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

April 10, 2003

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Geotechnical, Environmental and
Materials Consultants

April 10, 2003
File Number 03-018

SCS Engineers
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Suite 700
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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.

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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} cm^2/sec. The filling schedule at the Southeast Landfill was originally based on a design coefficient of consolidation of 1.5×10^{-4} cm^2/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. 04/10/03
Senior Project Manager
Florida Registration No. 36382

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

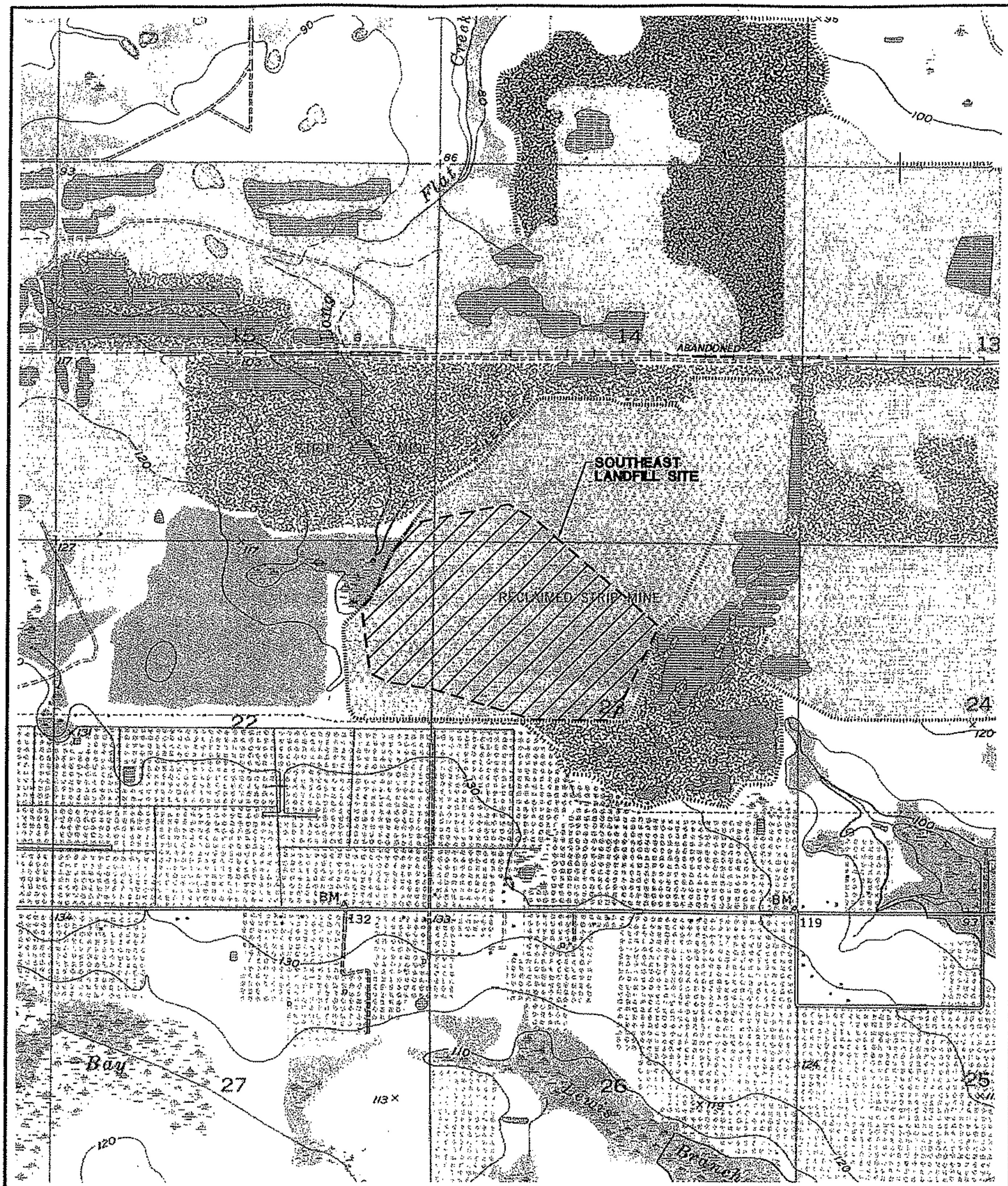
Area	Test Site	Piezoprobe Designation	Piezoprobe Tip Depth Below Ground Surface (ft)	Elevation of Piezoprobe Tip (ft, NGVD)	Horizontal Coefficient of Consolidation, c_h (cm²/sec)	Vertical Coefficient of Consolidation, c_v* (cm²/sec)
Phase I	PC-1GA	P356	56.0	+115.7	$4.4x10^{-4}$	$2.2x10^{-5}$
	PC-1H	P257	57.0	+106.1	$3.4x10^{-3}$	$1.7x10^{-4}$
Phase III	PC-3C	P439	39.0 42.0 44.5	+118.1 +115.1 +112.6	$4.5x10^{-3}$ $1.6x10^{-3}$ $2.2x10^{-3}$	$2.3x10^{-4}$ $8.0x10^{-5}$ $1.1x10^{-4}$
Phase IV	PC-4D	P656	56.1 59.4 63.7	+111.2 +107.9 +103.6	$3.5x10^{-3}$ $3.2x10^{-3}$ $2.5x10^{-4}$	$1.8x10^{-4}$ $1.6x10^{-4}$ $1.3x10^{-5}$

* 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)



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: 03/31/03
FILE NO. 01-122	APPROVED BY: FKC	FIGURE: 1

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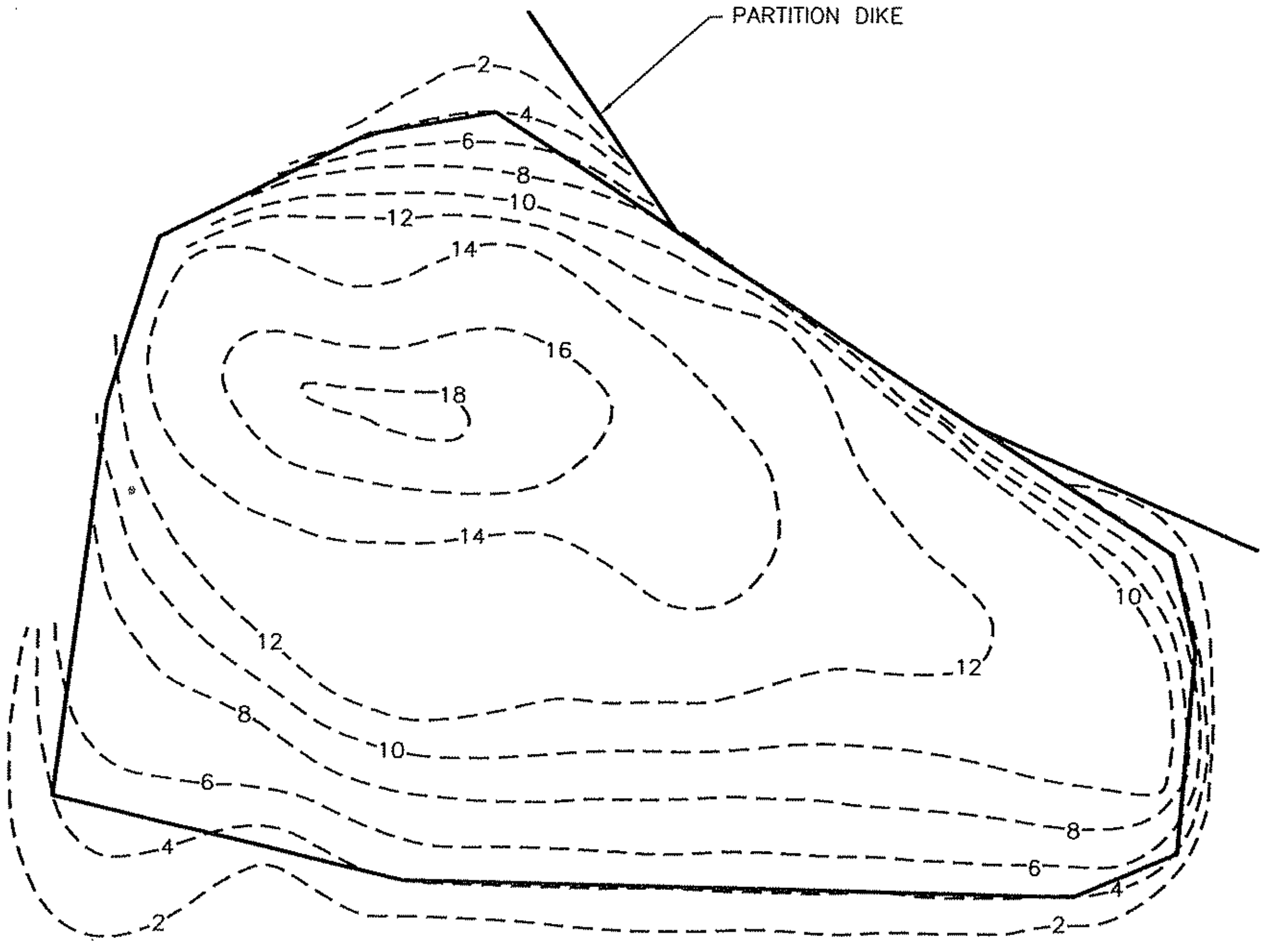

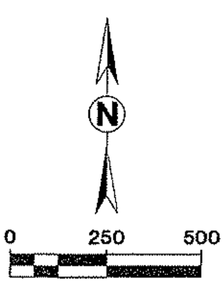

LEGEND

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

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SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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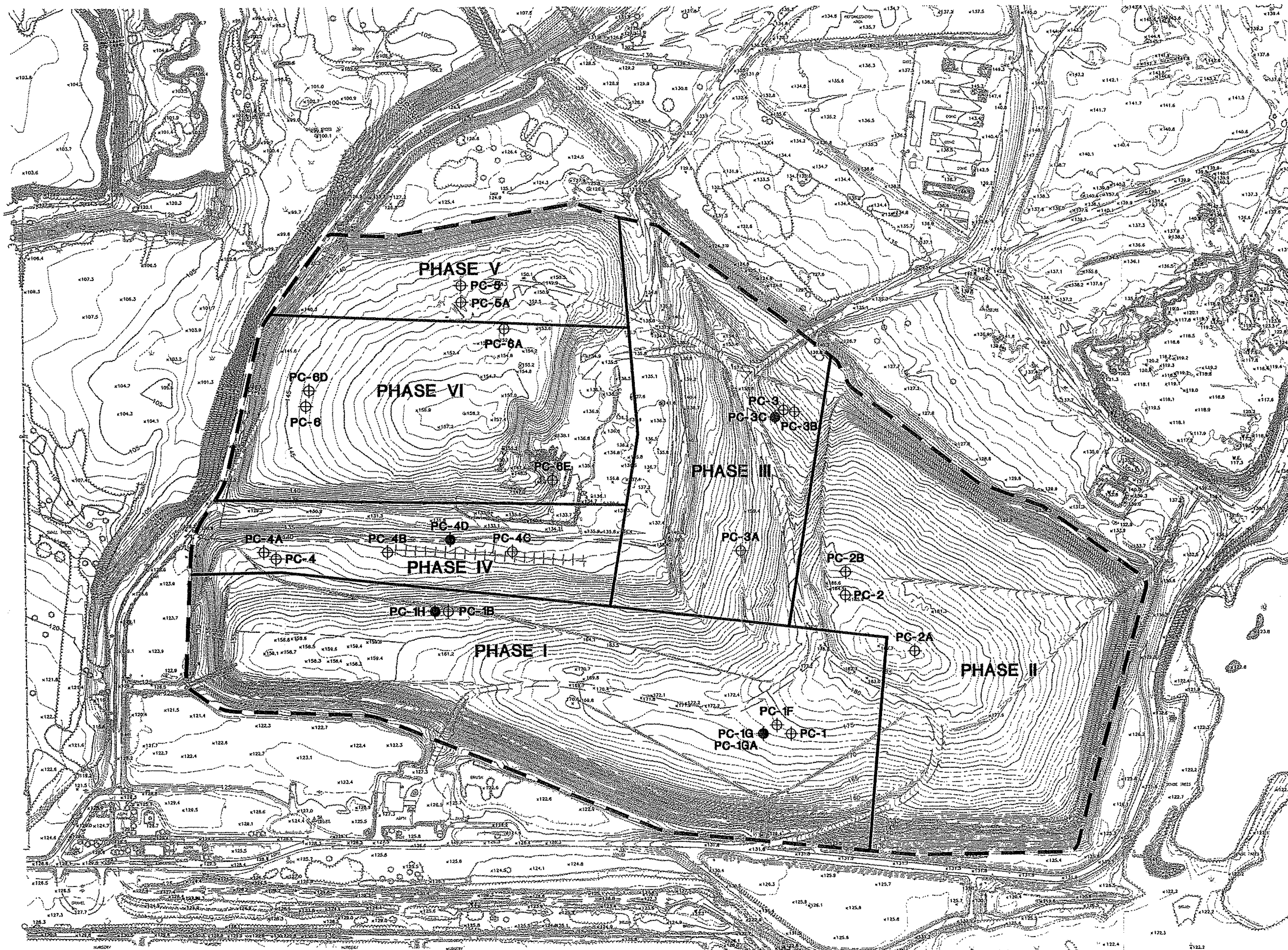
FILE NO. 03-018	APPROVED BY: FCC	FIGURE: 2

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



N

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

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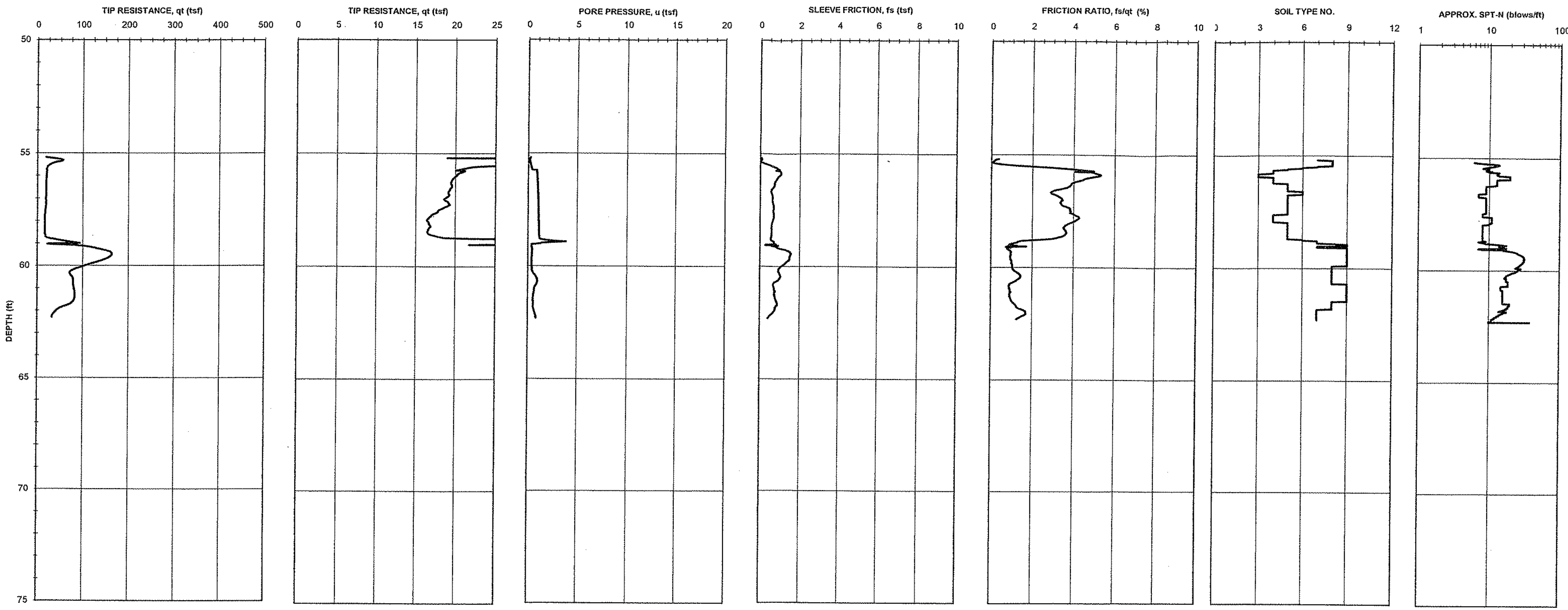
DRAWN BY: BTW	CHECKED BY: SA	DATE: 03/28/03
FILE NO. 03-018	APPROVED BY: FICC	FIGURE: 3



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 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

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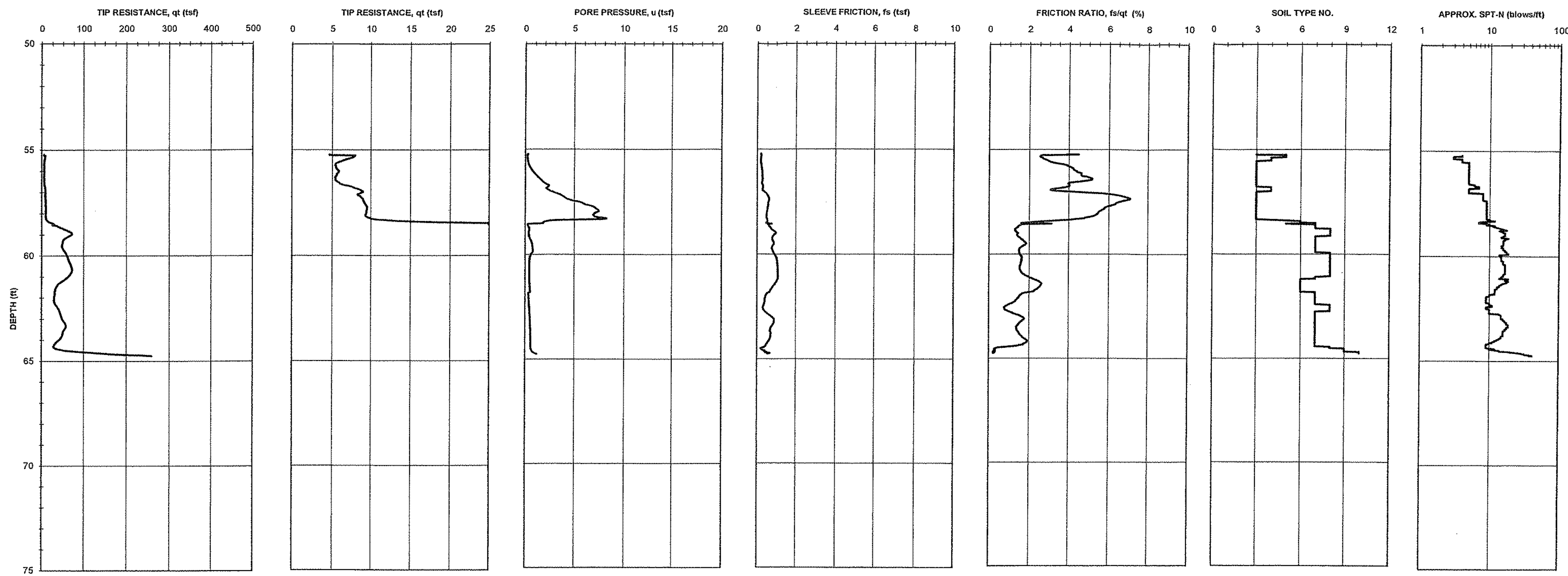
DRAWN BY: N.S	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 4



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

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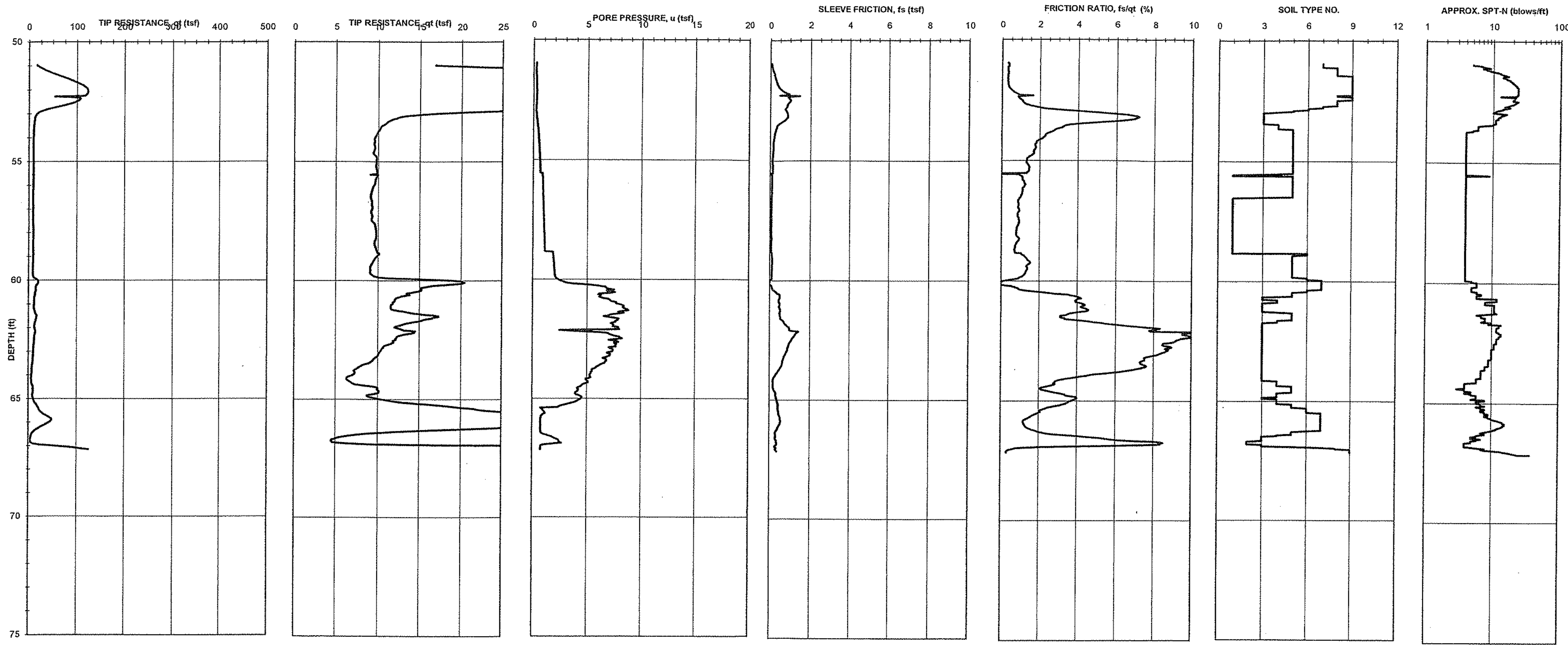
DRAWN BY: N.S	CHECKED BY: S.A	DATE: 03/27/03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 5



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: 02/26/2003
SURFACE ELEVATION (FT, NGVD): 163.1
COORDINATE LOCATION (FT): N 1,250, 379.2
E 595,948.5

PENETRATION TEST DATA FOR PIEZOCONE SOUNDING PC-1H

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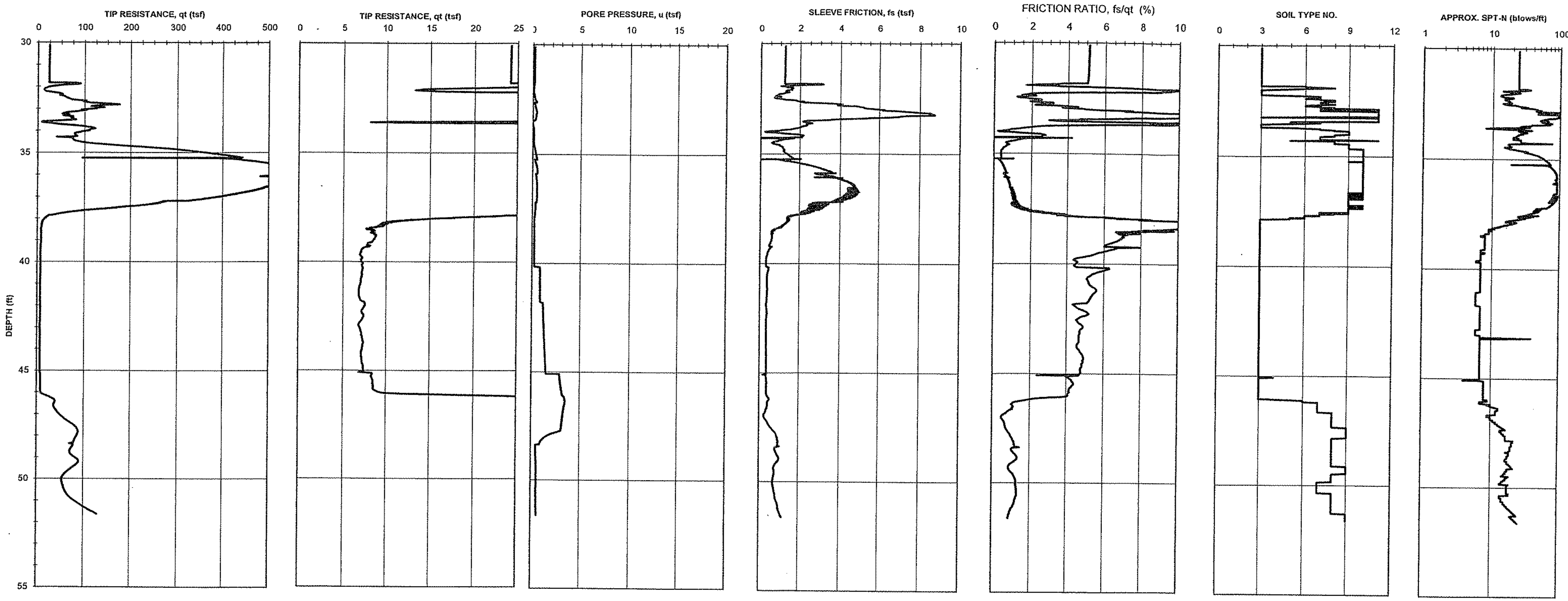
HILLSBOROUGH COUNTY, FLORIDA

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

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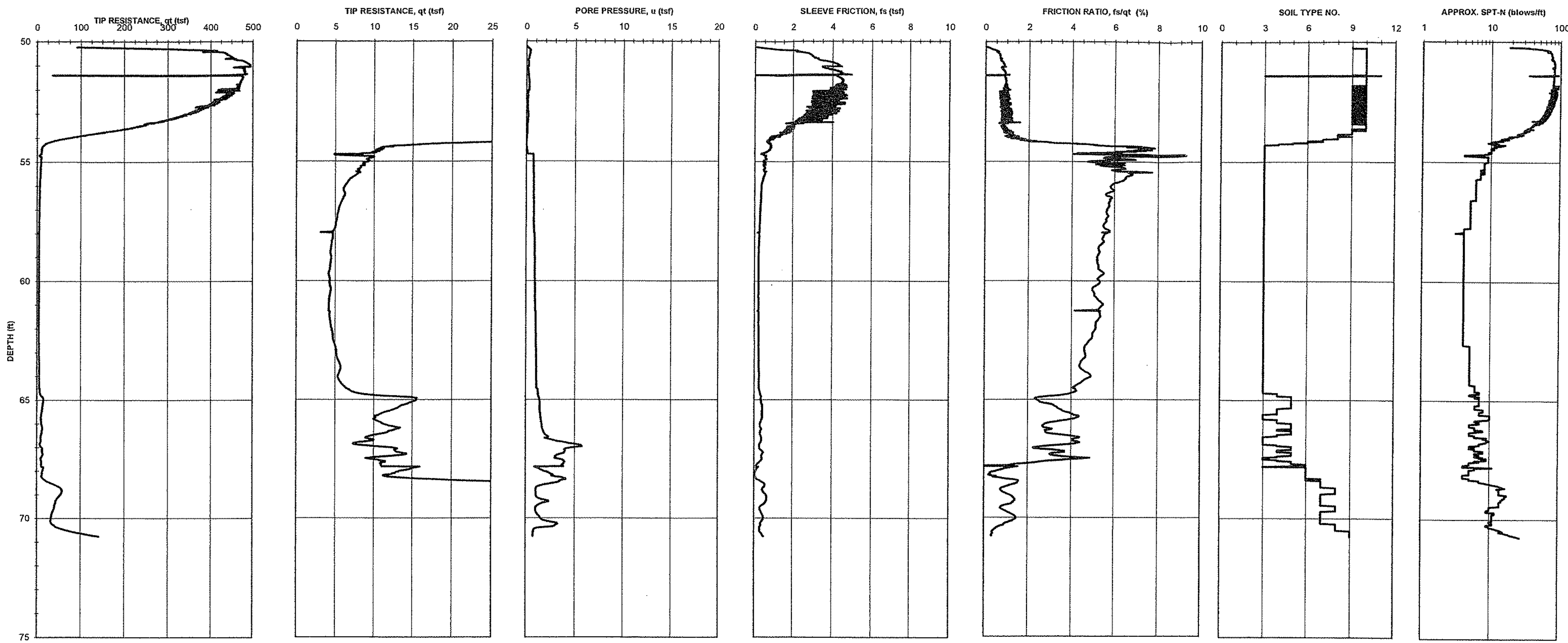
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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

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HILLSBOROUGH COUNTY, FLORIDA

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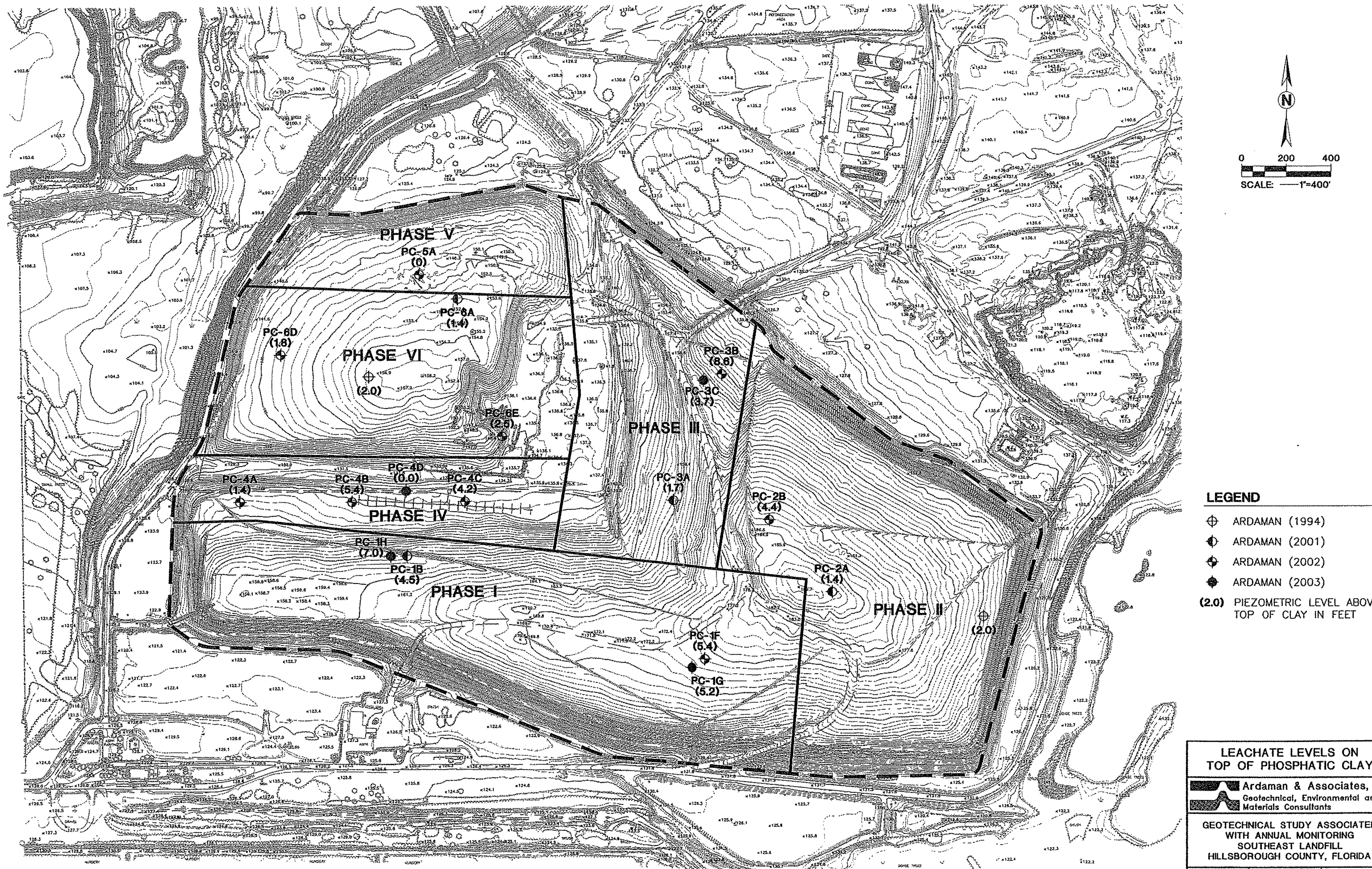
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 8



LEACHATE LEVELS ON TOP OF PHOSPHATIC CLAY

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FILE NO. 03-018	APPROVED BY: FCC	FIGURE: 9

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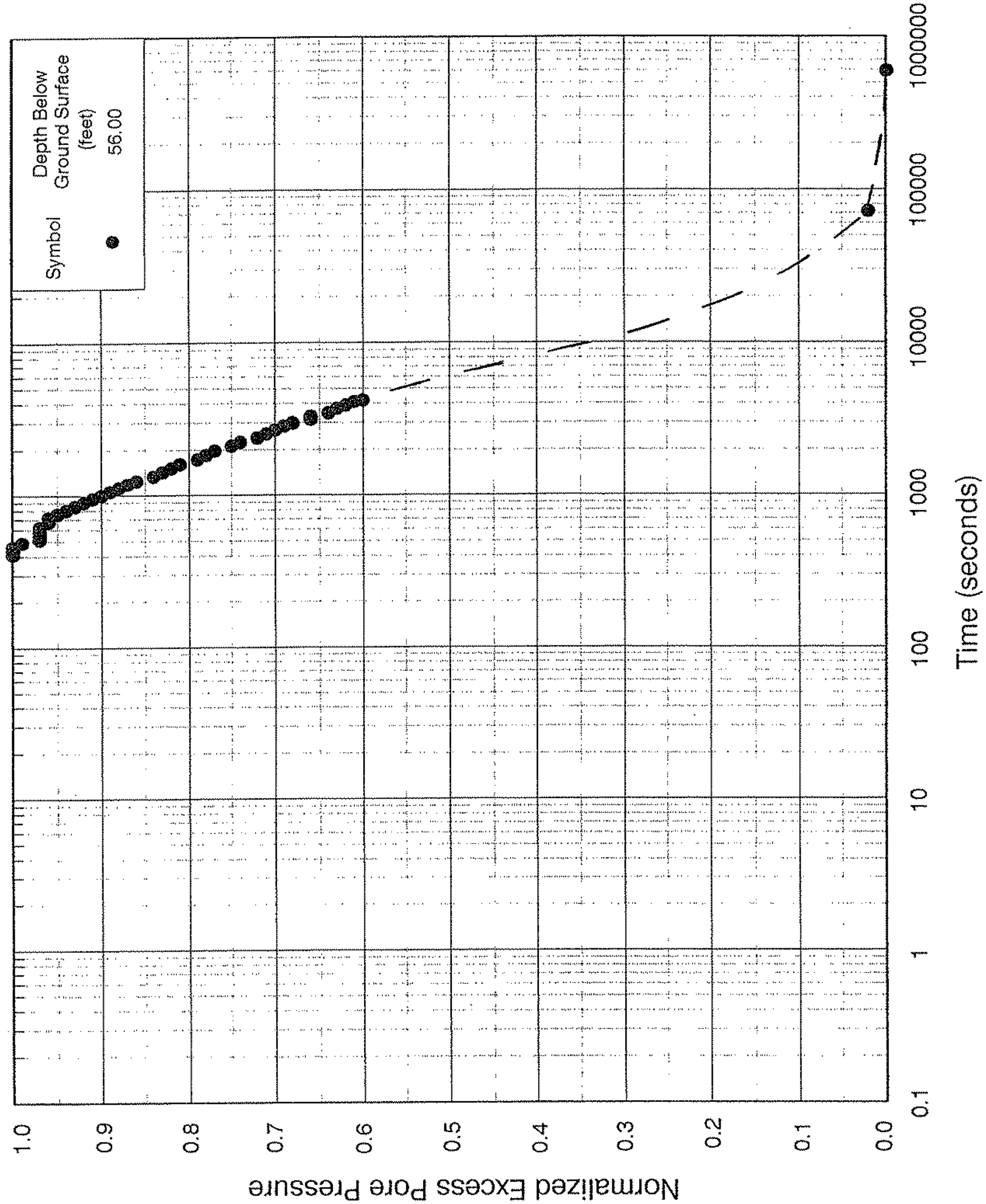

EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P356 AT PC-1G

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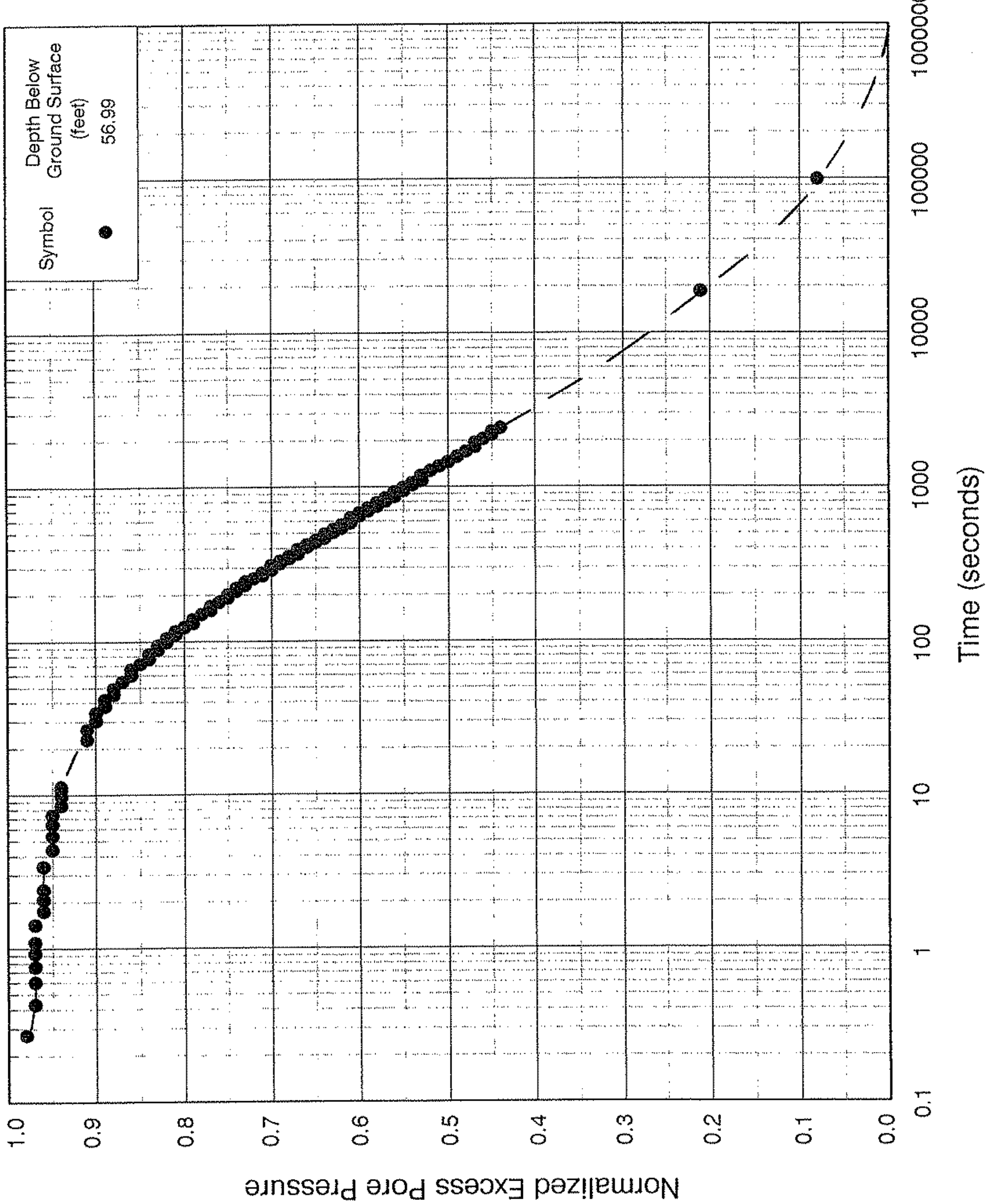
DRAWN BY: SA	CHECKED BY: SA	DATE: 03-27-03
FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 10

p356.drw



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EXCESS PORE PRESSURE DISSIPATION
PIEZOPROBE P257 AT PC-1H

GEOTECHNICAL STUDY ASSOCIATED
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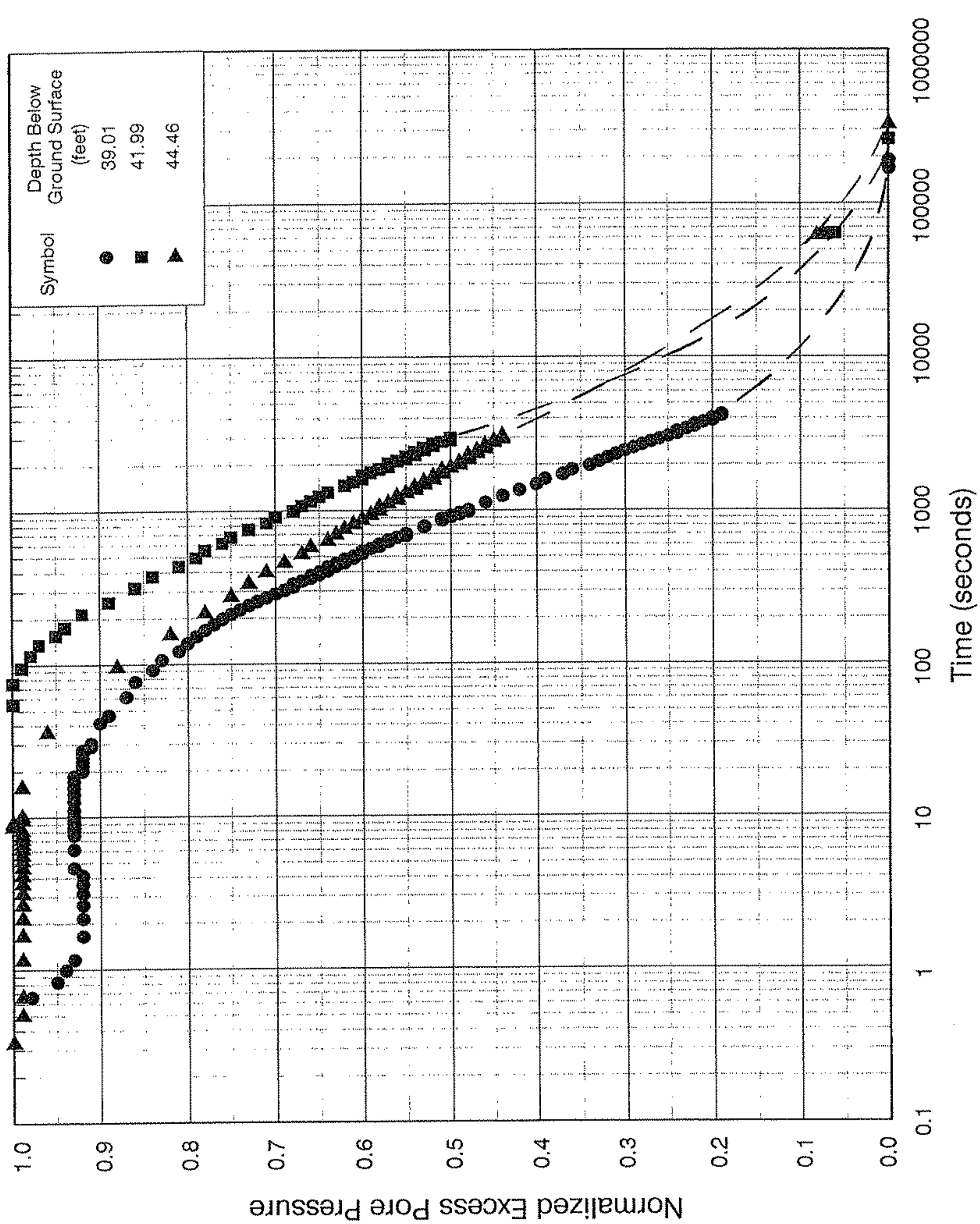
HILLSBOROUGH COUNTY, FLORIDA

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

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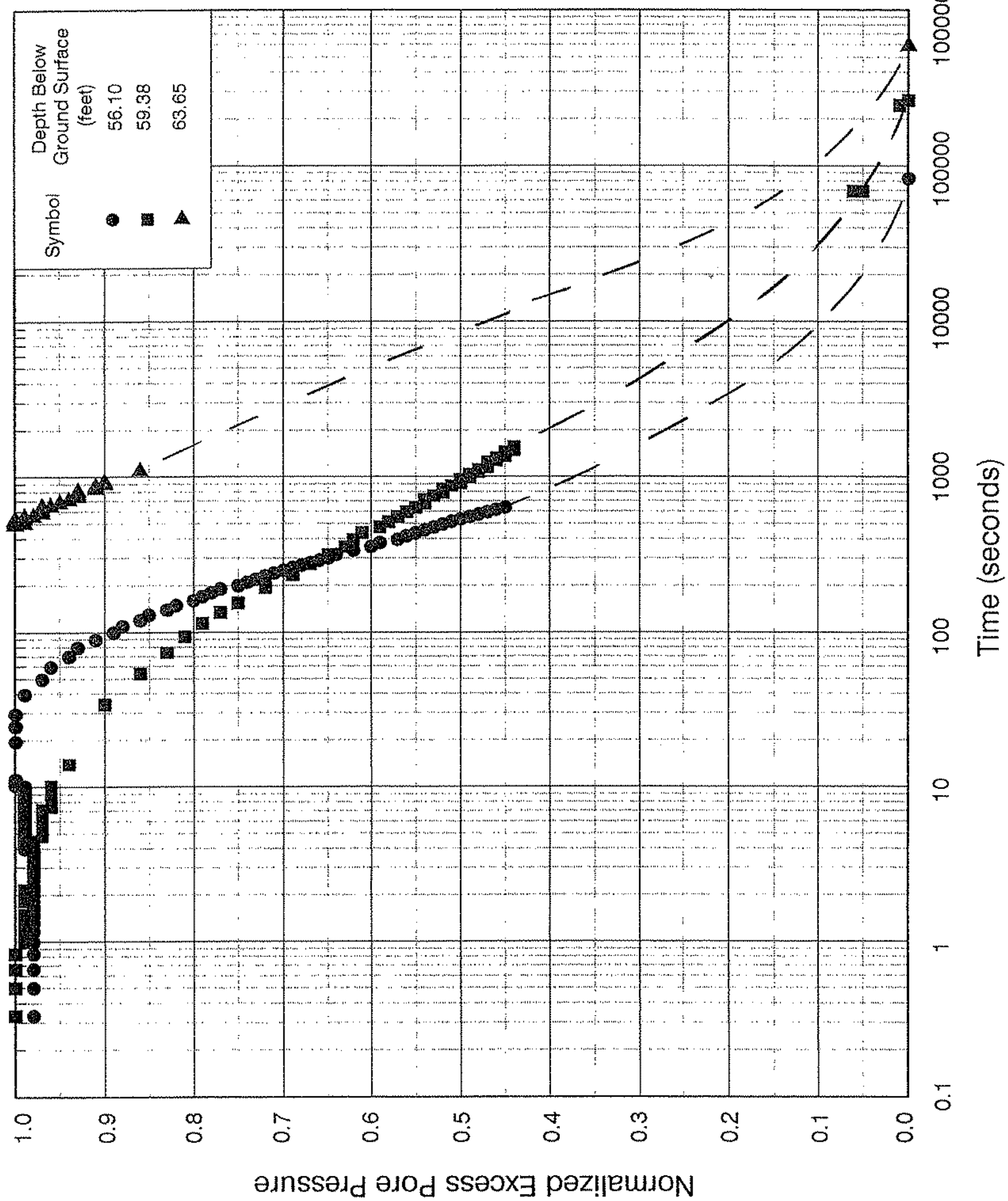
SOUTHEAST LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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

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HILLSBOROUGH COUNTY, FLORIDA

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FILE NO.: 03-018	APPROVED BY: FKC	FIGURE: 13

p656.drw