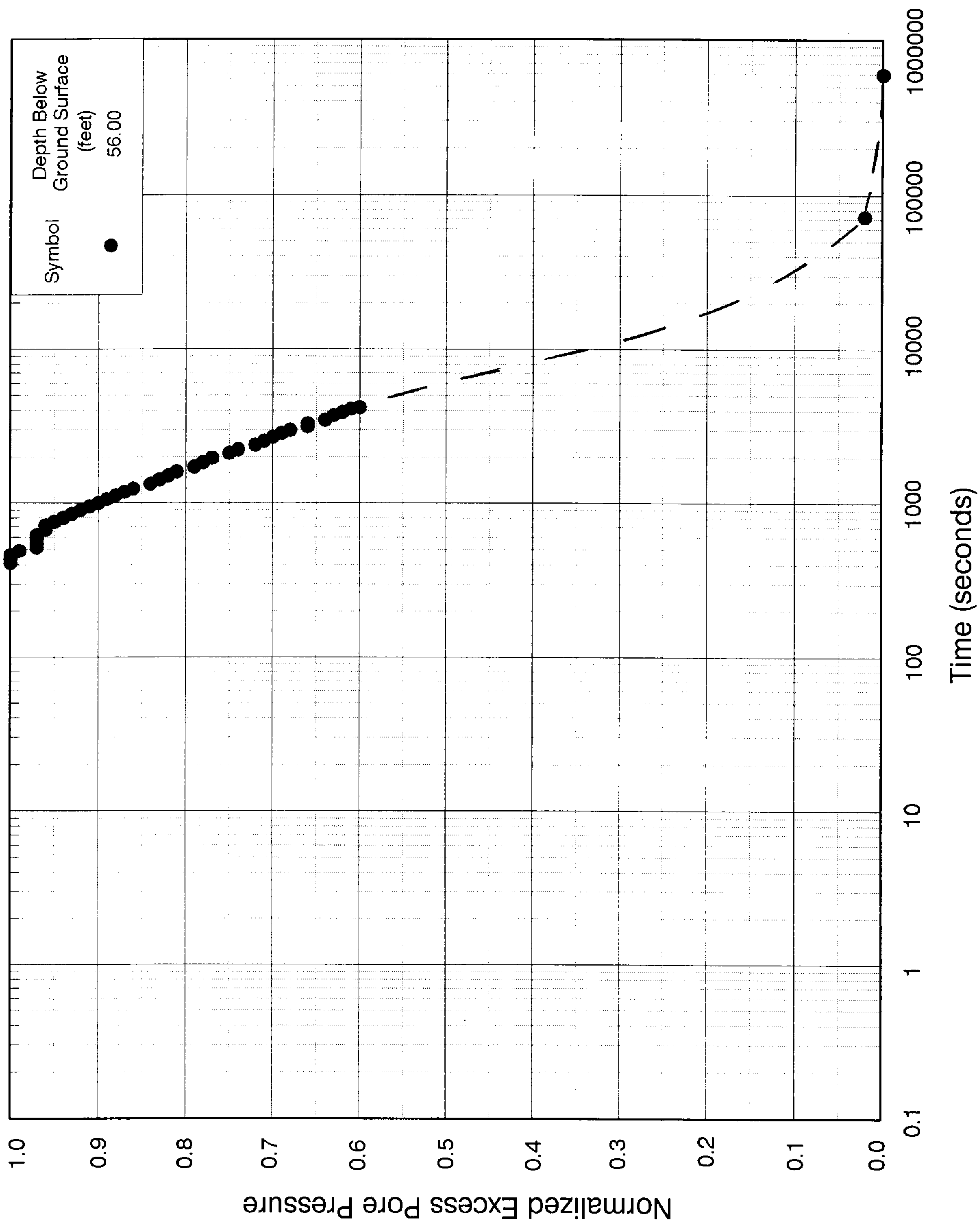
LEACHATE LEVELS ON TOP OF PHOSPHATIC CLAY

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: BTW	CHECKED BY: SA	DATE: 03/28/03
FILE NO. 03-018	APPROVED BY: FKC	FIGURE: 9

T:\Corporate\03\03-018\03018-04.dwg 04/02/03 CD



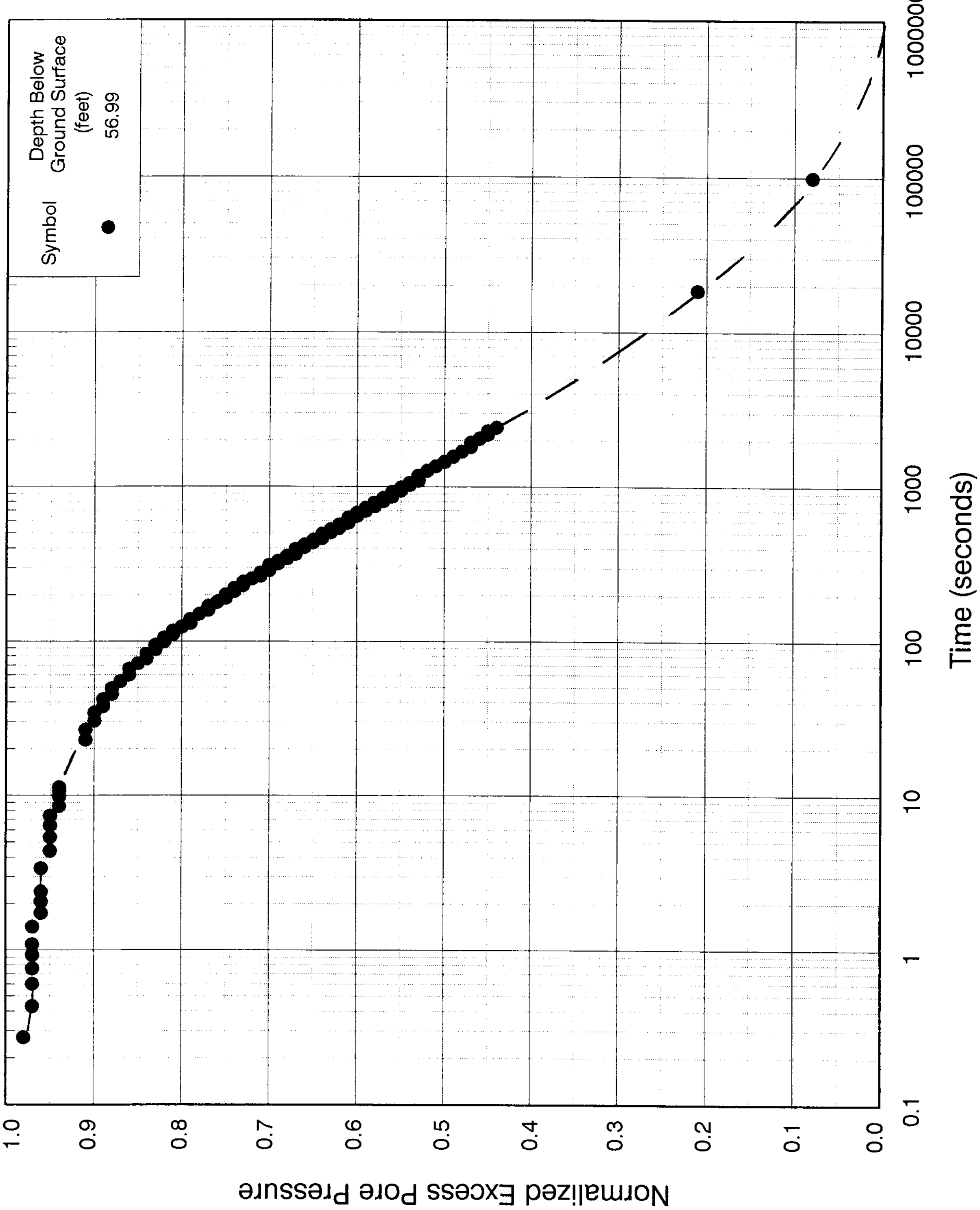
EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P356 AT PC-1G

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 03-27-03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 10

p356.drw



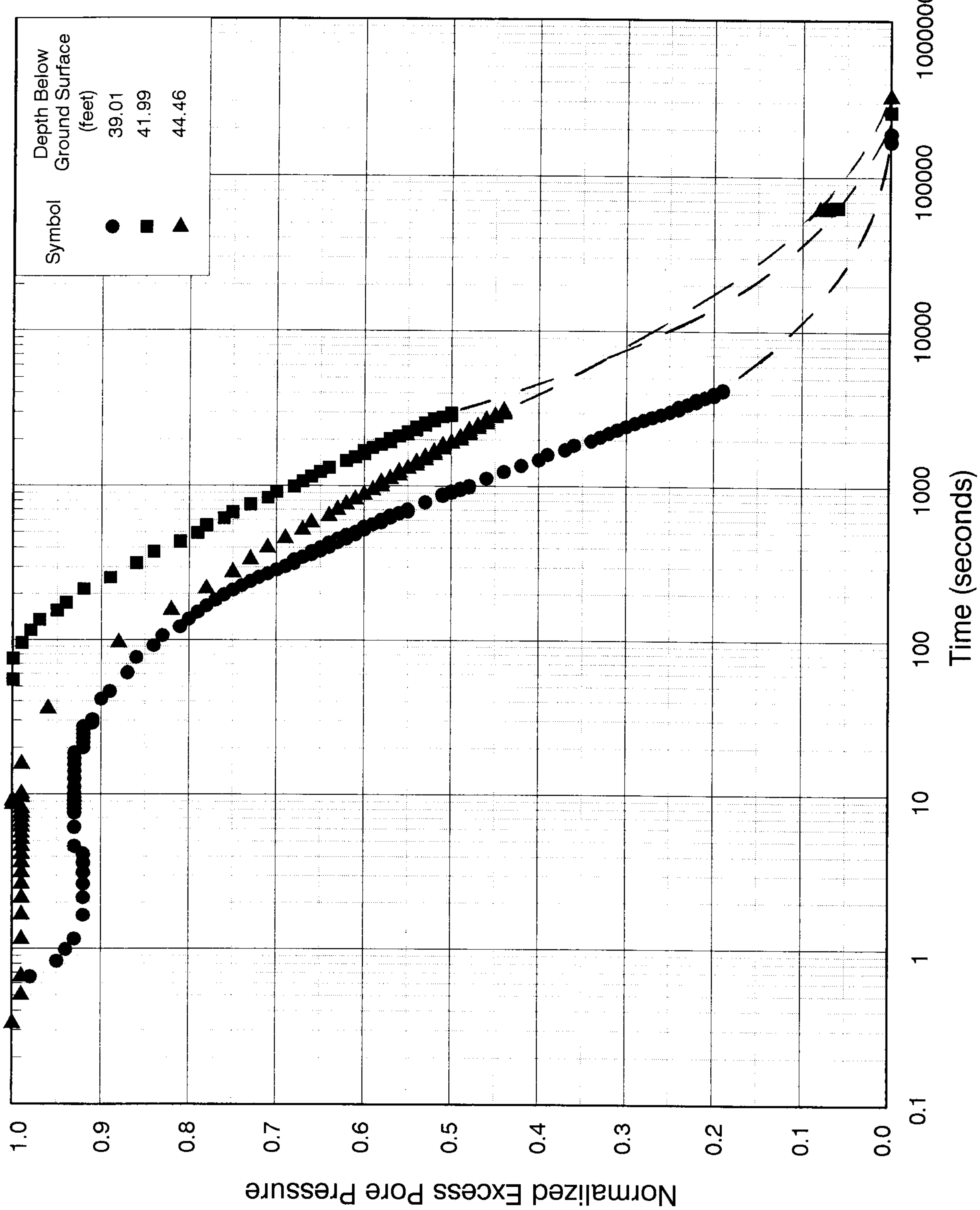
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P257 AT PC-1H

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING SOUTHEAST LANDFILL HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 03-27-03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 11

p257.drw



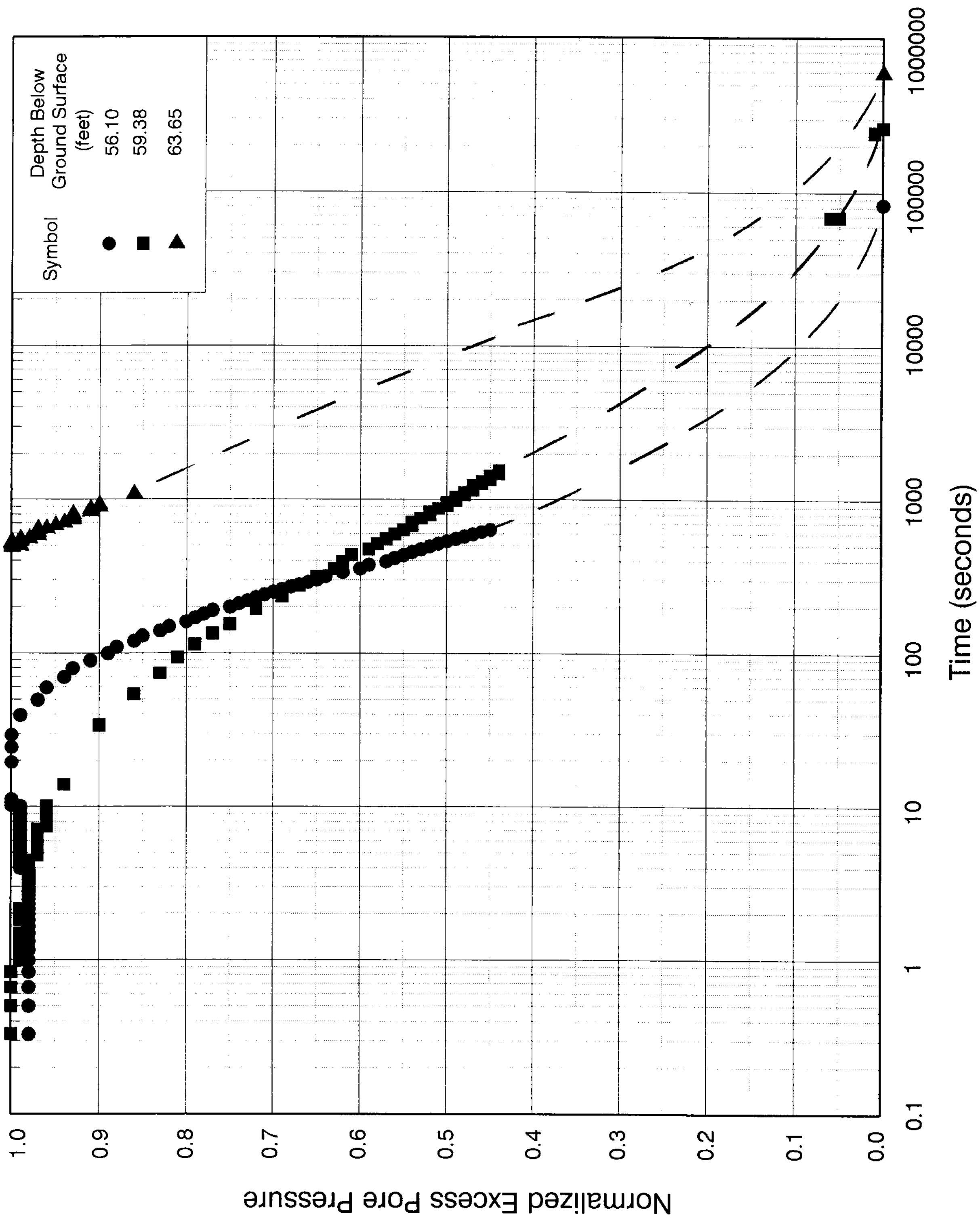
EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P439 AT PC-3C

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED
WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 03-27-03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 12

p439.drw



EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P656 AT PC-4D

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

GEOTECHNICAL STUDY ASSOCIATED WITH ANNUAL MONITORING
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

DRAWN BY: SA	CHECKED BY: SA	DATE: 03-27-03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 13

p656.drw