Geotechnical Evaluation, Hydrogeological Survey and Groundwater Monitoring Plan Sarasota Central Landfill Complex Sarasota County, Florida

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FILE

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

March 10, 1992
File Number 89-135

Camp Dresser & McKee Inc.
201 Montgomery Avenue
Sarasota, Florida 34243

Attention: Mr. John A. Banks, P.E.

Subject: Geotechnical Evaluation, Hydrogeological Survey and Groundwater Monitoring Plan, Sarasota County Central Landfill Complex, Sarasota, Florida

Gentlemen:

As requested by Mr. John Banks and authorized by Camp Dresser & McKee Inc., we are pleased to present the results of our Geotechnical Evaluation, Hydrogeological Survey and Groundwater Monitoring Plan for the subject site. Borrow and foundation evaluations are included for the project.

This report has been prepared for the exclusive use of Camp Dresser & McKee Inc. (CDM) and Sarasota County for specific application to the subject facility in accordance with generally accepted geotechnical and hydrogeological engineering practice. No other warranty, expressed or implied, is made.

It has been a pleasure assisting you on this phase of the project. Please do not hesitate to contact the undersigned or our Mr. David G. Sawitzki if you have any questions.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Herbert G. Stangland, Jr., P.E.
Senior Water Resources Engineer

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Enclosures

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INTRODUCTION

Site Location And Design Assumptions

The site for the proposed Sarasota County Central Landfill Complex, which is located northeast of the town of Laurel, contains 6,152 acres (approximately 9.6 square miles). As shown on Figure 1, the proposed site, the Walton Tract, is located in Sections 1 through 4 and 9 through 16, Township 38 South, Range 19 East, Sarasota County, Florida. A 1989 aerial photo of the site with a scale of 1 inch equals 900 feet is presented in Figure 2.

The Sarasota County Central Landfill Complex includes a Class I and Class III landfills to be designed to Florida Department of Environmental Regulation (FDER) requirements. The Class I landfill is to be located in the north central portion of the site, as shown on Figure 3. In addition to the Class I landfill, a Class III landfill, which will receive only trash or yard trash and construction and demolition debris, is proposed east of the Class I landfill area. Proposed borrow areas for the landfill are located west of the landfill footprint in the northern one-half of the property.

Scope Of Work

The following tasks were performed by Ardaman & Associates, Inc. for this project:

- Compiled and reviewed available aerial photographs, geological literature, the soil survey report of the site, and the data collected from previous studies.
- Planned and conducted a field exploration program consisting of 79 Standard Penetration Test (SPT) borings to determine the subsurface conditions at the site and to recover soil samples for laboratory testing.
- Installed 16 shallow and 3 deep monitor wells to document the groundwater table levels, the direction of groundwater flow, and to measure the hydraulic conductivity of the subsurface soils.
- Tested all wells for pH, conductivity, salinity and temperature in the field and had water chemistry analyses performed on water samples from four wells.
- Planned and conducted a laboratory testing program to characterize the engineering properties of representative soil samples retrieved from the site.
- Evaluated the results of the field and laboratory programs and the hydrogeological data at the site with respect to the use of the site for a landfill.
- Performed foundation analyses to assess the suitability of subsurface soils to support the proposed landfill.
- Compiled field and laboratory data to locate and assess the availability of borrow material for daily, intermediate and final cover as well as for a clay component of a bottom liner system.
- Summarized liner requirements for the Class I landfill.

- Prepared a groundwater monitoring plan for the landfills.
- Prepared this report to document our hydrogeological and geotechnical engineering evaluations for the proposed landfill site.

SITE CONDITIONS

Geographic Setting

Lying in the gulf coastal lowlands, the study area is part of the barrier island coastal strip physiographic division of the southwestern flatwoods district described by H. K. Brooks (1981). This division is characterized by elevations of less than 20 feet (NGVD) and the presence of barrier islands along the coast.

Displaying a flat topography, the study area is poorly drained containing intermittent depressions which are seasonally dry. Surface water from the site flows into the Myakka River on the east and Cow Pen Slough Canal on the west of the area. East of the landfill footprints, surface water drains to the Myakka River primarily via sheet flow. No defined channel system is evident. West of the landfill footprints, surface water drains to Cow Pen Slough Canal primarily via the Cow Pen Slough east of the Canal and by sheet flow west of the Canal.

According to a recent topographic survey of the area provided to us by Camp Dresser & McKee Inc. (CDM), the site land surface elevations typically vary from 14 to 22 feet (NGVD) except in the flood plain of the Myakka River where the elevations are lower than 10 feet (NGVD). The land generally slopes from north to south and from west to east toward the Myakka River on the east and from east to west toward Cow Pen Slough Canal on the west. The highest ground elevations are in Section 3 along the northern border of the site. The lowest ground elevations are in Sections 12 and 13 near the southeastern corner of the site.

The detailed soil survey prepared by the U.S. Soil Conservation Service (1954) indicates that the predominant upland surficial soils between the Myakka River and Cow Pen Slough Canal are the somewhat poorly drained Adamsville and Immokalee soil series. The Immokalee soils have an "organic pan" layer below 30 inches. This soil series was formed from thick stratified beds of acid sands. The Adamsville soil consists of fine sand overlying finer grained alkaline soils. The fine sands in this series are typically 42 inches thick or more. Both the Adamsville and Immokalee soils, without drainage improvements, have a seasonal high water table of 0 to 2 feet below land surface.

Meteorology

The general climatic conditions at the site are subtropical. The annual precipitation for a normal year (average of time period 1951-1980) at Bradenton and Myakka River State Park, as reported by the National Oceanic and Atmospheric Administration (NOAA), is 55.67 and 56.81 inches, respectively. The mean monthly rainfall distribution in a normal year at the Bradenton and Myakka River State Park stations is presented in Table 1. As can be seen, about 61 percent of the annual precipitation occurs in a 4-month period between June and September.

According to NOAA, the annual average temperature in a normal year at the Bradenton station is 71.9°F. The coldest month recorded is in January with an average temperature of 60.7°F. The warmest month recorded is in August with an average temperature of 81.5°F.

Geological Setting

Based upon published literature and our past experience in the vicinity of the study area, the following description defines the stratigraphic sequence beneath the area. The generalized hydrogeologic units for the study area are presented in Table 2. Localized variations, which are common in the upper 100 feet, are expected.

Scott (1988) reported on the lithostratigraphy of the Hawthorn Group (Miocene age deposits) of Florida and has outlined several relatively new names for the units which make up the stratigraphic column. The new sequence of lithological units as described by Scott (1988) in descending order are listed as follows for the site:

Elevation (Ft. NGVD) From	To	Geological Unit - Description
20	5	Undifferentiated Sediments - generally consists of unnamed, nonphosphatic sands (often surficial) and unnamed fossiliferous sands and shell beds.
5	-25	Peace River Formation - new name for the combined upper Hawthorn Group. This formation consists of interbedded quartz sands, clays and carbonates. The siliciclastic component predominates and is the distinguishing lithologic feature of the unit. Typically the siliciclastics comprise two-thirds or more of the formation. The quartz sands are characteristically clayey, calcareous to dolomitic, phosphatic, very fine to medium grained, and poorly consolidated. Clay beds are quite common in the Peace River Formation. The clays are quartz sandy, silty, calcareous to dolomitic, phosphatic, and poorly to moderately indurated. Carbonates also occur throughout the Peace River Formation. Characteristically these carbonates comprise less than 33 percent of the Peace River section. The carbonates may be either limestone or dolostone. Chert occurs sporadically in the Peace River Formation. Characteristically, the chert appears to be a replacement of the carbonates although silicified clays do occur.
-25	-450	Arcadia Formation - new name for the lower Hawthorn carbonate section in south Florida. The Arcadia Formation, with the exception of the Nocatee Member, consists predominantly of limestone and dolostone containing varying amounts of quartz sand, clay and phosphate grains. Thin beds of quartz sand and clay often are present interspersed throughout the section. These thin sands and clays are generally very calcareous or dolomitic and phosphatic. Dolomite is generally the most abundant carbonate component of the Arcadia Formation except in the Tampa Member. Clay beds occur sporadically throughout the Arcadia Formation, are thin, generally less than 5 feet thick, and of limited areal extent. The clays are quartz sandy, silty, phosphatic, dolomitic and poorly to moderately indurated. Quartz sand beds also occur sporadically and are generally less than 5 feet thick. The sands are very fine to medium grained (characteristically fine grained), poorly to moderately indurated, clayey, dolomitic and phosphatic. Chert is sporadically present in the Arcadia Formation, however, typically not in Sarasota County.

-250 -400 The Tampa Member, which occurs between -250 ft and -400 ft, (NGVD) consists predominantly of limestone with subordinate dolostone, sands, and clays. The lithology of the Tampa Member is very similar to the limestone portion of the Arcadia Formation with the exception of its phosphate content which is almost always noticeably less than in the Arcadia Formation. Phosphate grains generally are present in the Tampa Member in amounts less than 3 percent although beds containing greater percentages do occur, particularly near the facies change limits of the member. Lithologically, the limestones are variably quartz sandy and clayey with minor to no phosphate. Fossil molds are often present and include mollusks, foraminifera and algae. Sand and clay beds occur sporadically within the Tampa Member. Lithologically, they are identical to those described for the Arcadia Formation except for the phosphate content which is significantly lower in the Tampa Member. Siliceous beds are often present in the more updip portions of the Tampa.

-450 -1300 Suwannee, Ocala and Avon Park Limestones - these limestones form the Floridan aquifer. These units occur at depths from 400 to 475 feet and extend to a depth of approximately 1300 feet below land surface (Wolansky, 1983). The Suwannee Limestone is a soft granular limestone and is underlain by the light colored, fine grained, massive Ocala Limestone which contains beds of dolomite at its base. The Avon Park Limestone is a granular to chalky fossiliferous limestone and interbedded fractured dolomite with gypsum and anhydrite which are found in greater concentrations at the base of the formation.

Hydrogeological Setting

The surficial, intermediate and Floridan aquifer systems comprise the three hydrogeologic systems present at the site. The term system refers to both the aquifer and confining units. The following description summarizes the general hydrogeological characteristics and the properties of the aquifers and confining units from literature data.

Surficial Aquifer System

The surficial aquifer system in the study area of Sarasota County consists of approximately 10 to 15 feet of sandy undifferentiated sediments. Low permeability clayey layers generally occur from elevation about +10 to -40 feet (NGVD) and have a wide areal extent throughout the area. The site is within a broad region where beds 10 feet or more in thickness with low hydraulic conductivity occur within 50 feet of the surface (Buono et al., 1979). The direction of groundwater movement in the surficial aquifer is locally controlled by natural surface drainage features as well as man-made drainage features such as Cow Pen Slough Canal. At the site, groundwater is controlled by the water levels in the Myakka River on the eastern half of the property and Cow Pen Slough Canal on the western half of the property.

Recharge to the surficial aquifer is mainly from rainfall, while discharge from the aquifer is mainly through evapotranspiration, direct surface runoff and lateral seepage to surface waters. Wells in the surficial aquifer can provide water for domestic water supplies and low volume agricultural uses such as livestock watering. Fluctuations in the water table are generally seasonal and vary within a 5-foot range. The highest levels, 0 to 2 feet below land surface, typically occur in

September or October, while the lowest water levels typically occur during April or May. Wolansky (1983) reports that the transmissivity for this aquifer for the Sarasota-Port Charlotte area is between 500 ft^2/day and 10,000 ft^2/day with an average of 1,300 ft^2/day. The storage coefficient ranges between 0.05 and 0.25 with an average of 0.20. These values vary significantly due to the variability in the thickness and hydraulic conductivity of the surficial soils which range from shell beds and rock units with high hydraulic conductivity to clayey fine sands with low hydraulic conductivity under both water table and leaky artesian conditions. Based upon the available total dissolved solids data, the surficial aquifer is classified under Florida Administration Code 17-3.403 as a G-II aquifer.

Intermediate Aquifer System

The intermediate aquifer system consists of all sediments that lie between and collectively retard the exchange of water between the overlying surficial aquifer system and the underlying Floridan aquifer system. These sediments in general consist of fine grained clastic deposits interbedded with carbonate strata belonging to all or parts of the Miocene and younger age formations. Wolansky (1983), distinguished two aquifer/confining unit systems for Sarasota County, namely the Tamiami - Upper Hawthorn aquifer and confining unit, which occurs in the Peace River Formation, and the Lower Hawthorn - Upper Tampa aquifer and confining unit, which occurs in the Arcadia Formation. The top of the Upper Hawthorn aquifer occurs at about 40 feet below sea level. This unit has an average thickness of about 100 feet. The lower Hawthorn-upper Tampa aquifer is the lowermost transmissive unit of the intermediate aquifer system. The top of this aquifer ranges from about 200 to about 250 feet below sea level. This unit ranges in thickness from about 150 to 200 feet.

The Tamiami - Upper Hawthorn aquifer consists of the sandy limestones and sandstones of the old Tamiami Formation and the sandy limestones and dolomites from the upper portion of the old Hawthorn Formation. The Tamiami-upper Hawthorn aquifer (Duerr and Wolansky, 1986) consists of partially consolidated deposits of phosphatic marl, shell, sand and clayey sand, and thin beds of phosphatic limestone. Many lateral facies changes occur within the stratigraphic units. The regional groundwater flow direction in this aquifer unit is to the west and southwest at the study area (Wolansky, 1983) and the potentiometric surface in this unit fluctuates above and below the elevation of the water table. Water table readings from the Southwest Florida Water Management District ROMP wells (1983) to the east and west of the site indicate that the site is between an area of upward flow and an area of downward flow through the upper confining unit. Localized pumping drawdowns can depress the potentiometric surface as much as 20 feet during the peak pumping periods of the dry season. The most widely exploited aquifer unit in Sarasota County is the Tamiami - Upper Hawthorn aquifer. It provides most of the domestic and agricultural water supply to private wells in the Sarasota-Charlotte County area. The transmissivity of the Tamiami - Upper Hawthorn aquifer in the Sarasota-Port Charlotte area ranges between 500 ft^2/day and 3,500 ft^2/day, averaging 2,600 ft^2/day. The storage coefficient typically is between 0.5×10^{-4} and 1.5×10^{-4} and averages 1.0×10^{-4} (Wolansky, 1983). The leakage coefficient is on the order of 1.3×10^{-5} ft/day/ft (Wolansky, 1983). Duerr and Wolansky (1986) report transmissivity, storage coefficient and leakage coefficient of 800 ft^2 per day, 0.0001 and 0.0002 ft/day per ft, respectively for a site near Venice. Duerr and others (1988) report a transmissivity of 2,400 ft^2 per day from an aquifer performance test performed near the south edge of the site. The test was performed at a depth of 87 to 205 feet below land surface. Available total dissolved solids data for the Tamiami - Upper Hawthorn aquifer range between 500 mg/l and 1000 mg/l, classifying this aquifer under FAC 17-3.403 as a G-II aquifer.

The confining unit between the Tamiami-Upper Hawthorn aquifer and the underlying Lower Hawthorn-Upper Tampa aquifer consists of layers of sandy clay and marl and zones of limestone and dolomite containing interbedded clay which fills the fractures and voids. The stratigraphic location and amount of clay and marl in this confining unit can vary causing variations in the leakage (Scott and MacGill, 1981).

According to Wolansky (1983), groundwater flow within the Lower Hawthorn - Upper Tampa aquifer is from east to west. The transmissivity of the Lower Hawthorn - Upper Tampa aquifer ranges between 500 ft^2/day and 10,000 ft^2/day, with an average of 2,600 ft^2/day in the Sarasota-Port Charlotte area. The storage coefficient has a range of between 0.5×10^{-4} and 3.0×10^{-4} with an average of 2.0×10^{-4} (Wolansky 1983). The leakage coefficient for this aquifer is on the order of 1.5×10^{-6} ft/day/ft (Wolansky 1983). Duerr and Wolansky (1986) report transmissivitities, storage coefficients and leakage coefficients of 2,500 and 9,000 ft^2/day, 1.0×10^{-4} and 1.2×10^{-4}, and 1.0×10^{-4} and 12.3×10^{-4} ft/day/ft for two tests in the central Sarasota County area. The potentiometric surface of this aquifer unit is generally about 10 feet higher than that of the Tamiami - Upper Hawthorn aquifer (Wolansky et al., 1983). Groundwater from the aquifer is used for agricultural supplies or demineralized for use as a public water supply.

The Floridan Aquifer System

The confining unit between the Lower Hawthorn-Upper Tampa aquifer and the Upper Floridan aquifer, occurs between -400 and -450 feet below sea level and consisting of a residual layer of stiff calcareous clay with a low hydraulic conductivity. Wolansky (1983), reports an average leakage coefficient on the order of 5×10^{-6} ft/day/ft. The Floridan aquifer, encountered at an approximate elevation of -450 feet (NGVD) at the study area (Wolansky, 1983), includes the Suwannee Limestone, Ocala Limestone and the Avon Park Formation. The lower portion of the old Tampa Formation, below the confining unit, is also included as part of the Floridan aquifer in some locations (Joyner & Sutcliffe, 1976).

The direction of flow in the Floridan aquifer at the site is to the northwest. According to Wolansky (1983), the transmissivity of the Floridan aquifer in the Sarasota County-Port Charlotte area, ranges from 100,000 ft^2/day to 500,000 ft^2/day with a storage coefficient that ranges from 1.1×10^{-3} to 1.7×10^{-3} averaging 1.3×10^{-3}. The leakage coefficient ranges from 1×10^{-6} to 1×10^{-5} ft/day/ft. The potentiometric surface of the upper Floridan aquifer is approximately 10 to 15 feet above that of the Lower Hawthorn - Upper Tampa aquifer (Wolansky et al., 1985).

Although the Floridan aquifer's production capabilities exceed those of the overlying intermediate aquifers, the quality of the water withdrawn is not as high as that of the intermediate aquifer system; therefore, it is not exploited as extensively, but is used for some agricultural water supplies.

FIELD EXPLORATION AND LABORATORY TESTING PROGRAM

Boring And Sampling Program

The approximate location of each test boring drilled at the site is shown on Figure 2. In an effort to minimize disturbance of the heavily vegetated and wooded site, borings were placed along existing trails or other readily accessible areas. The boring locations were determined in the field from points of reference with the use of an uncontrolled mosaic aerial photograph similar to Figure 2. Land surface elevations at the borings were estimated to the nearest 0.1 foot based on the 1 inch equals 800 feet scale topographic map with numerous spot elevations provided to us by CDM. The locations and elevations should be considered accurate only to the degree implied by the methods used.

The results of these borings are presented in the form of boring logs in Appendix A and generalized soil profiles in Figures 4 through 6. The stratification represents our interpretation of the field logs and the results of laboratory testing of the recovered soil samples from the borings. The stratification lines shown on the boring profiles represent the approximate boundary between soil types and the transitions may be more gradual than implied.

The soil boring profiles are representative of subsurface conditions only at their respective locations and for their depths of penetration. Local variations of the subsurface materials in the area are anticipated and may be encountered. The relative density of cohesionless soils and the consistency of cohesive soils may be inferred from the engineering classification table presented with the soil boring profiles. The classification table is based on empirical correlations with the SPT blow count values (N-values).

All Standard Penetration Test (SPT) borings were performed in general accordance with ASTM Standard D-1586. Split-spoon soil samples recovered from each interval of the SPT during the field exploration were immediately sealed in the field in air-tight jars and later returned to our Orlando laboratory for additional testing and classification. The procedure used for performing the SPT is presented in Appendix B.

Phase I Program

The field exploration program for Phase I of the project was as follows:

- Drilled 26 SPT borings (twenty 50-foot and six 100-foot borings) to investigate the stratification of the site soils on approximately 1000-foot centers within the landfill area for foundation analyses.

- Collected disturbed samples to be used for laboratory classification testing.

- Collected an undisturbed sample of clay to be used for laboratory consolidation testing.

As discussed above, disturbed samples consisted of SPT jar samples which were returned to our laboratory for natural moisture, percent fines and Atterberg limit determinations. An undisturbed Shelby tube sample was obtained for the purpose of determining the pre-consolidation pressure within a clay layer beneath the proposed landfill footprint. The procedure for taking the Shelby tube is summarized in Appendix B.

Phase II Program

The field exploration program for Phase II of the project was as follows:

- Drilled 53 SPT borings to depths typically between 35 and 50 feet to investigate the stratification of the site soils on approximately 1000-foot centers around the landfill area and particularly where potential borrow areas were designated.

- Performed rock corings to obtain samples for laboratory classification testing.

- Collected disturbed and undisturbed samples of soils to be used for laboratory testing.

- Installed 16 shallow and 3 deep monitor wells around the study site to document the water table, to perform *in situ* hydraulic conductivity testing, and to document both lateral and vertical groundwater flow directions.

- Measured *in situ* water quality at each of the wells and obtained water samples from of the wells for laboratory chemical analysis.

Disturbed soil sampling for Phase II of the field program included collection of both SPT jar samples from which natural moisture, fines content and Atterberg limit determinations were performed, and bag samples (25 lbs to 35 lbs) for the purpose of proctor testing, sieve analyses, Atterberg limit determinations, hydraulic conductivity testing, and carbonate content determinations. In addition several rock cores were retrieved and returned to our laboratory where the rock mass rating classification system was used to classify the rock. Undisturbed Shelby tube samples were also retrieved from the field and transported back to our laboratory for determining the engineering properties of the soils.

The Phase II boring program was designed to primarily investigate potential soils for borrow material in the identified borrow areas.

Monitor Well Installation

A total of 16 shallow (typically 15 feet deep) and 3 deep (ranging between 77 and 92 feet deep) monitor wells were installed to establish a water table map for the site, vertical and horizontal groundwater gradients beneath the landfill, horizontal hydraulic conductivities of the soils adjacent to the collection zones for the wells, and background groundwater quality. Figure 2 shows the location of each of the monitoring wells and Table 3 tabulates the construction details for each monitor well. A graphical representation of each monitor well showing location of screen, sand pack and grout is included on the appropriate boring log in Appendix A. All of the monitor wells were constructed with 2-inch diameter Schedule 40, threaded, flush-joint, PVC casing.

The 2-inch diameter monitor wells were installed by drilling a 6-inch diameter hole to the final well depth, inserting a section of 2-inch diameter slotted (.010-inch slot) PVC pipe connected to a 2-inch diameter solid PVC riser pipe, backfilling the annular space around the slotted section of the pipe with 20-30 silica sand, backfilling a one foot layer of fine sand over the silica sand and then grouting the remaining annular space with neat cement to land surface. Well covers and protective pads were also provided for each well.

Field Hydraulic Conductivity Testing

In situ hydraulic conductivity or "sensitivity" tests were performed at 12 of the 19 installed monitor wells. Both falling and rising head methods were performed by raising or lowering the water level in the monitor well standpipe and then measuring the time rate of change of the water level in the monitor well. Average calculated horizontal hydraulic conductivities at each of the tested monitor wells are presented in Table 3. Typically the horizontal hydraulic conductivity ranged between 2 feet/day and 20 feet/day. The horizontal hydraulic conductivity for the fine sand to silty fine sand ranged between 2.5 and 159 feet/day with an average of 33 feet/day from six tests. The horizontal hydraulic conductivity for the silty to clayey fine sands ranged between 4.8 and

54 feet/day with an average of 17 feet/day from six tests.

Water Table Data

Water levels at each monitor well were measured in July 1990, December 1991, and February 1992. In addition, the water level at 7 surface water monitoring stations installed by Sarasota County personnel were also measured in December 1991 and February 1992. These data are compiled in Table 4 and water table contour maps summarizing the data are presented in Figures 7 and 8. The July 1990 map (Figure 7) represents high water table conditions and the February 1992 map (Figure 8) represents low water table conditions.

Water Quality Data

In situ water quality parameters including pH, specific conductance, salinity and temperature were measured in the field in July 1991 for all monitor wells with the exception of P-14D which was not installed at the time. These data are compiled in Table 5. In addition 4 water samples were retrieved from P-2D, P-7S, P-9 and P-11 and transported to Flowers Laboratory in Orlando for chemical analyses. Parameters tested included total phosphorous, total nitrogen and the primary and secondary drinking water list parameters, except for the volatile organics, TTHM and radionuclides.

LABORATORY TESTING PROGRAM

General Laboratory Testing Program

All recovered split-spoon samples obtained during the field exploration were returned to our laboratory for visual classification. Visual classification was performed in general accordance with the procedures outlined by the Unified Soil Classification System (USCS). These soil descriptions are presented next to the sample depth on each of the boring logs presented in Appendix A.

The laboratory program associated with the soil samples collected as part of the Phase I field program included primarily soil classification testing. In addition to visual examination, the samples were tested for natural moisture content, percent fines content and Atterberg limit determinations. In addition, one consolidation test was conducted on an undisturbed sample of a clay layer to determine the pre-consolidation pressure of this layer for use in our foundation evaluation.

The laboratory program associated with the soil samples collected during this Phase II field program included more detailed soil testing, as well as chemical testing. Laboratory testing included sieve analyses, Atterberg limits, proctor tests, laboratory hydraulic conductivity tests, strength tests (of rock material) and carbonate content tests.

Classification Tests

Soil classification tests included natural moisture contents performed in accordance with ASTM Standard D 2216 and percent fines determinations performed in accordance with ASTM Standard D 421. Percent fines is defined as the percent by dry weight passing a U.S. No. 200 standard sieve. Over 100 natural moisture contents and percent fines determinations were performed on soils from the subject site. The results of these determinations are included on the boring logs in Appendix A next to the sample depth.

Sieve Analyses

Sieve analyses were performed on selected samples in accordance with ASTM Standard D 2487. Grain size plots for these samples are presented in Appendix C. The tested soils were selected for evaluation based on their potential use as borrow materials and thus all tested samples were retrieved from test holes associated with the borrow areas outlined on Figure 2.

Atterberg Limits

Atterberg limit determinations (ASTM Standard D-2487) were made primarily on potential borrow material; however, some were made on samples retrieved as part of Phase I of the field exploration. The Atterberg limits determined during Phase I are included on the boring logs in Appendix A. Atterberg limit determinations performed as part of the borrow material evaluation are presented in Table 6 for those soils tested.

Density Testing

Moisture-density relationships are used to establish the compaction characteristics of a soil. Modified (ASTM D-698) and Standard (ASTM D-1557) Proctor compaction tests were conducted on several samples of potential borrow materials obtained from areas that are and were within borrow areas at the study site. The results of these tests are included in Figures 9, 10, 11 and 12. Figure 9 summarizes the Proctor data while Figures 10 through 12 summarize the density-moisture-permeability relationship for select borrow soils.

Laboratory Hydraulic Conductivity Testing

Laboratory hydraulic conductivity tests were conducted on several remolded samples for which Proctor testing was conducted. The tests were performed on remolded specimens with a diameter of approximately 3.5 cm and a length of approximately 8.9 cm. Constant head hydraulic conductivity tests were performed in specially manufactured triaxial-type permeameters with the test specimens encased in latex membranes. The head difference across the samples was monitored with an electric pore pressure transducer and was either automatically or manually recorded from a digital voltmeter. Water was used as the permeant, and the quantity of flow occurring through the specimens was monitored with time in 20 cc-burettes. Sufficient quantities of flow were allowed to pass through the specimens until constant values of the hydraulic conductivity were obtained. Generally constant head permeability tests were conducted at two separate moisture contents and densities for each of the soil samples and these data are presented in Table 7 and Figures 10 through 12. These latter three figures present a moisture-density-hydraulic conductivity relationship for each soil sample.

Rock Testing

Rock cores retrieved in the field were returned to our laboratory for general classification testing using a Geomechanics Classification system. The resulting rock mass rating is presented in Table 8. Table 8 also provides the Rock Quality Designation (RQD) for each flight cored and the unconfined compressive strength as determined in accordance with ASTM Standard D 2938.

Several bag samples of borrow soils were tested for the amount of rock and shell in the soil samples obtained in the field using flight augers. The samples were tested using the U.S. No. 4 and 3/8 inch sieves. Table 9 provides the results of this laboratory testing.

Carbonate Content Testing

The calcium and magnesium carbonate [(Ca,Mg)CO_3] content of soil is defined as the dry weight of sample which is (Ca,Mg)CO_3 as a percentage of the total weight of dry sample. To perform this analysis each sample was oven dried and pulverized fine enough to pass a U.S. No. 60 sieve. After that the sample was digested with excess hydrochloric acid to dissolve all the carbonate mineral and leave the sample solution acidic after the reaction is complete. Next the acid solution is neutralized and the quantity of basic solution added to neutralize it is measured to determine an equivalent $CaCO_3$ content. Carbonate content testing was conducted on a total of 7 samples of borrow materials retrieved from the site. The resulting values are presented in Table 6 as a percentage of total dry sample weight.

Water Quality Testing

A total of four water samples were retrieved from four of the monitor wells at the study site, P-2D, P-7S, P-9 and P-11. These water samples were transported to Flowers Chemicals Laboratories in Orlando for chemical analysis to obtain total nitrogen, total phosphorous, and the primary and secondary drinking water parameters except for volatile organics and radionuclides. The results of the chemical analyses are presented in Table 10. These data represent background water quality characteristics for the site.

ANALYSES AND CONCLUSIONS

Generalized Soil Profile

The results of the test borings for the field exploration are summarized on the soil boring logs presented in Appendix A. The boring profiles and related information presented in this report are based on the driller's field logs and visual examination and classification testing of soil samples in the laboratory. The delineation between soil types shown on the logs is approximate and the descriptions represent our interpretation of subsurface soil conditions at the designated boring location. While the borings are representative of subsurface soil conditions at their respective locations and for their respective vertical distances, local variations characteristic of the subsurface materials are anticipated and may be encountered. Surficial aquifer water level depths were documented at each hole by the drilling crew at the time of drilling. The first reading typically represents the first visual evidence of water during SPT drilling while the second reading typically represents the water level in the open borehole after drilling has been completed.

The results of our test borings indicate the following generalized soil profile:

Depth Below Ground Surface (Feet)		Soil Description
From	To	
0	5	Gray to brown fine sand with organic material and roots. Most of these samples were calcareous to some extent as indicated by moderate to slight reaction with hydrochloric acid. Standard Penetration Test N-Values typically ranged from 4 to 25 in this zone.
5	18	Gray to brown calcareous silty to clayey fine sand. Standard Penetration Test N-Values typically ranged from 10 to 30.

18	40	Gray to brown calcareous clayey fine sand with significant amounts of shell and rock fragments. A solid rock layer, often associated with a circulation loss, was noted frequently (at variable depth) as were local loose zones, again associated with partial or complete drilling circulation losses. Locally, a 3-to 10-foot thick layer of stiff gray to green/gray clay was documented within the proposed landfill footprint. Standard Penetration Test N-Values were highly variable due to the presence of rock but typically were not lower than 20.
40	100	Gray calcareous clayey fine sand to silty fine sand interbedded with layers containing rock fragments. Solid rock layers, associated with circulation loss were noted frequently (at variable depth) as were local loose zones, again associated with circulation loss zones. Standard Penetration Test N-Values were highly variable due to the presence of rock but typically were not lower than 20.

The above soil profile is outlined in general terms only. Please refer to the boring logs in Appendix A for more detailed descriptions at each of the test locations and the soil profiles in Figures 4 through 6 to see trends and variations. As part of the laboratory classification of the soil samples, many samples were treated with hydrochloric acid to determine whether or not they contained calcareous material. Virtually every sample tested did react with the acid, most reacted strongly. Not all samples were tested; consequently, this descriptive term was left off of the boring logs.

Site Specific Hydrogeology

The hydrogeological units underlying the site consist of the surficial aquifer system, intermediate aquifer system (Tamiami-upper Hawthorn and lower Hawthorn-upper Tampa aquifer), and the Floridan aquifer system. The available hydrogeological data indicate that the surficial aquifer is typically less than 15 feet thick; however, two areas on the site have sand thicknesses greater than 20 feet. These thicker deposits are west of Cow Pen Slough Canal (33 feet at TH-65) and in the vicinity of the Myakka River on the east (26 feet at TH-31). The transmissivity of the surficial aquifer typically is about 100 ft^2 per day. Duerr and Wolansky (1986) report transmissivities in the surficial aquifer ranging from 1,000 to 1,800 ft^2 per day from three tests in central Sarasota County. These values probably are from thick shell bed deposits.

Surficial aquifer groundwater at the study site is controlled by the Myakka River to the east of the property and Cow Pen Slough Canal on the western half of the property. East of the proposed landfill footprint, surficial groundwater flows east toward the Myakka River. The surficial groundwater beneath the other half of the property flows west toward Cow Pen Slough Canal east of the Canal, and east toward Cow Pen Slough Canal west of the Canal.

Table 4 presents surficial water level data measured at all monitor wells and staff gages on three occasions (July 17, 18 & 19, 1990, December 6, 10 & 13, 1991 and February 17,1992). Figure 7 presents a high water table elevation map of the site based on the July 1990 sampling information. The water table elevations range between 9.3 and 19.97 feet (NGVD). Figure 8 presents a low water table elevation map of the site based on the February 1992 sampling information. The water table elevations range between 8.9 and 16.6 feet (NGVD). Generally, water levels are higher for the July sampling than the February sampling reflecting differences in water levels between the wet and dry seasons. Exceptions to this trend occur along Cow Pen Slough Canal. Water levels in monitor wells P-15 and P-16 are influenced by Cow Pen Slough

Canal which is controlled by a sluice gate approximately 1 mile below the southern property boundary. This sluice gate is maintained at elevation 7.0 feet (NGVD) during the wet season (between June 1 and October 1) and at elevation 11.0 feet (NGVD) during the dry season (between October 1 and June 1). These fluctuations in water levels will impact the water table near the Canal.

Low permeability clayey layers generally occur from elevation about +10 to -40 feet (NGVD) and have a wide areal extent. The site is within a broad region where beds 10 feet or more in thickness with low hydraulic conductivity occur within 50 feet of the surface.

The Tamiami-upper Hawthorn aquifer is the uppermost part of the intermediate aquifer system. The top of the intermediate aquifer system is about 30 feet to about 40 feet below sea level and the upper unit has an average thickness of about 100 feet. The first transmissive zone is about 50 to about 75 feet below sea level. The lower Hawthorn-upper Tampa aquifer is the lowermost aquifer of the intermediate aquifer system. The top of this aquifer ranges from about 190 to about 220 feet below sea level and ranges in thickness from about 200 to 250 feet.

The Tamiami-upper Hawthorn aquifer (Duerr and Wolansky, 1986) consists of partially consolidated deposits of phosphatic marl, shell, sand and clayey sand, and thin beds of phosphatic limestone. Many lateral facies changes occur within the stratigraphic units. The transmissivity of this aquifer probably is on the order of 1,000 ft^2 per day based on the permeability and aquifer thickness documented at TH-31. Duerr and Wolansky (1986) report transmissivity, storage coefficient and leakage coefficient of 800 ft^2 per day, 0.0001 and 0.0002 ft/day per ft, respectively for a site near Venice. Duerr and others (1988) report a transmissivity of 2,400 ft^2 per day from an aquifer performance test performed near the south edge of the site. The test was performed at a depth of 87 to 205 feet below land surface.

The Tamiami-upper Hawthorn aquifer at the site is recharged by downward leakage from the overlying surficial aquifer, upward leakage from the underlying lower Hawthorn-upper Tampa aquifer and groundwater inflow from adjacent areas. The water table ranges from less than 2 feet below to 10 feet higher than the potentiometric surface in the Tamiami-upper Hawthorn aquifer. The potentiometric surface of the lower Hawthorn-upper Tampa aquifer is 5 to 10 feet lower than the potentiometric surface of the Tamiami-upper Hawthorn aquifer unit.

Well clusters at the same respective locations (P-2S and P-2D, and, P-14S and P-14D) can be used to document upward or downward gradients between the surficial and intermediate aquifers. From Table 4 it can be seen that the hydraulic gradients are both upward and downward. This type of fluctuating upward and downward flow direction is typical of the region. In the north part of the site (P-2) the hydraulic gradient was downward during July 1990 and February 1992 but upward during December 1991. In the south part of the site (P-14) the hydraulic gradient was upward during December and February. No data were available for July 1990. The potentiometric surface elevations of the artesian unit ranged between 13.16 and 15.87 feet (NGVD). The potentiometric surface was higher in the north in December 1991 and slightly lower in February 1992.

The deepest borings on the site penetrate only the top of the Tamiami-upper Hawthorn aquifer unit; therefore, this assessment does not incorporate site specific data in the artesian aquifers below this depth.

The Floridan aquifer system consists of the Upper and Lower Floridan aquifers separated by a "tight" middle confining unit. The vertically continuous sequence of carbonate rocks of generally high permeability that are of Tertiary age, are hydraulically connected to each other in varying degrees, and whose permeability is several orders of magnitude greater than that of the rocks that bound the system above and below form the Floridan aquifer. The middle unit and lower Floridan aquifer generally contain saltwater and are not used for potable supply even with a desalinization system.

The Upper Floridan aquifer is a major source of fresh groundwater for most of southwest Florida; however, in this area the water is too mineralized to be used as potable water without use of a desalinization system. The top of the Floridan aquifer is about 450 to 475 feet below land surface. According to Wolansky (1983), the transmissivity, storage coefficient and leakage coefficient for the Floridan aquifer in the Sarasota-Port Charlotte area range from 100,000 to 500,000 ft^2/day, 1.1 x 10^{-3} to 1.7 x 10^{-3} and 1 x 10^{-5} to 1 x 10^{-6} ft/day/ft, respectively. The potentiometric surface of the Floridan aquifer is 10 to 15 feet above the potentiometric surface of the lower Hawthorn-upper Tampa aquifer according to Wolansky and others (1985). The direction of flow in the Floridan aquifer at the site is to the northwest.

Duerr and Wolansky (1986) report that the quality of water in the surficial aquifer and the intermediate aquifer system probably is acceptable for potable use away from the coast. Water from the Floridan aquifer system is used primarily for agricultural purposes because it is too highly mineralized for potable use without desalinization. The artesian pressure of the various aquifers generally increases with depth except in the heavily pumped upper intermediate aquifer unit.

The total dissolved solids in the groundwater of the surficial aquifer based on specific conductance values of water from 16 monitor wells ranged from about 100 to 1,900 mg/l with an average of approximately 700 mg/l. The specific conductance values ranged from 163 to 2,540 μmhos/cm with an average and standard deviation of 944 and 559 μmhos/cm, respectively. The specific conductance value times 0.75 was used to estimate total dissolved solids. The Florida secondary drinking water standard for total dissolved solids is 500 mg/l.

The chemistry data from the groundwater at the onsite monitor wells are summarized in Table 10. The total dissolved solids from the groundwater in the top of the Tamiami-upper Hawthorn aquifer at TH-31 (P-2D) was 600 mg/l, which is slightly above the State standard for drinking water of 500 mg/l. Lead concentration exceeded the 0.05 mg/l drinking water standard at all wells except P-7S. The lead analysis was performed on an unfiltered sample; therefore, the measured concentration may not be representative of the actual groundwater because of the possibility that the preserved metals sample may have contained suspended particulates.

Well Inventory

A well inventory was compiled for the study site and a 1-mile perimeter around the study site. Both County and SWFWMD records were compiled for the following sections in Sarasota County:

Township	Range	Section(s)	Notes
38 South	19 East	1, 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, 16	Sections occupied partly or wholly by study property
38 South	19 East	5, 8, 17, 20, 21, 22, 23, 24	Sections around perimeter of property
38 South	20 East	6, 7, 18	
37 South	19 East	32, 33, 34, 35, 36	
37 South	20 East	31	

A total of 40 wells were identified through the use of the county and water management district files and these are compiled in Table 11. Ardaman & Associates, Inc. also interviewed various County and CDM personnel in an effort to identify other possible wells within the property. These sources provided a map prepared by Dr. Hawkins, land owner to the north, and a cultural resource assessment prepared by Piper Archeological Research Inc. Possible wells identified through this research are shown on Figure 2. Possible wells were identified in five sections of the property. Three wells were located in Section 1 in the northeast corner of the property. Well A could be at a small one-story residential building in the extreme northeast corner of the property. No well can be located here. Well B was a flowing well that was grouted up and abandoned in June 1989. Well C was identified on the map from Dr. Hawkins. One well (Well D) was identified in Section 10 south of the Class III site. This well was also identified on the Dr. Hawkins map. Two wells were identified in Section 3 in the north central edge of the property. Well E is at the residence in the out parcel north of the property. Well F was indicated by the presence of a windmill and animal watering station near the west edge of the landfill area. Piper (1989) reports this well as a water-pumping windmill dating from the ca. 1900 to 1920 period. Three wells have been identified in Section 9 in the southwest part of the study property. Well I was a flowing well that was grouted up and abandoned in June 1989. Wells G and H were identified on the Dr. Hawkin's map. Visits to the site could not locate any additional information about these possible on-site wells. Well(s) in the area of development will be located, if present, and properly abandoned prior to any construction.

Potential for Sinkhole Development

There are three distinct types of sinkholes which have developed in Florida. The first type is the classical collapse sink, which is generally steep-sided and rocky. It occurs when a cavity can no longer support the weight of the overlying soil and rock. This type of sink generally occurs when the limestone is at or near the surface and solution weathering is still very active. It is unlikely that cavities in ancient rocks at great depth below the surface, which have undergone much more intensive solution weathering in the past, are large enough to cause a deep-seated roof collapse. Any cavity which is large enough to have caused a roof collapse would have done so when it was closer to the surface and the beam action or arching effects of the overlying formation was not as great as it is today.

The second type of sink which is more common though not as dramatic as the collapse sink, is called a doline or solution sink. There is no physical disturbance of the soluble rock beneath a doline. Subsidence of the overlying soil occurs due to gradual lowering of the rock surface and/or the gradual dissolution or leaching of calcium carbonate from the calcareous soils and rocks which exists between the ground surface and the underlying aquifer. The Florida Geological Survey estimates that this type of subsidence occurs at the rate of one foot every five to six thousand years. Because the water flows radially to the intersection of vertical joints where the water enters the rock mass, the surface expression of the rock lowering or the leaching of the soluble soil constituents is a shallow depression located over the intersection of the joints. In some cases, the surface depression has the same shape as the original calcareous deposits, as in the case of a shell bed which has dissolved or partially dissolved since deposition.

The third type of sinkhole and probably the most common type of sink occurring in Florida is the erosion sink. Erosion sinks most frequently occur in an environment with the following characteristics:

- Limestones overlain by relatively pervious unconsolidated sediments, e.g. sandy soils.
- Cavity systems present in the limestone.
- A water table higher than the potentiometric surface in the underlying limestone.
- A breach of the limestone into the cavernous zone creating a point of high recharge to the artesian aquifer.

Under these circumstances water moving down into the limestone may take large amounts of sediment into the cavernous system creating a void in the overlying sediment. When the void in the overlying sediment reaches the size where the roof is no longer stable, the overburden will suddenly collapse. In many cases, the overburden is visible after the collapse, but some sinks of this type have occurred in which the collapsed overburden disappeared into the cavity system. In other cases, the sudden subsidence of the ground surface is only six inches to one foot deep.

Because solutioning is most active along fractures and joints in the limestone, it is desirable when studying the sinkhole potential of a site to ascertain the location of these features. The intersection of two joints is of particular interest. When the limestone surface is buried under overlying sediment, it is not possible to directly map these features. However, they can be inferred from linear surface expressions, e.g., stream segments, alignment of ponded depressions, alignment of similar vegetation and topography, variations in photographic tones, etc. These linear surface features are called lineaments.

Figure 13 presents a lineament map of the study area. The lineaments were discerned from aerial photographs and topographic maps. These linear features were grouped as first through third order features. Distinguishing these were as follows: first-order features - major drainage features (I lineaments); second-order features - major tributary features (II lineaments); third-order features - aligned ponds or variations in photographic tones (III lineaments). The primary direction of the lineaments is southwest-northeast. All lineaments at the site are judged to be third-order features typical for such a karst environment in Florida.

The presence of linear surface features is only one of the factors which must be considered in assessing the potential for sinkhole activity. Other factors include thickness of clay beds above the limestone layers, hydraulic head difference between the water table and potentiometric surface in artesian aquifers and groundwater pumping. Interbedded, relatively impermeable silts and clays are prevalent from about +10 to -40 feet (NGVD). As already documented, the vertical groundwater flow direction fluctuates between upward and downward during the wet and dry seasons, respectively. Figure 14 shows the site in relation to the sinkhole regions in Florida. As shown, the site is located in the least probable area for sinkhole development in Florida.

Additionally, a sinkhole inventory was performed for Sarasota County using the data base of the

Florida Sinkhole Research Institute. Four "sinkhole" occurrences have been recorded in Sarasota County. Two small sinkholes occurred in Venice and were reported to have been caused by processes related to construction and development and not from the previously discussed geological processes. A third sinkhole, induced by well drilling processes, occurred at Englewood. Finally, a fourth sinkhole was reported at Sarasota Beach on Siesta Key. None of these sinkholes are from normal geological processes.

A total of 79 SPT borings were performed at the study site and no cavities or loose raveling zones were encountered at any of the borings. The water loss zones represent significant changes in transmissivity values over a short vertical distance as opposed to any sinkhole related phenomenon. Furthermore, two surface depressional features were evaluated by performing SPT borings at the edge of and within the depression to look for evidence of ancient sinkhole collapse. These depressions are located on Figure 2 and the corresponding borings (TH-42, TH-43, TH-37 and TH-59) are presented in Appendix A and in generalized form on Figure 6 - cross sections I-I and J-J, respectively. No evidence of ancient sinkhole collapse was found at the depressional features investigated. The site does not have hydrogeological characteristics typical of sinkhole prone areas.

In summary, the past and present geologic, hydrologic and geotechnical evidence indicates that the conditions favorable for the development of sinkholes do not exist at the site. Furthermore, no evidence of recent sinkholes has been observed and recorded in the past in the area, nor do any of the aerial photographs indicate recent sinkhole activity. (The shallow depressions at the site are, in our opinion, the result of long term dissolution of calcareous materials in the surficial aquifer system.) It is our opinion that the potential for sinkhole activity at the subject site is extremely low.

Borrow Material Evaluation

At a typical Class I landfill site, there are many uses for borrow material, the largest of which is for daily, intermediate and final cover. Additional potential requirements for borrow material at landfills include: the clayey soil component of either a composite or double synthetic liner system; the constructed subbase of the liner system; granular materials for use in the leachate collection and detection systems; and protective soil cover for the liner. The following paragraphs discuss the availability and suitability of these materials at the subject site.

Over 20 SPT borings were performed along the edge and within the designated borrow areas to evaluate potential sources of borrow materials for use in conjunction with landfill operations. Figure 15 provides detailed soil profiles within these borrow areas. The locations of the cross sections are shown on Figure 2.

<u>Initial And Intermediate Cover</u>

Initial (daily) cover is a 6-inch layer of earth used to enclose a volume of solid waste prior to intermediate or final cover. Class I landfills must receive initial cover at the end of each working day. An intermediate cover of one foot of compacted earth in addition to the 6-inch initial cover must be applied within 7 days if additional solid waste will not be deposited on top of the cell within 180 days of cell completion. Initial and/or intermediate cover is applied to minimize adverse environmental, safety, or health effects such as those resulting from birds, unauthorized wastes, blowing litter, odors, vectors or fires. Initial or intermediate cover generally consists of a non-organic granular fill that is easily placed and compacted to form a firm working surface for equipment and personnel. Abundant quantities of near-surface sandy materials exist in the proposed borrow areas that would be suitable for this purpose. Soils with strata Numbers 1 through 7 shown on Figure 15 can be used for daily and intermediate cover. The more plastic soils (e.g., Strata 9 and 10) generally should not be used for initial or intermediate cover because of the potential for routing leachate away from the leachate collection system and because of their poorer traction when wet.

Final Cover

Final cover is used to cover the top and sides of a landfill when fill operations cease. Final cover must contain a synthetic membrane, clayey soil, or chemically-or physically-amended soil to minimize infiltration. Top soil or soil that will sustain vegetative growth must overlay the synthetic membrane or the clay component of the final cover. The final cover must be at least 24 inches thick over the refuse. The soil used for daily and intermediate cover are suitable for covering and protecting the synthetic liner or the clay component of the final cover. Flexible membrane liners must also be protected from physical damage from above and below the membrane. All materials in direct contact with the liner must be free of rocks, roots, debris, sharps or particles larger than 3/8 inch.

Strata 9 and 10, which occur sporadically above the bedrock layer are the site soils that have the most potential to serve as a clay liner component of the final cover. It may be possible to segregate these strata during daily borrow operations and stockpile these soils for future use. (See further discussion below in the Excavation of Borrow Materials section).

Bottom Liner

The state rules for Solid Waste Management Facilities (F.A.C. Chapter 17-701) require that all new landfills permitted after August 1, 1990 have a leachate collection and removal system in conjunction with either a composite liner or double flexible membrane liner. A composite liner is comprised of two components. The upper component is a 60-mil or thicker synthetic liner with a minimum water vapor transmission rate of 1×10^{-11} cm/sec or less. The lower component of the composite liner consists of at least 18 inches of clay with a maximum saturated hydraulic conductivity of 1×10^{-7} cm/sec constructed in 6-inch lifts.

The double membrane liner option calls for an upper and lower 60-mil flexible membrane separated by a secondary leachate collection and leak detection system, with a minimum hydraulic transmissivity of 1.0×10^{-3} m^2/sec, designed to keep the drainage layer from becoming completely saturated. The lower geomembrane is to be placed directly on a sub-base which should be a minimum of 6 inches thick and have a saturated hydraulic conductivity of less than or equal to 1.0×10^{-5} cm/sec.

A protective soil cover of not less than 24 inches is required over the upper membrane of either liner option.

The soil needed for liner construction must classify as a clayey sand or sandy clay in accordance with the Unified Soil Classification System (USCS) and typically needs to have a plasticity index between 20 and 70 percent. To achieve a saturated hydraulic conductivity under field conditions of 10^{-7} cm/sec or less, the saturated hydraulic conductivity under laboratory conditions should be no greater than 5×10^{-8} cm/sec.

Bag samples were obtained from several test holes to evaluate the potential for obtaining a clay borrow with a maximum saturated hydraulic conductivity of 10^{-7} cm/sec. Proctor, Atterberg Limits, sieve analyses and permeability test results were performed as part of this evaluation.

Modified Proctor (ASTM D-1557) and Standard Proctor (ASTM D-698) compaction tests were performed on representative samples of clayey soils with some potential for liner construction based on fines content. The results of these proctor tests are presented in Figure 9 (one test was also conducted on the sandy soils from TH-A-5 and TH-A-6). Three types of clayey soils are evident from the Proctor test data. Type I has a plasticity index of approximately 30 percent and an optimum moisture content from the Standard Proctor compactive effort of approximately 20 percent. These soils are not present in the proposed borrow areas. Type II soils, which do occur in the proposed borrow areas, have a plasticity index of approximately 10 percent and an optimum moisture content from the Standard Proctor compactive effort of approximately 10 percent. Type III soils, which occurred only in TH-A-1, are more plastic than the other tested soils but were also not found in the presently proposed borrow areas.

The fines content and plasticity indices of potential liner soils are presented in Table 6. The soil with the highest potential for use as a liner material is Strata 9, a silty to sandy clay, encountered sporadically just above the bedrock layer within the proposed borrow areas (See, e.g., TH-52 from 11 to 14 feet). This soil has a fines content of 76 percent and plasticity index of 15 to 20 percent. Permeability testing of this soil compacted wet of optimum to the Standard Proctor density indicated a saturated hydraulic conductivity of 9 x 10^{-8} cm/sec (See Table 9). Based on the above, Strata 9 is not recommended for use as the clay component of a composite bottom liner. It is our opinion that a source of suitable soil for liner construction is not available within the proposed borrow areas at the site. If a composite liner is selected for the landfill, soil for the clay component will need to be obtained from an off-site source.

Leachate Collection System

Under the landfill rule, the drainage layer over a composite liner must be designed to limit leachate depth on the liner during landfill operation to 1 inch except for one week following the design 25 year, 24-hour storm event. The drainage layer over the liner will be at least 12 inches thick and shall have a hydraulic conductivity of not less than 1 x 10^{-3} cm/sec at a slope to promote drainage.

In addition to the specified hydraulic conductivity, the chemical make-up of the drainage layer is also important. In particular, only non-calcareous, inert granular soils are normally specified for this layer to preclude undesirable reactions with the landfill leachate. Soils with high carbonate contents, for example, can react with the leachate from the landfill resulting in possible dissolution of the drainage layer and clogging of the underdrain system. Our evaluation of the borings and laboratory testing of soil samples retrieved within the defined borrow areas indicate that most of the relatively clean sandy soils are calcareous to varying degrees, consequently we do not recommend their use in the drainage layer. They may, however, be used as part of the protective soil above the drainage layer.

Excavation Of Borrow Materials

Borrow materials suitable for daily, intermediate and final top cover are available within the designated borrow areas. Based on the available borings and laboratory testing, clayey borrow potentially suitable for use as a soil top liner exists within the proposed borrow areas, however, these clayey soils are not areally extensive and are typically encountered at deep depths (between 16 and 30 feet below land surface). Careful management of the borrow areas would be required for the maximum utilization of these clayey soils for a top liner. The clayey borrow would need to be separated and stockpiled for such use as necessary during excavation of daily and intermediate cover. Additional investigation would be required to determine how and if this concept could be implemented cost effectively.

The presence of rock layers at the study site may also present excavation problems. Although not continuous over the entire site, rock layers were encountered at depths of less than 20 feet and soil samples containing rock fragments and SPT "N-Values" greater than 50 blows per 12 inches were also quite common at depths less than 20 feet. Several rock cores were retrieved in the field and laboratory test data for to these cores is presented in Table 8. Although classified as very poor rock, this material may require blasting where its removal is necessary.

Borrow materials can be excavated from the designated borrow areas either in the wet, using a dragline, or in the dry, using scraper pans. The dewatering system for excavating in the dry may consist of a perimeter ditch and one or more sumps. The sump discharge water would need to be placed in environmentally acceptable areas, e.g., in the stormwater retention ponds, to minimize potential adverse environmental impacts.

Foundation Evaluation

Foundation analyses were performed for the critical landfill cross section to determine the structural integrity of the landfill and foundation soils. Based upon the proposed landfill design provided to us by CDM (Figure 3), the final landfill configuration will have side slopes of 5H:1V with 20-foot wide benches placed at elevation intervals of 20 feet. This results in an overall landfill slope of 5.7H:1V as measured from natural ground to the crest of the landfill (see Figure 16). The overall height of the landfill will be 100 feet above grade and no refuse is to be placed below grade. Either a composite or double synthetic bottom liner system will be a part of the landfill design. A synthetic drainage net and geotextile filter fabric which together could comprise the primary leachate collection and removal system are to lie directly above either liner scenario to maintain the hydraulic head close to the liner surface.

The soil profile indicates several soil types directly beneath the landfill footprint. The surficial soils, from 0 to 18 feet below ground surface, are typically medium to dense sandy materials with varying amounts of silt and clay and have Standard Penetration Test "N-Values" ranging from 5 to 20. It was assumed that any unsuitable surficial organic or soft materials will be removed prior to liner construction and this material was not considered in the analyses. Underlying the sandy surficial soils were silty to clayey fine sands with significant rock and shell fragments and higher Standard Penetration Test "N-Values", typically ranging between 15 and greater than 50 blows per 12 inches. A stiff clay layer (average of all Standard Penetration Test "N-Values" equal to 21) with variable thickness (maximum 10 feet) was encountered at depths ranging from 18 to 40 feet beneath a large section of the landfill footprint, as were loosely consolidated rock layers. The predominant material below the surficial soil deposits, however, is silty to clayey fine sands. Below a depth of 50 feet, high SPT "N-Values" (greater than 50 blows per 12 inches) were encountered. The clayey to silty fine sand underlying the proposed landfill was assumed to be saturated (i.e. the water table was placed at the natural ground surface) and was given a buoyant unit weight of 65 pcf and a friction angle of 30°. A unit weight of 45 pcf and an angle of internal friction of 26° was assumed for the landfill refuse material.

The natural ground foundation soils underlying the proposed landfill footprint are very dense and competent and our stability analyses document that they will provide adequate support for the proposed waste fill materials. The critical element controlling stability of the proposed landfill is the synthetic liner and underdrain system. The HDPE liner material is typically very smooth and has a much lower friction angle than most earthen construction materials. The smooth liner surface is particularly critical at the interface of the liner with other geotextiles, resulting in a relatively high potential for sliding at the contact interface.

There are four basic material interfaces in either bottom liner and underdrain scenario that need to be evaluated. These include: 1) HDPE liner to underlying soil, 2) HDPE liner to HDPE drainage net, 3) HDPE drainage net to geotextile and 4) geotextile to soil cover. After the final material selections are made for the liner and underdrain construction, we recommend that the coefficient of friction for each of the interface materials be established by laboratory testing of the actual materials used in construction. These data should then be used to refine the preliminary stability analyses presented in this report.

Based on a literature review and our experience with similar lines and geotextile materials, we have determined that the critical condition of sliding (i.e., lowest coefficient of friction) will most likely occur at the interface of the HDPE liner with the HDPE drainage net. Reported values of friction in the literature available to us indicate considerable variation, depending on material type and manufacturer, however our experience combined with a recent evaluation of a landfill stability failure (Mitchell, Seed and Seed, 1990 and Seed, Mitchell and Seed, 1990) indicate that a value of 8° is appropriate.

We have performed preliminary stability analyses including translational sliding failure at the HDPE liner - HDPE drainage net interface and circular arc stability analyses as shown in Figure 16. A minimum factor of safety of 1.6 was calculated for the translational type failure while a minimum factor of safety of 2.6 was calculated for a circular arc type failure which passed almost entirely through the refuse. A factor of safety of 1.5 is generally considered adequate for these types of analyses.

The total foundation settlement resulting from the proposed landfill has been predicted based on the 100-foot high proposed landfill design and considering a refuse unit weight of 45 pcf. The total load applied by the landfill at the maximum height will be 4,500 lb/ft^2. Standard Penetration Test borings TH-1 through TH-26 were used to establish conditions beneath the proposed landfill and based on this information it was concluded that only the shallow 18 feet of sandy soils and the stiff clay layer underlying the first hard layer will contribute to settlements.

Settlements within the upper 18 feet of sandy soils were calculated using the method developed by Peck and Bazaraa, (1969). This method correlates Standard Penetration Test "N-Values" with the load necessary to induce a 1-inch settlement and then the actual settlement is calculated for the actual load applied. This method results in approximately 2 inches of settlement for the upper 18 feet of soils.

The stiff clay layer was evaluated for settlement potential using classical consolidation theory. A laboratory consolidation test on an undisturbed sample of this clay resulted in a compression index of 0.113 and a preconsolidation pressure of approximately 7,000 psf. The natural moisture content of the clay was approximately 131% and the liquid and plastic limits were 327% and 106%, respectively resulting in a plasticity index of 221%. The present consolidation pressure existing on the clay layer is approximately 2,100 psf and when the additional landfill load of 4,500 psf is considered the total stress on the clay will be approximately 6,600 psf. Our calculations indicate settlements of 2 inches or less will occur considering a 10-foot thick clay layer.

Combining the settlements calculated for the two layers the maximum expected foundation settlement under the weight of the proposed landfill is 4 inches. This magnitude of settlement will not adversely affect the performance of the liner.

No adverse geotechnical siting factor is apparent from the geotechnical investigation that would preclude use of the site for a Class I landfill.

Groundwater Impact Assessment

In our opinion, the potential for measurable groundwater impacts resulting from construction of a properly designed solid waste disposal facility on the site are extremely remote even on the site itself let alone on any adjacent properties, for example, the MacArthur Reserve Tract. Certainly, measurable impacts, if any, would be limited to the immediate vicinity of the landfill, i.e., within 20 feet vertically and 100 feet horizontally of the liner.

A landfill on this site will not be permitted if the County cannot provide reasonable assurance that the primary and secondary groundwater standards will be met at the edge of the zone of discharge, i.e., at the base of the surficial aquifer directly beneath the liner and 100 feet adjacent to the edge of the refuse. The FDER has developed very stringent design standards for landfill liners and leachate collection systems. The most recent revisions to these design standards require either composite or double liner systems beneath all Class I landfills. During the various revisions to the liner design standards which have occurred in the past 5 years, the performance criteria have evolved from an allowable leakage of almost 2 inches per year to less than 0.003 inches/year. In terms of liner effectiveness, the liner design standard has evolved from one that was 80 to 90 percent effective to one that is better than 99.97 percent effective in preventing the movement of leachate through the liner system.

As shown by the water table maps contained on Figures 7 and 8, groundwater seepage beneath the proposed Class I landfill is toward Cow Pen Slough Canal. Any predicted groundwater impacts would occur beneath and downgradient from the landfill. There is no potential for groundwater impacts upgradient from the landfill. For this reason, and because the site is separated from the MacArthur Tract by the Myakka River, there is no potential for groundwater from the proposed landfills to reach the MacArthur Tract through the surficial aquifer.

The production zone for the wells installed at the MacArthur Reserve is vertically separated from the surficial aquifer by more than 100 feet of clay confining units. It is our understanding that the MacArthur Tract wells tap the upper Floridan aquifer, the top of which is approximately 450 feet below land surface. Groundwater in this deeper production zone naturally flows vertically upward into the intermediate aquifer and laterally from the MacArthur Reserve toward the Walton Tract. Although pumping could reverse the gradient in the Floridan aquifer and across the confining layer, the probability that a drop of groundwater from the site would enter the production zone of the Upper Floridan aquifer on the MacArthur Tract within the next 1000 years is essentially zero.

Groundwater Monitoring Plan

The following groundwater monitoring plan shows the location of the proposed monitoring wells, construction details of the monitor wells, and water sampling and chemical analysis protocol for the proposed Class I and Class III landfills.

Replaced w/ Attachment 9 - Plan for Leachate Monitoring Surface Water + Ground Water CDM 7/93

Well Locations

The 14 proposed monitor well locations for the site are shown in Figure 17. The plan shows 13 surficial aquifer monitor wells placed at approximately 1000-foot spacing along the perimeter downgradient of the two landfill areas. The downgradient areas are defined by the water table maps in Figures 7 and 8. The down gradient positions are primarily along the west and south sides of the landfills and along the east side of the Class III area. The same spacing was considered around the two landfills because the County in the future may want to convert a portion of the Class III area to a Class I type landfill. The upgradient monitor well (MW-1) is located north of the landfill about 500 away. The water table elevation data from the site (Figures 7 and 8) indicate that the highest water table elevations are in this area of the site. The compliance wells are located approximately 100 feet from the edge of the refuse. No artesian aquifer wells are proposed because of the thick confining units and the fact that the leakage through the liner will be such small quantities. At least 40 feet of clayey deposits separate the surficial aquifer from the upper zone of the intermediate aquifer system.

Well Construction

The new monitoring wells will be constructed using the guidelines provided in ASTM D-5092 generally summarized in the following manner. A hollow-stem auger boring will be drilled at each site to the top of the first clayey unit. The bottom of the well screen will be located at this depth. The top of the well screen will be located approximately 5 feet below land surface. The minimum well screen length will be 5 feet. After installation, the wells will be developed until the pumped water is clear.

A schematic of monitor well construction is presented in Figure 18. The 2-inch diameter wells will be installed by advancing a 6-inch diameter hole to the final well depth, inserting a length of 2-inch diameter No. 10 slotted PVC pipe connected to a 2-inch diameter schedule 40 PVC riser, backfilling the annular space with silica sand to above the screen, installing a one foot thick tamped bentonite seal above the collection zone and backfilling with a neat cement grout to land surface. Each of the monitor wells will be protected by a vented cap with a protective casing installed with a lockable cover.

The following pertinent hydrogeological data will be documented for each monitor well:

- Well identification
- Latitude/longitude of well
- Aquifer monitored
- Casing diameter
- Casing type and length
- Elevation at land surface
- Elevation of top and bottom of collection zone
- Total depth of well
- Screen type and slot size
- Lithologic description of the screened zone
- Direction of groundwater flow in screened zone
- Elevation at top of pipe

Sampling Protocol

Each well would be sampled quarterly. Grab samples would be taken using a peristaltic, submersible or bladder pump or bailer in accordance with a site specific quality assurance project plan developed as part of the conditions of the construction permit. The procedures for sampling are summarized as follows:

- Transport the sample bottles and preservatives to the site as provided by the water analysis laboratory certified for the specific analyses.

- Rinse, with distilled water, the tubing or sampling device to be used for sample collection to avoid cross contamination if decontaminated or new tubing is not brought to the field for each well.
- Measure *in situ* water level to the nearest .01 foot from the top of the casing. Purge the well of a minimum of three casing volumes prior to sampling. (A casing volume is determined by subtracting the water table depth from the depth of the well then calculating the volume within that length of casing.) Record water level at the start of pumping and every 5 minutes thereafter. Guidelines for obtaining water level measurements are provided in Table 12.
- Withdraw water sample and place into proper container once measurement values from three consecutive readings are essentially constant. Laboratory instructions (e.g., type of bottle, quantity of sample, and preservative) must be followed carefully and thoroughly. Record types of materials that the water sample contacted during collection (e.g., teflon, pvc, steel).
- Label sample bottle with well identification(s), final temperature, pH, conductivity, date and sampler's initials.
- Ice samples down as soon as the sample is obtained and prepare for transportation to water analysis laboratory.
- Complete field note-taking as per water sample log sheet shown in Table 13. Document the pump operating time prior to collection of sample plus pumping rate at well in gallons per minute. Alternatively, document the casing volumes evacuated from the well prior to sampling.
- Transmit collected samples to water analysis laboratory within 24 hours of sampling. The chain of custody form to be used is shown in Table 14.

Sample collection, preparation and testing procedures will adhere to the applicable procedures set forth by the Florida Department of Environmental Regulation.

<u>Groundwater Monitoring Parameters</u>

The following suite of parameters is proposed for the routine groundwater monitoring program:

<u>Field Determinations</u>

- Water level
- Temperature
- pH
- Specific Conductance

Laboratory Determinations

- Total organic carbon
- Total dissolved solids
- pH
- Sodium
- Ammonium as N
- Iron
- Bicarbonate

The above physical and chemical analyses should be documented quarterly.

The water levels should be recorded prior to evacuating wells for sample collection. Elevation references should include the top of the well casing and land surface at each well site at a precision of ±0.1 foot for land surface and ±0.01 foot for the well casing.

Other Monitoring

Other monitoring is suggested to manage the landfill system at this site. A raingage should document daily rainfall. In addition, the quantities of leachate collected should be determined. Furthermore, staff gages should be installed and monitored at least weekly to understand water level fluctuations at ponds that have a surface water outlet. This supplementary monitoring program should provide the data for optimum management of the landfill and stormwater systems at this site.

Initially this supplemental water data should be compiled on a monthly basis.

REFERENCES

Brooks, H. K., 1981. Physiographic Map of Florida, Florida Institute of Food and Agricultural Sciences, Gainesville, Florida.

Buono, A., Spechler, R.M., Barr, G.L. and Wolansky, R.M., 1979. Generalized Thickness of the Confining Bed Overlying the Floridan Aquifer, Southwest Florida Water Management District. U.S, Geological Survey WRI 79-1171, Tallahassee, Florida.

Duerr, A.D., Hunn, D.J. Lewelling, B.R. and Trommer, J.T. (1988). Geohydrology and 1985 Water Withdrawals of the Aquifer Systems in Southwest Florida, with Emphasis on the Intermediate Aquifer System. U.S. Geological Survey WRI No. 87-4259. Tallahassee, Florida.

Duerr, A.D., and Wolansky, R.M. (1986). Hydrogeology of the Surficial and Intermediate Aquifers of Central Sarasota County, Florida. U.S. Geological Survey WRI No. 86-4068. Tallahassee, Florida.

Hardin, Kenneth W., Estabrook, Richard W., and Hansen, Howard F. (1989). Cultural Resource Assessment Survey of the Sarasota County Solid Waste Disposal Site, Sarasota County, Florida. Piper Archaeological Research, Inc. St. Petersburg, Florida.

Joyner, B.F. and Sutcliffe, H. Jr., 1976. Water Resources of the Myakka River Basin Area, Southwest Florida. U.S. Geological Survey WRI Report 76-58, Tallahassee, Florida.

Mitchell, James K., Seed, Raymond B., and Seed, H. Bolton, April 1990. Kettleman Hills Waste Landfill Slope Failure. I: Liner-system Properties. ASCE Journal of Geotechnical Engineering. Vol 116, No. 4. New York, New York.

Peck, R.B., and Bazaraa, A.R., May 1969. "Discussion Of Settliment Of Spread Footings On Sand," by D'Appolonia et al., Journal Of Soil Mechanics And Foundation Division, ASCE.

Scott, Thomas M., 1988. The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida, Florida Geological Survey Bulletin No. 59, Tallahassee, Florida.

Scott, Thomas M. and MacGill, Peter L., 1981. Geology of the Hawthorn Formation in Central Florida. Florida Bureau of Geology Report of Investigation No. 91, Tallahassee, Florida.

Seed, Raymond B., Mitchell, James K., and Seed, H. Bolton, April 1990. Kettleman Hills Waste Landfill Slope Failure. II: Stability Analyses. ASCE Journal of Geotechnical Engineering. Vol 116, No. 4. New York, New York.

U.S. Soil Conservation Service, 1954. Detailed Soil Survey of Sarasota County. U.S. Department of Agriculture, Washington, D.C.

Wolansky, Richard M., 1983. Hydrogeology of the Sarasota Port Charlotte Area, Florida. U.S. Geological Survey WRI Report 82-4089, Tallahassee, Florida.

Wolansky, Richard M. and Corral, M.A. Jr., 1985. Aquifer Tests in West-Central Florida, 1952-76. U.S. Geological Survey WRI Report 84-4044, Tallahassee, Florida.

TABLE 1

Summary of Mean Monthly Climatological Data

Month	BRADENTON 5 ESE		MYAKKA RIVER STATE PARK	
	Precipitation (inches)	Temperature (°F)	Precipitation (inches)	Temperature (°F)
January	2.77	60.9	2.55	Not Available
February	3.03	61.8	3.08	Not Available
March	2.92	66.4	2.82	Not Available
April	2.02	70.8	2.16	Not Available
May	3.24	76.0	3.84	Not Available
June	7.38	79.7	8.33	Not Available
July	8.82	81.2	8.43	Not Available
August	9.60	81.5	9.35	Not Available
September	8.45	80.5	8.59	Not Available
October	3.10	74.5	3.37	Not Available
November	1.97	67.5	2.12	Not Available
December	2.37	62.2	2.17	Not Available
Totals	55.67	71.9	56.81	Not Available

Note: Mean values of temperature and precipitation are compiled from recorded data between the years 1951 - 1980.

TABLE 2

Generalized Hydrogeologic Units

<table>
<tr><th colspan="2">SERIES</th><th colspan="4">SOUTHERN FLORIDA*</th><th colspan="2">ELEVATION AT SITE (FEET NGVD)</th></tr>
<tr><td colspan="2">Pleistocene and Holocene</td><td colspan="4">Undifferentiated Sediments</td><td colspan="2" rowspan="2">5 to 20†</td></tr>
<tr><td colspan="2" rowspan="2">Pliocene</td><td colspan="4">Tamiami Formation*</td></tr>
<tr><td rowspan="6">Hawthorn Group</td><td rowspan="3">Bone Valley Formation</td><td colspan="2">Wabasso Beds*</td><td rowspan="3">0*</td><td>0*</td></tr>
<tr><td rowspan="5">Miocene</td><td>Upper</td><td colspan="2" rowspan="2">Peace River Formation*</td><td rowspan="2">5 to -25†</td></tr>
<tr><td>Middle</td></tr>
<tr><td rowspan="3">Lower</td><td colspan="3">Arcadia</td><td colspan="2">-25 to -450*</td></tr>
<tr><td>Tampa Mbr.*</td><td colspan="2" rowspan="2">Formation*</td><td>-250 to -400*</td><td rowspan="2"></td></tr>
<tr><td>Nocatee Mbr.*</td><td>0*</td></tr>
<tr><td colspan="2">Oligocene</td><td colspan="4">Suwannee Limestone</td><td colspan="2" rowspan="3">-450 to -1300‡</td></tr>
<tr><td colspan="2" rowspan="2">Eocene</td><td colspan="4">Ocala Group</td></tr>
<tr><td colspan="4">Avon Park Formation</td></tr>
</table>

Reference: * Scott, 1988
† Phase I boring data
‡ Wolansky, 1983

TABLE 3

Monitor Well Construction Details And Insitu Hydraulic Conductivity Results

WELL NO.	WELL DIA. (in.)	ELEVATION OF TOP OF RISER (FT NGVD)	RISER HEIGHT (FT)	GROUND ELEVATION (FT NGVD)	TOTAL WELL DEPTH[1]	SCREENED ZONE ELEVATION (FT NGVD)	HYDRAULIC CONDUCTIVITY OF GEOLOGIC MEDIA AT SCREEN INTERVAL (cm/sec)	LITHOLOGY OF GEOLOGIC MEDIA AT SCREENED INTERVAL	REMARKS
P-1	2	21.30	3.00	18.3	17.6	9.1 → 4.1	5.6×10^{-2}	Brownish gray silty fine sand	at TH-53
P-2S	2	22.83	3.20	19.6	13.5	14.6 → 9.6	1.9×10^{-3}	Gray silty fine sand	at TH-51
P-2D	2	22.62	3.10	19.5	79.1	-39.5 → -54.5	1.9×10^{-2}	Gray slightly clayey fine sand with rock	at TH-51
P-3	2	20.79	3.00	17.8	14.3	11.8 → 6.8	N/A	Brownish gray slightly clayey fine sand	at TH-52
P-4	2	23.03	2.95	20.1	15.3	13.1 → 8.1	8.9×10^{-4}	Gray silty fine sand	at TH-20
P-5	2	24.16	2.90	21.3	18.2	11.3 → 6.3	N/A	Brown slightly clayey fine sand	at TH-23
P-6	2	23.93	2.75	21.2	18.1	11.2 → 6.2	3.5×10^{-3}	Gray slightly clayey fine sand	at TH-27
P-7S	2	23.73	2.95	20.8	18.3	10.8 → 5.8	1.7×10^{-3}	Gray slightly silty to clayey fine sand	at TH-31
P-7D[2]	2	23.84	3.05	20.8	95.1[2]	-59.2 → -69.2	N/A	Rock with gray silt	at TH-31
P-8	2	18.25	2.74	15.5	18.1	5.5 → 0.5	1.0×10^{-3}	Gray slightly silty to silty fine sand	at TH-35
P-9	2	18.45	2.90	15.6	18.2	5.5 → 6.5	N/A	Gray clayey fine sand	
P-10	2	22.27	3.00	19.3	13.3	14.3 → 9.3	3.3×10^{-3}	Brown to gray silty fine sand	at TH-37
P-11	2	20.55	3.00	17.6	13.3	12.6 → 7.6	N/A	Gray silty fine sand	at TH-39
P-12	2	22.21	3.00	19.2	16.3	11.2 → 6.2	N/A	Gray fine sand to silty fine sand	at TH-4
P-13	2	19.70	3.05	16.7	18.4	6.6 → 1.6	3.9×10^{-3}	Brownish gray slightly clayey fine sand	at TH-56
P-14S	2	20.26	3.00	17.3	18.3	7.3 → 2.3	7.2×10^{-3}	Gray fine sand	at TH-60
P-14D	4	20.30	3.23	17.1	94.2	-50.9 → -70.9	4.6×10^{-3}	Gray clayey fine sand with rock	at TH-60
P-15	2	23.84	3.00	20.8	18.3	10.8 → 5.8	N/A	Brown to gray slightly clayey fine sand	at TH-61
P-16	2	21.78	3.00	18.8	18.3	8.8 → 3.8	2.4×10^{-3}	Gray clayey to silty fine sand	at TH-63

1 Measured from the top of riser.
2 Monitor well is damaged - appears to be plugged below elevation -8.1 ft NGVD.

TABLE 4

Water Table Elevations

STATION[1] NO.	ELEVATION OF TOP OF RISER OR STAFF GAUGE (FT NGVD)	JULY 1990		DECEMBER 1991		FEBRUARY 17, 1992	
		DEPTH TO WATER (FEET)	WATER ELEVATION (FT NGVD)	DEPTH TO WATER (FEET)	WATER ELEVATION (FT NGVD)	DEPTH TO WATER (FEET)	WATER ELEVATION (FT NGVD)
P-1	21.30	7.02	14.28	9.40	11.90	10.48	10.82
P-2S	22.83	4.45	18.38	8.04	14.79	7.56	15.27
P-2D	22.62	7.97	14.65	6.75	15.87	9.46	13.16
P-3	20.79	4.24	16.55	6.70	14.09	7.04	13.75
P-4	23.03	3.95	19.08	6.56	16.47	7.51	15.52
P-5	24.16	4.19	19.97	7.02	17.14	7.70	16.46
P-6	23.93	4.72	19.21	6.98	16.95	7.55	16.38
P-7S	23.73	4.54	19.19	6.73	17.00	7.12	16.61
P-7D[2]	23.84	13.94	9.90	18.03	5.81	13.40	10.44
P-8	18.25	4.08	14.17	6.57	11.68	7.22	11.03
P-9	18.45	5.45	13.00	7.27	11.18	8.75	9.70
P-10	22.27	2.97	19.30	6.85	15.42	7.72	14.55
P-11	20.55	3.22	17.33	6.29	14.26	6.89	13.66
P-12	22.21	3.00	19.21	5.52	16.69	6.02	16.19
P-13	19.70	4.39	15.31	6.11	13.59	7.55	12.15
P-14S	20.26	5.25	15.01	7.13	13.13	8.83	11.43
P-14D	20.30	--[3]	--	5.70	14.60	6.85	13.45
P-15	23.84	14.50	9.34	13.12	10.72	13.15	10.69
P-16	21.78	12.30	9.48	11.19	10.59	11.32	10.46
SW-B1	12.92	--[3]	--	4.20	8.72	2.10	10.82
SW-B2	22.54	--[3]	--	5.60	16.94	DRY	--
SW-B3	15.36	--[3]	--	5.40	9.96	5.60	9.76
SW-B4	18.43	--[3]	--	DRY	--	DRY	--
SW-B5	13.00	--[3]	--	4.10	8.90	2.00	11.00
SW-B6	14.87	--[3]	--	5.60	9.27	6.00	8.87
SW-B7	21.63	--[3]	--	4.40	17.23	DRY	--

1 P - monitor well location; SW - staff gauge location
2 Monitor well is damaged - appears to be plugged to elevation -8.1 ft NGVD.
3 Monitor well or staff gauge not installed at time of sampling.

TABLE 5

Water Quality Data
(Collected 7/19/90)

WELL NO.	ELEVATION OF TOP OF RISER (FT NGVD)	WATER ELEVATION (FT NGVD)	pH	CONDUCTIVITY (μMHOS/cm)	SALINITY (ppt)	TEMP. (°c)
P-1	21.30	14.28	6.81	630	0.10	23.5
P-2S	22.83	18.38	6.50	650	0.20	26.5
P-2D	22.62	14.65	6.90	990	0.50	24.2
P-3	20.79	16.55	6.65	1410	0.80	26.8
P-4	23.03	19.08	6.60	630	0.20	26.0
P-5	24.16	19.97	6.71	920	0.30	25.5
P-6	23.93	19.21	6.49	1490	1.00	25.5
P-7S	23.73	19.19	5.38	163	0.00	25.6
P-7D[1]	23.84	9.90	--	--	--	--
P-8	18.25	14.17	5.64	232	0.00	26.5
P-9	18.45	13.00	6.40	2540	1.40	24.7
P-10	22.27	19.30	6.39	1190	0.20	26.5
P-11	20.55	17.33	6.63	750	0.20	27.5
P-12	22.21	19.21	6.09	1000	0.10	26.9
P-13	19.70	15.31	6.64	710	0.00	25.5
P-14S	20.26	15.01	6.60	720	0.00	25.1
P-14D[2]	20.30	--	--	--	--	--
P-15	23.84	9.34	7.25	1090	0.40	26.2
P-16	21.78	9.48	6.80	980	0.30	25.3

1 Monitor well is damaged - appears to be plugged below elevation -8.1 ft NGVD.

2 Monitor well not installed at time of sampling.

TABLE 6

Summary Of Laboratory Testing Of Borrow Material Samples

TEST HOLE	SAMPLE NUMBER	SAMPLE DEPTH (feet)	UNIFIED SOIL CLASSIFICATION AND DESCRIPTION	FINES CONTENT (% -200)	CARBONATE CONTENT (%)	ATTERBERG LIMITS (%)		
						LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
TH-A-1	BS #1	9.5 → 11.5	Greenish Gray Clayey Fine Sand (SC)	46	-	-	-	-
TH-A-1	BS #2	11.5 → 15.5	Light Greenish Gray Sandy Clay (CL)	57	-	-	-	-
TH-A-5	BS #1	4.0 → 14.0	Brown Silty Fine Sand (SM)	16	-	-	-	-
TH-A-6	BS #1	11.5 → 18.75	Brown Slightly Silty Fine Sand (SP-SM)	12	-	-	-	-
TH-19	BS #1	13 → 16	Brown Sandy Clay With Some Phosphate (CL)	75	88.4	37	6	31
TH-19	BS #2	16 → 19	Brown Clay With Trace Sand (CH)	85	86.0	56	27	29
TH-19	BS #3	19 → 23	Brown Sandy Clay With Lenses Of Slightly Clayey Fine Sand With Rock And Phosphate (CL)	71	77.5	48	21	27
TH-41	BS #1 BS #2	18 → 20 20 → 23	Gray Sandy Clay With Phosphate (CH)	78	80.7	55	26	29
TH-44	BS #1 BS #2	11 → 14 14 → 17	Gray-blue Clayey Fine Sand And Lenses Of Slightly Clayey Fine Sand With Trace Shell And Phosphate (SC)	35	24.5	26	11	15
TH-44	BS #3	17 → 20	Gray Clay And Lenses Of Clayey Fine Sand With Trace Shell Fragments (CH)	56	-	60	28	32
TH-48	BS #1 BS #2	13 → 16 16 → 19	Gray Sandy Clay With Shell And Phosphate (CL)	53	58.2	22	12	10
TH-48	BS #3	19 → 22	Gray Clayey Fine Sand With Shell, Phosphate And Cemented Sand (SC)	34	-	19	13	6
TH-52	BS #1	11 → 14	Brown Sandy Clay With Lenses Of Silty Fine Sand (CL)	76	-	42	27	15
TH-52	BS #1 BS #2 BS #4	11 → 14 14 → 17 20 → 23	Brown Sandy Clay With Lenses Of Silty Fine Sand (CL)	76	-	46	25	21
TH-52	BS #3	17 → 20	Brown Silty Fine Sand And Shell With Cemented Sand (SM)	16	-	19	12	7
TH-57	BS #1 BS #2	11 → 14 14 → 17	Gray Clayey Fine Sand And Shell And Cemented Sand (SC)	36	-	-	-	-
TH-67	BS #1 BS #2	12 → 15 15 → 18	Soft Gray Clayey Fine Sand With Large Shell Fragments (SC)	40	-	-	-	-
TH-69	BS #1 BS #2 BS #3	8 → 12 12 → 17 17 → 22	Gray Silty To Clayey Fine Sand With Shell And Phosphate And Cemented Sand (SC)	41	53.5	18	13	5

TABLE 7

Summary Of Laboratory Hydraulic Conductivity Testing Of Remolded Borrow Material Samples

COMPOSITE NUMBER	TEST HOLE/ SAMPLE NUMBER (DEPTH IN FEET)	FINES CONTENT (%)	INITIAL MOISTURE CONTENT (%)	FINAL MOISTURE CONTENT (%)	INITIAL γ_D (lb/ft^3)	FINAL γ_D (lb/ft^3)	DEGREE OF SATURATION (%)	Vertical Laboratory Hydraulic Conductivity (cm/sec)	VOID RATIO (e)
1	TH-A-1/BS#1 (9.5→11.5)	50	9.6	19.1	122.6	112.0	102	1.25×10^{-8}	0.50
	TH-A-1/BS#2 (11.5→15.5)	49	11.6	17.0	120.7	119.6	113	1.12×10^{-9}	0.41
2	TH-A-5/BS#1 (4.0→14.0)	15	9.3	15.5	116.1	117.3	100	1.60×10^{-4}	0.41
	TH-A-6/BS#1 (11.5→18.75)	14	13.3	17.5	110.2	113.7	102	4.00×10^{-4}	0.45
3	TH-52/BS#1 (11.0→14.0)	75	30.4	25.8	90.5	100.4	94.4	9.20×10^{-8}	0.86
		76	24.6	23.8	98.5	101.8	93.6	9.30×10^{-8}	0.71

TABLE 8

Summary Of Rock Core Samples

TEST HOLE	FLIGHT NO.	DEPTH (feet)	RQD* %	q_u MPa	ROCK MASS RATING**
TH-31	1	26 → 31	10	1.92	Very Poor
TH-31	2	31 → 36	13	2.53	Very Poor
TH-31	3	36 → 41	0	***	Very Poor
TH-31	4	41 → 46	38	1.54	Very Poor
TH-31	5	46 → 51	10	***	Very Poor
TH-56	1	21.5 → 26.5	68	N/T	N/T

$$RQD = \frac{\text{Total Length of Sample Pieces 4 inches or Longer}}{\text{Distance Cored}} \times 100\%$$

** Geomechanics Classification System

*** No sample long enough to be tested

N/T Not tested

TABLE 9

Test Results Of Shell And Rock In Borrow Samples

TEST HOLE	SAMPLE NUMBER	SAMPLE DEPTH (feet)	PERCENT BY DRY WEIGHT LARGER THAN 3/8 in.	PERCENT BY DRY WEIGHT LARGER THAN NO. 4 SIEVE	PERCENT BY DRY WEIGHT SMALLER THAN NO 4 SIEVE
TH-19	BS #1	13 → 16	2.0	6.0	94.0
TH-19	BS #2	16 → 19	0.4	1.2	98.8
TH-19	BS #3	19 → 23	1.7	3.5	96.5
TH-41	BS #1 BS #2	18 → 20 20 → 23	0.9	2.7	97.3
TH-44	BS #1 BS #2	11 → 14 14 → 17	0.9	2.0	98.0
TH-48	BS #1 BS #2	13 → 16 16 → 19	0.3	0.9	99.1
TH-48	BS #3	19 → 22	2.1	4.7	95.3
TH-57	BS #1	11 → 14	4.8	10.0	90.0
TH-57	BS #2	14 → 17	6.0	12.4	87.6
TH-69	BS #1	8 → 12	0.2	1.1	98.9
TH-69	BS #2	12 → 17	0.5	1.8	98.2
TH-69	BS #3	17 → 22	0.8	1.7	98.3

TABLE 10

Summary Of Water Chemistry Data

PARAMETER	UNITS OF MEASURE	MCL	MINIMUM DETECTION LEVEL	MONITOR WELL NO. SAMPLED 7/19/90			
				P-2D	P-7S	P-9	P-11
FIELD MEASUREMENTS							
Water Elevation	FT NGVD		0.01	17.75	22.14	15.90	20.33
Water Temperature	°c		0.1	24.2	25.6	24.7	27.5
Conductance	μmhos/cm		1	990	163	2540	750
pH (Field)	Std. Units		0.01	6.90	5.38	6.40	6.63
pH (Lab)	Std. Units		0.01	7.23	5.00	6.20	7.49
Sampling Method (see Note)	-		-	PP	PP	PP	PP
Filtered (Field, Lab, No)	-		-	NO	NO	NO	NO
PRIMARY DRINKING WATER STANDARDS							
Inorganic Constituents							
Arsenic, As	mg/l	0.05	0.0005	ND	ND	0.0052	ND
Barium, Ba	mg/l	1.0	0.01	ND	ND	ND	ND
Cadmium, Cd	mg/l	0.01	0.001	0.004	ND	0.008	ND
Chromium, Cr	mg/l	0.05	0.005	0.006	0.010	0.017	ND
Lead, Pb	mg/l	0.05	0.01	0.11	0.02	0.17	0.07
Mercury, Hg	mg/l	0.002	0.0002	ND	ND	ND	ND
Nitrate, as N	mg/l	10.0	0.01	0.26	0.53	0.91	0.56
Selenium, Se	mg/l	0.01	0.0005	ND	ND	ND	ND
Silver, Ag	mg/l	0.05	0.005	ND	ND	0.006	ND
Organics							
Endrin	μg/l	0.2	0.001	ND	ND	ND	ND
Lindane	μg/l	4	0.0005	ND	ND	ND	ND
Methoxychlor	μg/l	100	0.01	ND	ND	ND	ND
Toxaphene	μg/l	5	0.1	ND	ND	ND	ND
2,4-D	μg/l	100	0.005	ND	ND	ND	ND
2,4,5-TP, Silvex	μg/l	10	0.002	ND	ND	ND	ND

Note: ND - Not Detected; PP - Peristaltic Pump.

TABLE 10 - Continued

Summary Of Water Chemistry Data

PARAMETER	UNITS OF MEASURE	MCL	MINIMUM DETECTION LEVEL	MONITOR WELL NO. SAMPLED 7/19/90			
				P-2D	P-7S	P-9	P-11
SECONDARY DRINKING WATER STANDARDS							
Chloride, Cl	mg/l	250	0.01	106.50	36.76	72.11	82.51
Color	PCU	15	5	ND	65	150	150
Copper, Cu	mg/l	1.0	0.005	0.014	0.008	0.034	0.012
Fluoride, F	mg/l	2.0	0.005	0.759	0.089	0.136	0.252
Iron, Fe	mg/l	0.3	0.01	0.16	5.15	54.20	0.60
Manganese, Mn	mg/l	0.05	0.005	0.007	0.005	0.025	0.016
Odor	TON	3	1	ND	ND	ND	ND
Sulfate, SO_4	mg/l	250	0.2	48.5	12.9	1361.9	22.0
Surfactants	mg/l	0.5	0.1	ND	ND	ND	ND
Total Dissolved Solids, TDS	mg/l	500	2.5	604.2	180.0	2477.3	459.1
Zinc, Zn	mg/l	5.0	0.001	ND	ND	ND	ND
OTHER PARAMETERS							
Calcium, Ca	mg/l	N/A	0.1	94.4	8.3	83.4	90.5
Magnesium, Mg	mg/l	N/A	0.01	20.60	6.01	20.30	8.71
Nitrite, as N	mg/l	N/A	0.01	ND	0.01	0.02	0.14
Sodium, Na	mg/l	N/A	0.002	83.500	6.450	46.700	51.200
Total Alkalinity, as $CaCO_3$	mg/l	N/A	0.1	141.0	-	112.7	186.1
Total Kjeldahl Nitrogen	mg/l	N/A	0.1	1.0	1.4	1.5	1.8
Total Phosphorous	mg/l	N/A	0.1	0.2	0.4	0.3	1.0
Turbidity	NTU	N/A	0.05	2.5	6.0	27.0	5.9

Note: ND - Not Detected; PP - Peristaltic Pump.

TABLE 11

Well Inventory

NO.	SECTION-TOWNSHIP-RANGE	OWNER	DATE	DEPTH (FEET)	CASING		USE - QUANTITY
					DIA. (in.)	DEPTH (FEET)	
1[1]	3-38S-19E	P. Ferrara	-	72	3	39	Domestic
2[1]	3-38S-19E	Mike Walton	-	110	4	54	Irrigation
3[2]	5-38S-19E	Structural Concepts	-	160	4	50	Domestic
4[1]	8-38S-19E	Palmer Ranch	1988	180	4	80	Domestic - 1500 GPH
5[1]	8-38S-19E	Mel Hoehstecher	-	203	4	73	Test
6[1]	11-38S-19E	Paul Richmond	-	-	4	-	Domestic
7[1]	15-38S-19E	H. Jones	-	87	3	42	Domestic
8[1]	15-38S-19E	Austin	-	80	3	42	Domestic
9[1]	15-38S-19E	Richard C. Austin	-	81	3	63	Domestic
10[1]	15-38S-19E	Stephen Tehns	-	80	3	38	Domestic
11[1]	17-38S-19E	A. E. Gingerich	-	105	4	35	Domestic
12[1]	20-38S-19E	Porrenecchi	-	93	3	32	Domestic
13[1]	20-38S-19E	Fiore Construction	-	71	3	46	Domestic
14[1]	21-38S-19E	Derly	-	76	3	42	Domestic
15[1]	21-38S-19E	Bill Smith	-	-	4	-	Domestic
16[1]	21-38S-19E	Beacom	-	110	4	50	Domestic
17[1]	21-38S-19E	Michael Brook	-	83	3	42	Domestic
18[1]	21-38S-19E	M. Brock & S. Zukowdki	-	90	4	38	Domestic
19[2]	21-38S-19E	Sarasota Co.	1988	1800	8	1200	Monitor
20[1]	21-38S-19E	Diversified Drilling Corp.	-	147	4	65	Domestic
21[1]	21-38S-19E	Diversified Drilling Corp.	-	-	2	-	Monitor
22[2]	22-38S-19E	SWFWMD	1983	40	4	30	Monitor
23[2]	22-38S-19E	SWFWMD	1983	350	6	300	Monitor
24[2]	22-38S-19E	SWFWMD	1983	600	8	450	Monitor
25[1]	23-38S-19E	H.M. Hallmark	-	58	3	42	Domestic
26[2]	24-38S-19E	Sarasota Co.	1985	50	6	50	Test - 300 GPH
27[1]	18-38S-20E	SWFWMD	-	425	4	410	Monitor
28[1]	18-38S-20E	SWFWMD	-	67	6	32	Monitor
29[1]	33-37S-19E	Tom Monieaham	-	-	-	-	Domestic
30[3]	33-37S-19E	C. Hawkins	1966	100	2	40	Irrigation - 3,600 GPH
31[1]	34-37S-19E	Albritton Fruit Co. Hi Hat Ranch	-	600	12	379	Irrigation
32[2]	34-37S-19E	Albritton Fruit Co. Hi Hat Ranch	1987	747	12	362	Irrigation - 120,000 GPH
33[3]	34-37S-19E	Albritton Fruit Co. Hi Hat Ranch	1988	800	12	350	Irrigation - 120,000 GPH
34[3]	34-37S-19E	C. Hawkins	1966	100	2	40	Irrigation - 3,600 GPH
35[1]	35-37S-19E	Swearingen	-	155	3	47	Irrigation
36[1]	35-37S-19E	Carl Geist	-	108	4	50	Domestic
37[1]	36-37S-19E	Chris Owen	-	100	4	84	Domestic
38[1]	36-37S-19E	Jeko f. Hilary	-	240	4	98	Domestic
39[3]	36-37S-19E	L. Hawkins	1965	77	-	44	3,000 GPH
40[3]	Not Avail.	B. Hawkins	1966	604	6	54	Irrigation - 18,000 GPH

Notes:

1 Data from SWFWMD files.
2 Data from SWFWMD and Sarasota Co. files.
3 Data from Sarasota Co. files.

TALBE 12

REPORT SHEET
PIEZOMETER AND OBSERVATION WELLS

FILE NUMBER: ________________ DATE: ______________ INSPECTOR: ____________________

Well Number	Time	Elevation at Top of Casing feet (NGVD)	Measured Distance to Water Level from Top of Well Casing (feet)	Distance from Top of Well Casing to Ground Surface (feet)	Depth to Water Below Ground Surface (feet)	Groundwater Elevation feet (NGVD)

TABLE 13

ONITOR WELL SAMPLING DATA SHEET   FILE NO.:

LIENT: ____________________ SAMPLING LOCATION: ____________
ROJECT: ____________________ DATE SAMPLED ________ SAMPLED BY: ________
ROUND WATER SAMPLE ______ SURFACE WATER SAMPLE ______ OTHER ____________

STATIC WATER LEVEL READINGS AND WELL DATA

ATE AND TIME : ________ ________ GROUND SURFACE ELEV.: ________
.P. TO WATER LEVEL : ________ ________ R.P. ELEV. : ________
.P. TO BOTTOM OF WELL: ________ ________ GROUND WATER ELEV. : ________
IAMETER OF WELL: ______ EST. VOL. OF WELL: ________ GALS. * 3 = ________ GALS.

WATER QUALITY SAMPLING EQUIPMENT AND SAMPLING DATA

METER USED: ________ MODEL NO. ________ PH PROBE ________ MODEL ________
METER CAL. CHECK : TIME ______ 4 ____ 7 ____ ______ NOTES: ____________
TIME ______ 4 ____ 7 ____ ______ ____________
PECIFIC CONDUCTANCE METER USED: ____________ MODEL NO. ________
TER CAL. CHECK: TIME ______ CAL. SOLUTION USED ____________
TIME ______ CAL. SOLUTION USED ____________

TE TIME	TOTAL EST. GALS. PUMPED	TOTAL EST. WELL VOLS.	SPECIFIC CONDUCTANCE µ MHOS	PH	SALINITY 0/00	TEMP °c	NOTES: COLOR, SMELL, ETC.........

WATER QUALITY SAMPLING DATA

UMP USED FOR PURGING WELL : ____________ GALS. PURGED BEFORE SAMPLING ________
UMP/BAILER USED FOR SAMPLING: ____________ SAMPLING RATE ________
SAMPLE TAKEN DATE/TIME: ________ SAMPLED BY: ____________
HEM. LAB. DOING TESTING: ____________ SAMPLE NAME OR KIT NO. ________
AMPLE CONTAINERS: TYPE, NO., AND SIZE: ____________

SAMPLES ON ICE: YES ___ NO ___ DATE AND TIME SAMPLES DEL. TO LAB. ________
IELD DATA: PH _____ G MHOS ________ TEMP. _____ c SALINITY ________ 0/00
THER TEST/NOTES: ____________

Ardaman and Associates, Inc.

TABLE 14

PAGE_____ OF_____

CHAIN OF CUSTODY RECORD

CLIENT:

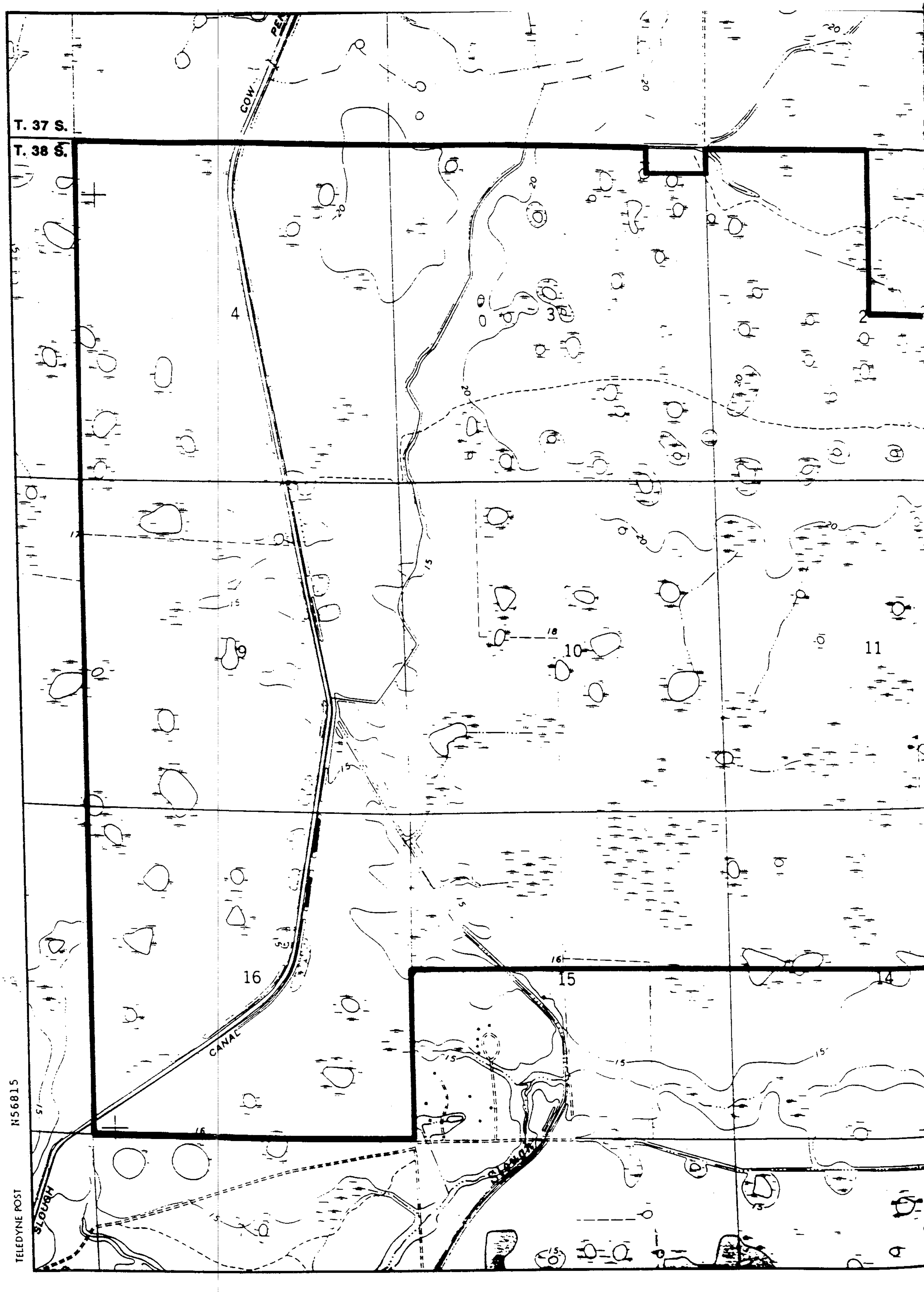
PROJECT:

FILE No.:

SAMPLER (SIGNATURE):

STATION No.	DATE	TIME	SAMPLE IDENTIFICATION			No. OF CONTAINERS	CONTAINER SIZE	CONTAINER TYPE	PRESERVATIVE TYPE	pH	FILTER (YES OR NO)	TEST PARAMETERS				COMMENTS
			KIT NUMBER	FIELD	LAB											

RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:
RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME:	REMARKS:
RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	RECEIVED FOR LABORATORY BY:		


T. 37 S.
T. 38 S.
COW
4
3
2
9
10
11
16
15
14
CANAL
SLOUGH
20
15
18
16

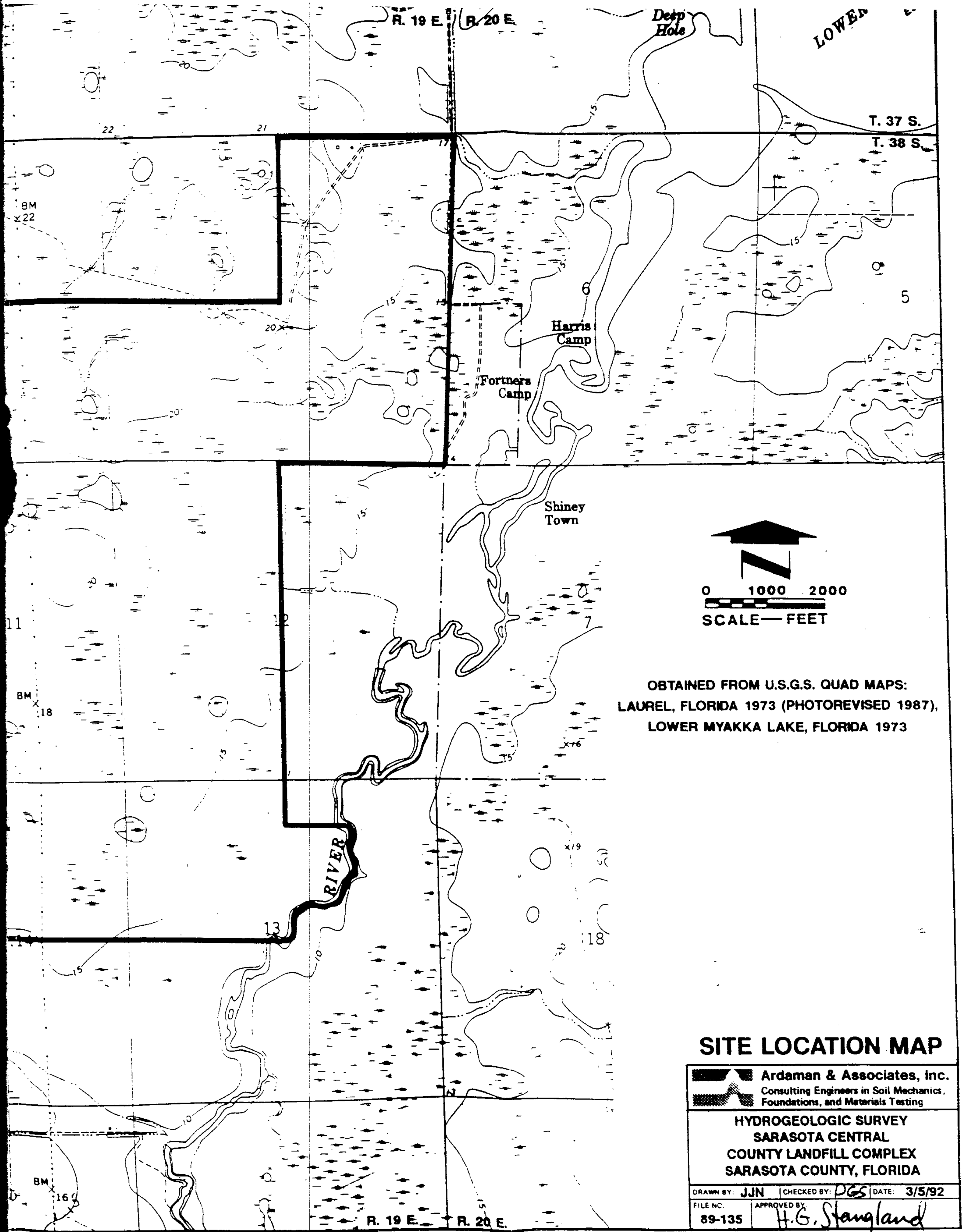
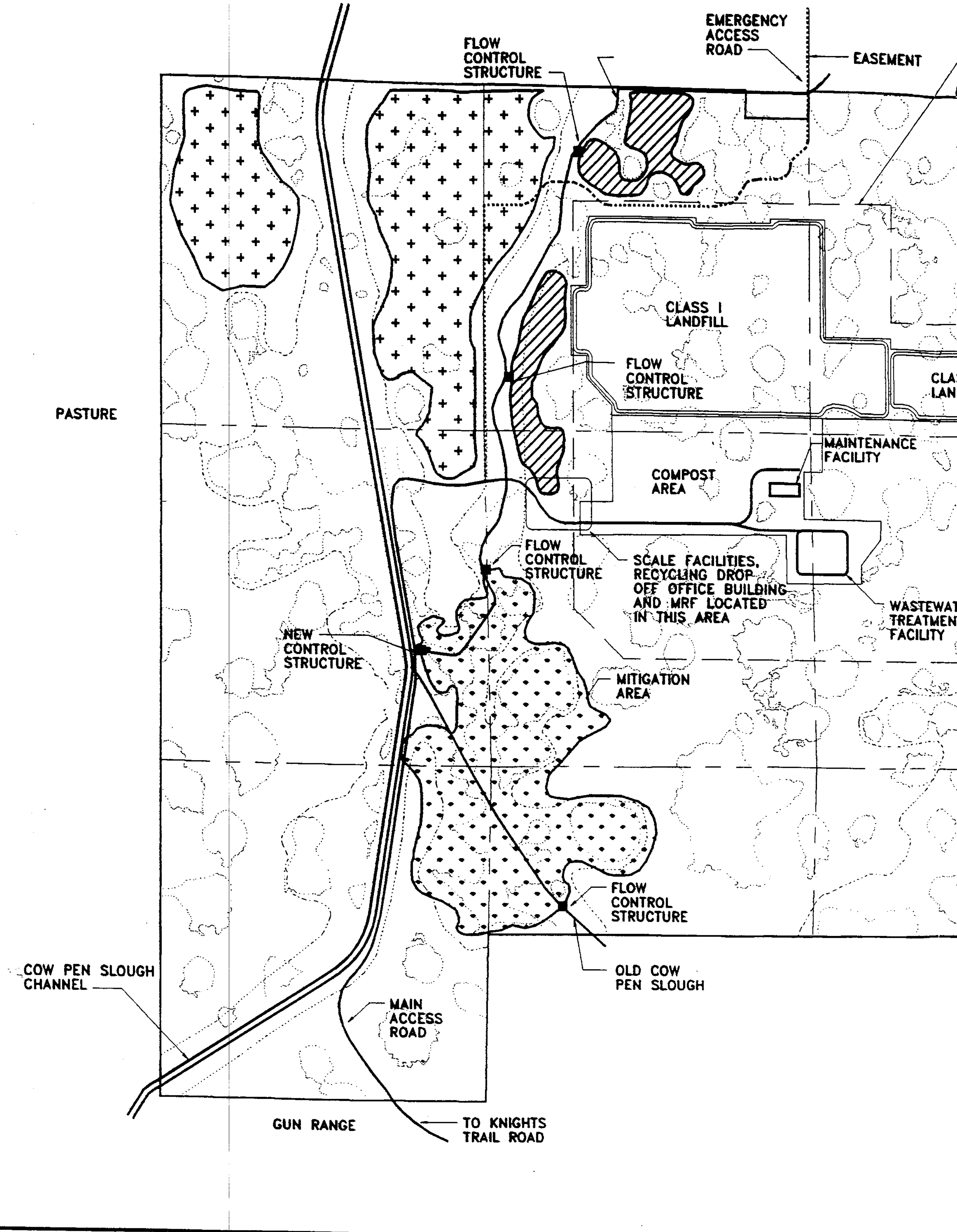
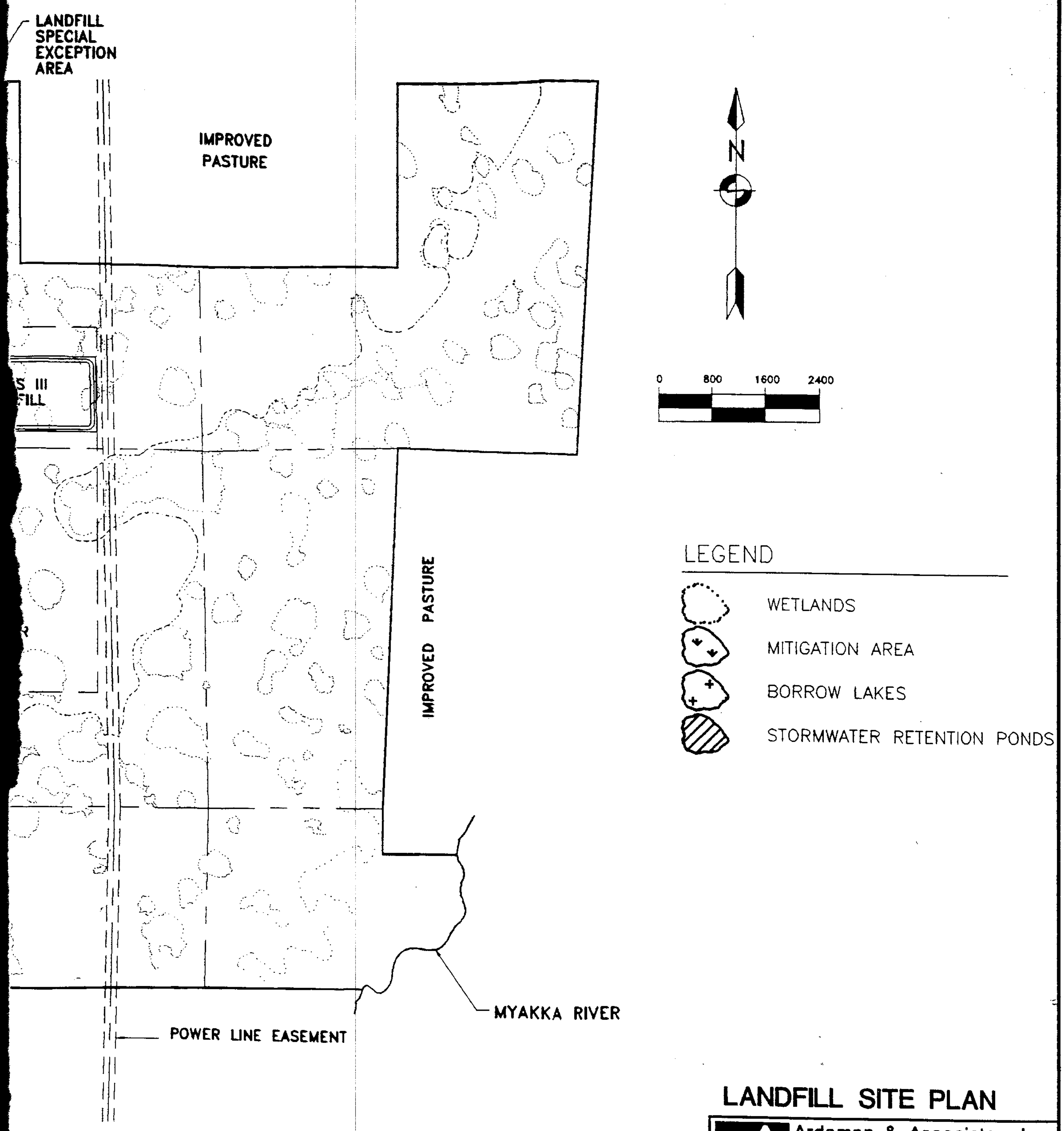

R. 19 E.
R. 20 E.
Deep Hole
LOWER
T. 37 S.
T. 38 S.
BM
22
Harris Camp
Fortners Camp
Shiney Town
0 1000 2000
SCALE—FEET
OBTAINED FROM U.S.G.S. QUAD MAPS:
LAUREL, FLORIDA 1973 (PHOTOREVISED 1987),
LOWER MYAKKA LAKE, FLORIDA 1973
RIVER
BM
18
BM
16
SITE LOCATION MAP
Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing
HYDROGEOLOGIC SURVEY
SARASOTA CENTRAL
COUNTY LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA
DRAWN BY: JJN
CHECKED BY: DGS
DATE: 3/5/92
FILE NO. 89-135
APPROVED BY H.G. Stangland

FIGURE 1


EMERGENCY ACCESS ROAD
EASEMENT
FLOW CONTROL STRUCTURE
CLASS I LANDFILL
FLOW CONTROL STRUCTURE
PASTURE
MAINTENANCE FACILITY
COMPOST AREA
FLOW CONTROL STRUCTURE
SCALE FACILITIES, RECYCLING DROP OFF OFFICE BUILDING AND MRF LOCATED IN THIS AREA
NEW CONTROL STRUCTURE
MITIGATION AREA
FLOW CONTROL STRUCTURE
COW PEN SLOUGH CHANNEL
OLD COW PEN SLOUGH
MAIN ACCESS ROAD
GUN RANGE
TO KNIGHTS TRAIL ROAD



LANDFILL SITE PLAN

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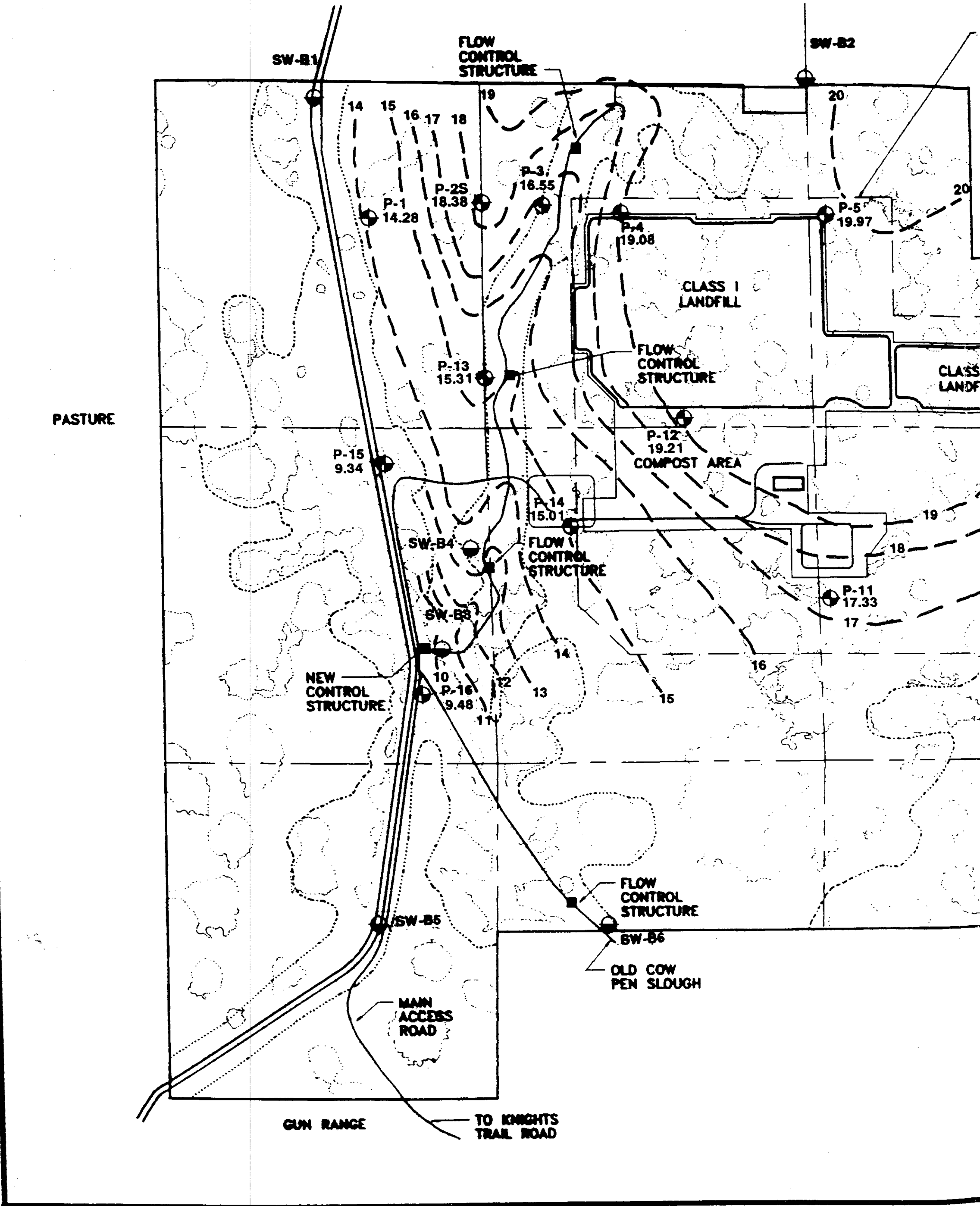
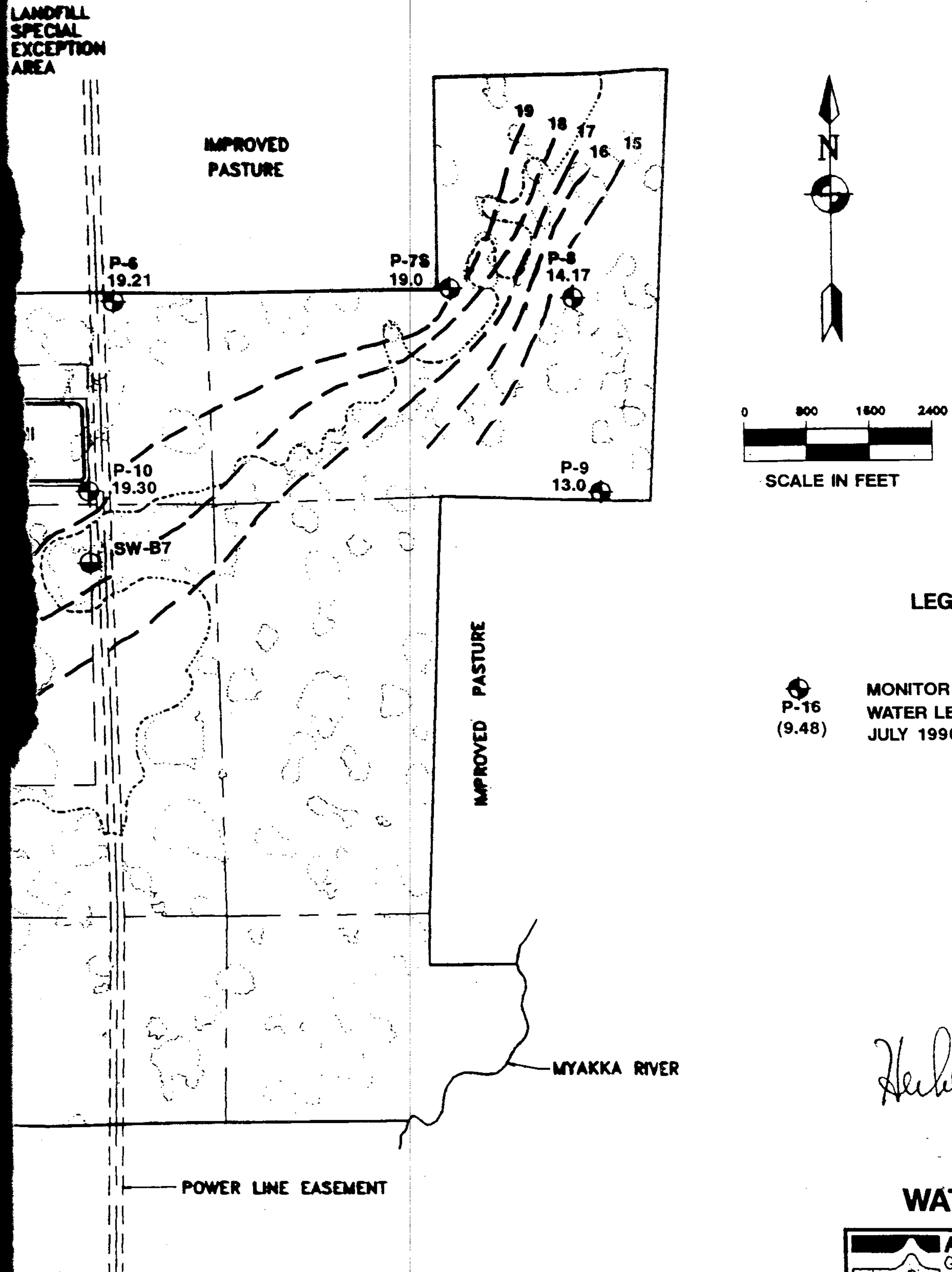
Geotechnical Environmental and Materials Consultants

HYDROGEOLOGIC SURVEY
SARASOTA CENTRAL COUNTY
LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: KJS	CHECKED BY: DGS	DATE: 12/26/91
FILE NO. 89-135	APPROVED BY: H.G. Stangland	

FIGURE 3


PASTURE
SW-B1
FLOW CONTROL STRUCTURE
SW-B2
P-1 14.28
P-2S 18.38
P-3 16.55
P-4 19.08
P-5 19.97
CLASS I LANDFILL
CLASS LANDF
FLOW CONTROL STRUCTURE
P-13 15.31
P-12 19.21
COMPOST AREA
P-15 9.34
P-14 15.01
SW-B4
FLOW CONTROL STRUCTURE
SW-B3
P-11 17.33
NEW CONTROL STRUCTURE
P-16 9.48
FLOW CONTROL STRUCTURE
SW-B5
SW-B6
OLD COW PEN SLOUGH
MAIN ACCESS ROAD
GUN RANGE
TO KNIGHTS TRAIL ROAD



LEGEND

P-16 (9.48) MONITOR WELL
WATER LEVEL ELEVATION (FT. NGVD)
JULY 1990

Herbert G. Stangland

JULY 1990

WATER TABLE MAP

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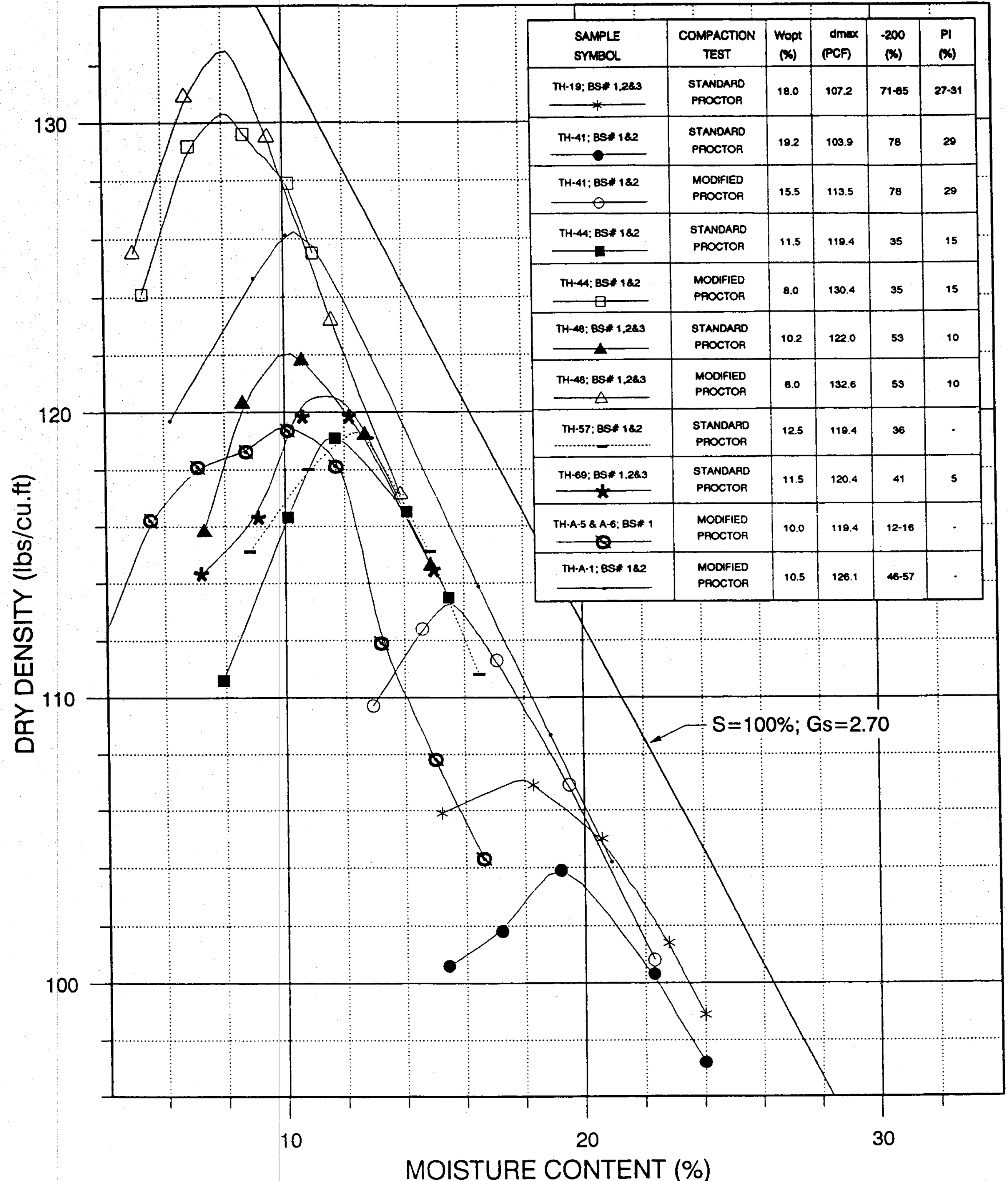
HYDROGEOLOGIC SURVEY
SARASOTA CENTRAL COUNTY
LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: KJS	CHECKED BY: JGS	DATE: 02/28/92
FILE NO. 89-135	APPROVED BY: H. G. Stangland	

FUGURE 7



SAMPLE SYMBOL	COMPACTION TEST	Wopt (%)	dmax (PCF)	-200 (%)	PI (%)
TH-19; BS# 1,2&3	STANDARD PROCTOR	18.0	107.2	71-85	27-31
TH-41; BS# 1&2	STANDARD PROCTOR	19.2	103.9	78	29
TH-41; BS# 1&2	MODIFIED PROCTOR	15.5	113.5	78	29
TH-44; BS# 1&2	STANDARD PROCTOR	11.5	119.4	35	15
TH-44; BS# 1&2	MODIFIED PROCTOR	8.0	130.4	35	15
TH-48; BS# 1,2&3	STANDARD PROCTOR	10.2	122.0	53	10
TH-48; BS# 1,2&3	MODIFIED PROCTOR	8.0	132.6	53	10
TH-57; BS# 1&2	STANDARD PROCTOR	12.5	119.4	36	-
TH-69; BS# 1,2&3	STANDARD PROCTOR	11.5	120.4	41	5
TH-A-5 & A-6; BS# 1	MODIFIED PROCTOR	10.0	119.4	12-16	-
TH-A-1; BS# 1&2	MODIFIED PROCTOR	10.5	126.1	46-57	-

PROCTOR COMPACTION CURVES

BORROW MATERIAL EVALUATION

E:\CDM\89135\BORROW\BORRPROC.DRW

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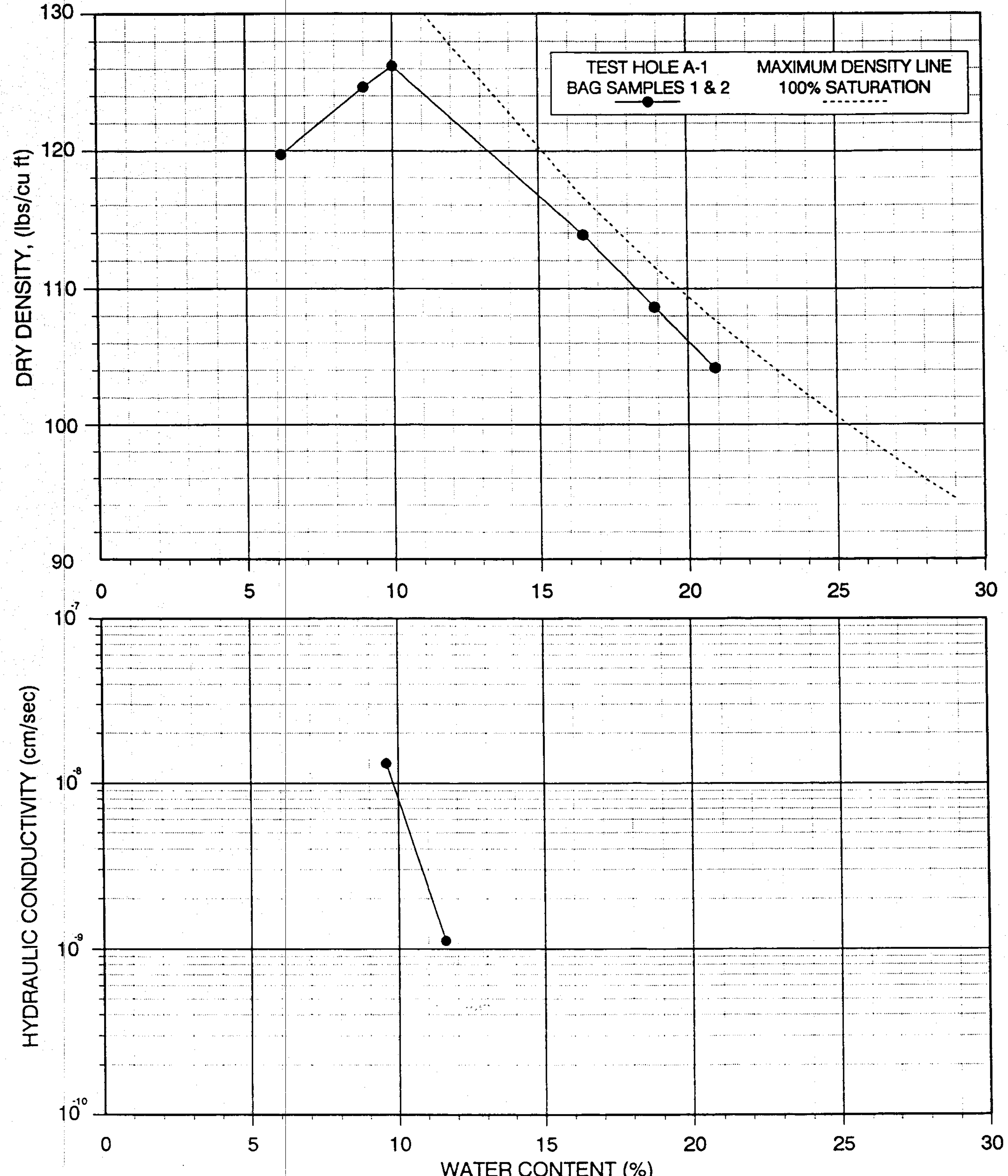
HYDROGEOLOGICAL SURVEY
SARASOTA CENTRAL COUNTY
LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: DGS	CHECKED BY: DGS	DATE: 03-04-92
FILE NO.: 89-135	APPROVED BY: H.G. Stangland	

FIGURE 9



MOISTURE - DENSITY -
HYDRAULIC CONDUCTIVITY RELATIONSHIP
COMPOSITE SAMPLE FROM TH-A-1
BAG SAMPLES 1 & 2

C:\CDM\89135\BORROW\TPROCA1.DRW

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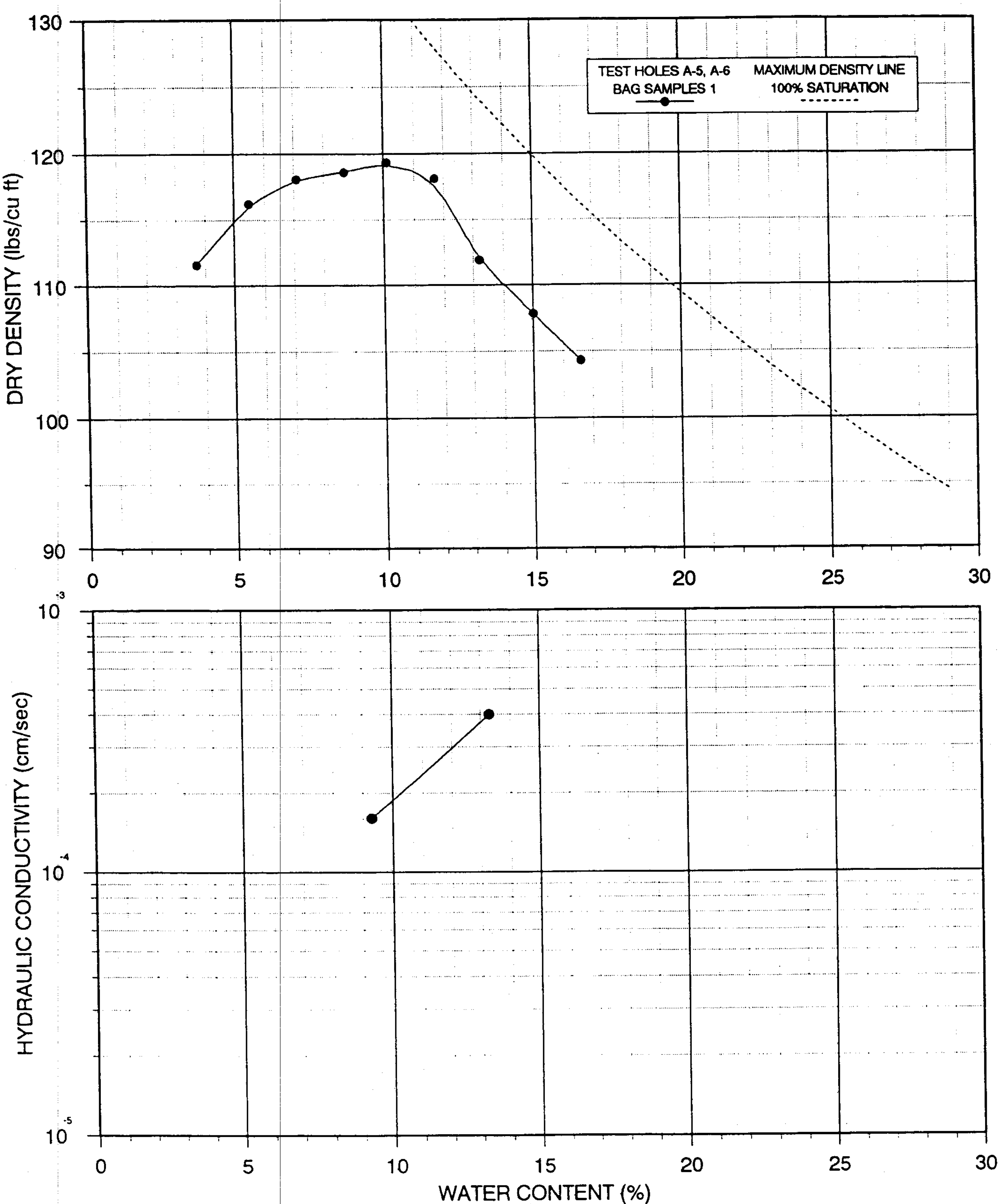
HYDROGEOLOGICAL SURVEY SARASOTA CENTRAL COUNTY LANDFILL COMPLEX SARASOTA COUNTY, FLORIDA		
DRAWN BY: DGS	CHECKED BY: DGS	DATE: 12-11-91
FILE NO.: 89-135	APPROVED BY: H.G. Stanaland	

FIGURE 10



MOISTURE - DENSITY -
HYDRAULIC CONDUCTIVITY RELATIONSHIP
COMPOSITE SAMPLE FROM TH-A-5 & TH-A-6
BAG SAMPLES 1

C:\CDM\89135\BORROW\TPROCA56.DRW

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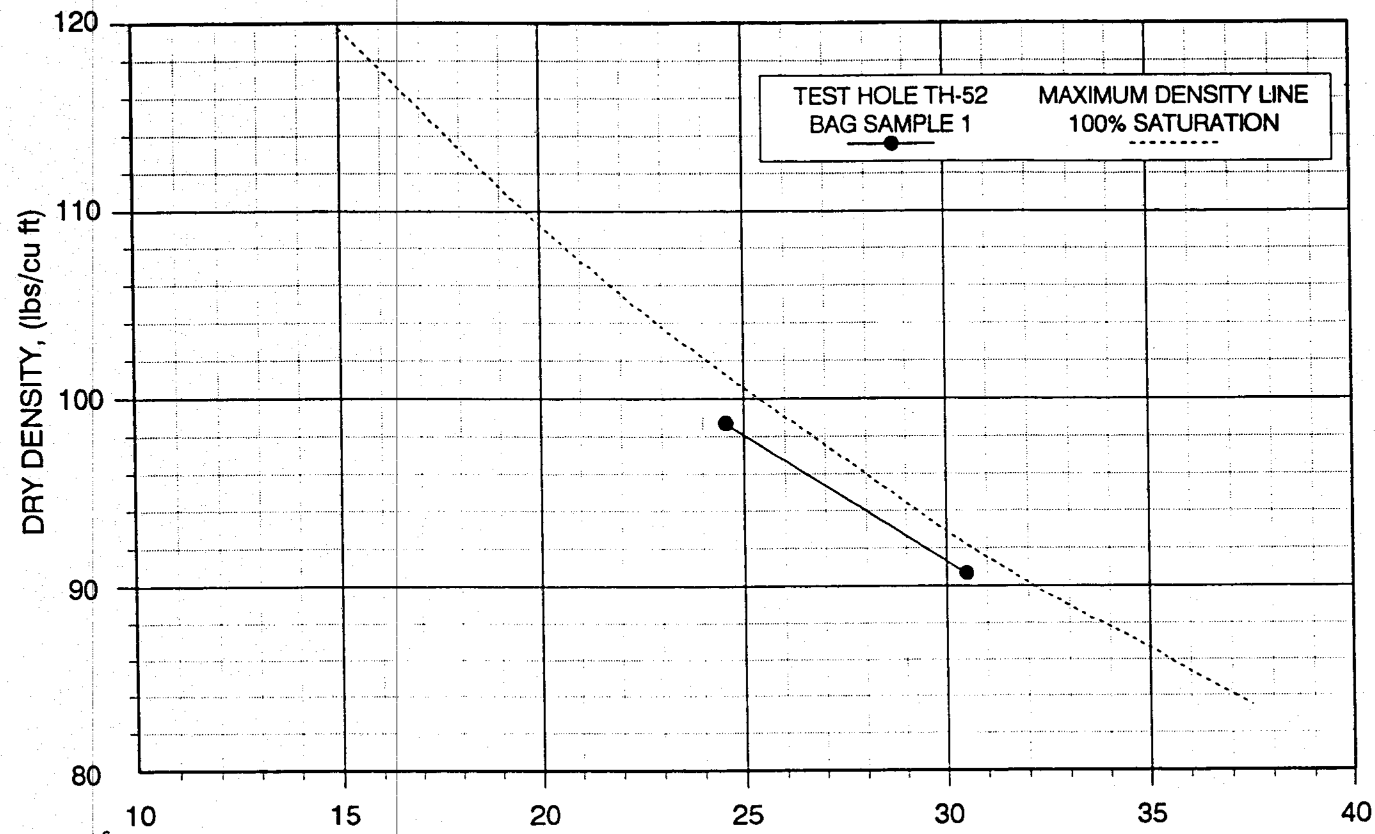
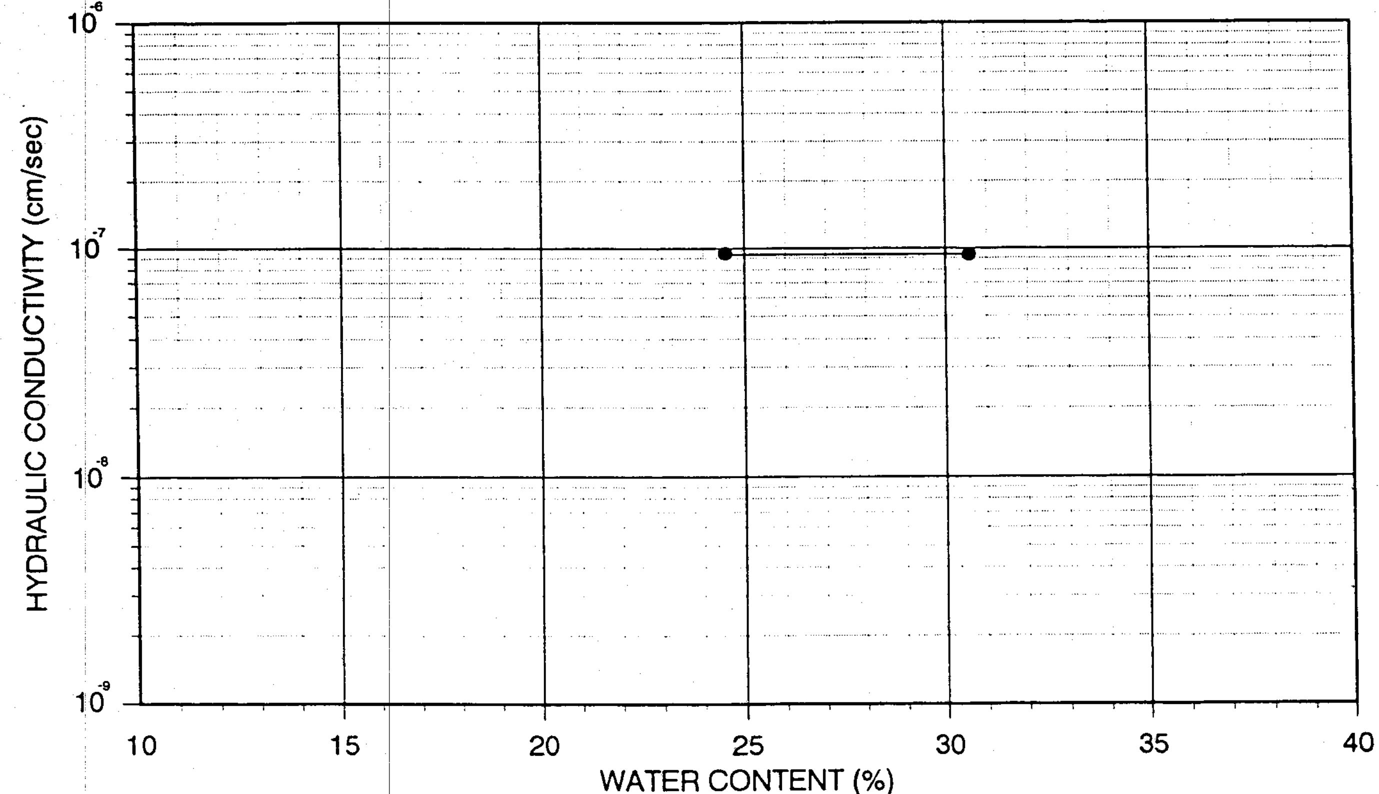
HYDROGEOLOGICAL SURVEY
SARASOTA CENTRAL COUNTY
LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: DGS	CHECKED BY: DGS	DATE: 12-11-91
FILE NO.: 89-135	APPROVED BY: H.G. Stangland	

FIGURE 11





MOISTURE - DENSITY -
HYDRAULIC CONDUCTIVITY RELATIONSHIP
COMPOSITE SAMPLE FROM TH-52
BAG SAMPLE 1 (11-14 FEET DEEP)

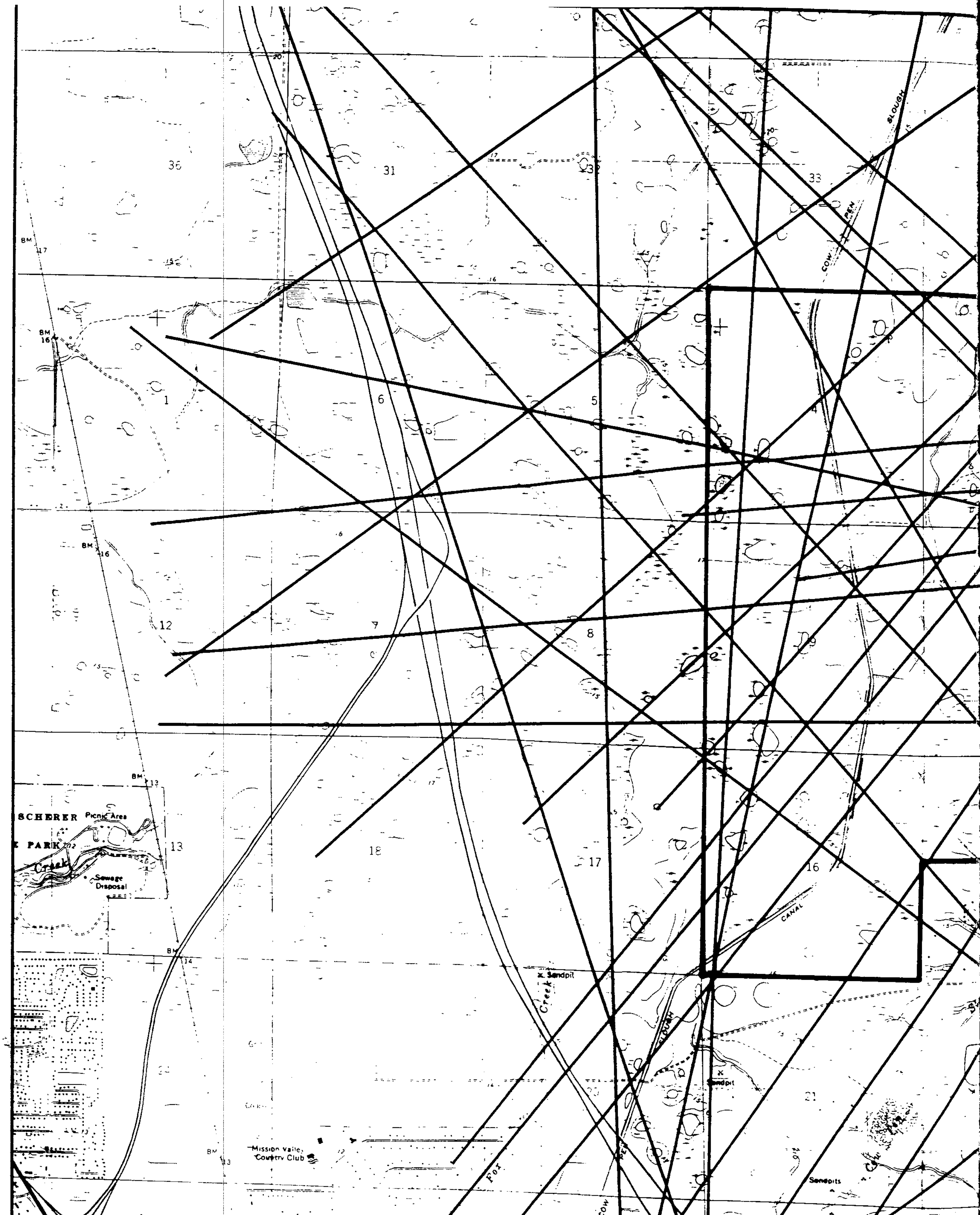
E:\CDM\89135\BORROW\TPROC52.DRW

Ardaman & Associates, Inc.
Consulting Engineers in Soils, Hydrology, Foundations and Materials Testing

HYDROGEOLOGICAL SURVEY
SARASOTA CENTRAL COUNTY
LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: DGS	CHECKED BY: DGS	DATE: 03-05-92
FILE NO.: 89-135	APPROVED BY: H.G. Stangland	

FIGURE 12



SOURCE: U.S.G.S. QUAD MAPS–LAUREL, FL. 1973 (PHOTOREVISED 1987) AND LOWER MYAKKA LAKE, FL. 1973

N36488

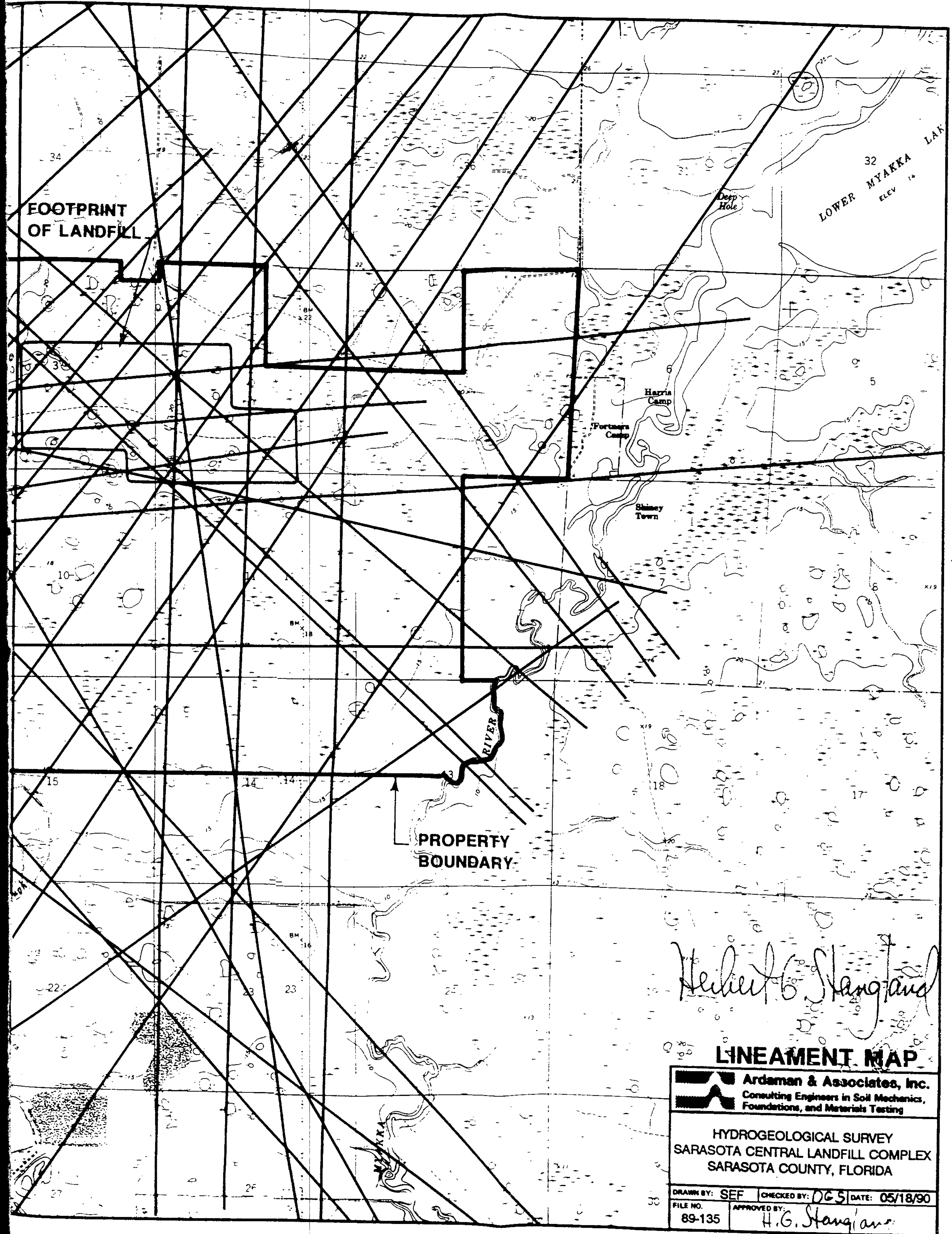
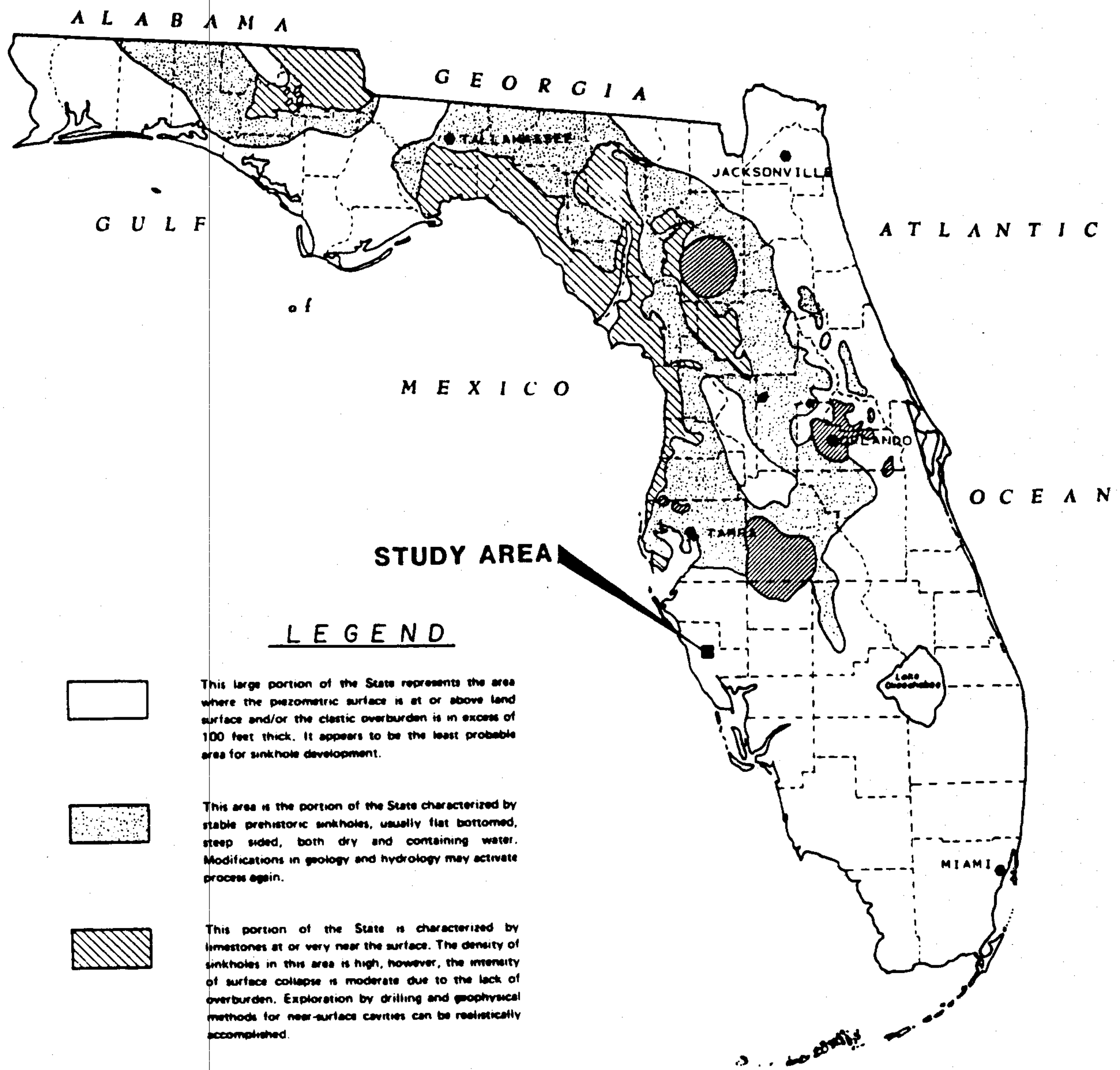

FOOTPRINT
OF LANDFILL
PROPERTY
BOUNDARY
LOWER MYAKKA LAK
ELEV 14
Deep Hole
Harris Camp
Fortners Camp
Shiney Town
RIVER
LINEAMENT MAP
Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing
HYDROGEOLOGICAL SURVEY
SARASOTA CENTRAL LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA
DRAWN BY: SEF
CHECKED BY: DGS
DATE: 05/18/90
FILE NO. 89-135
APPROVED BY: H.G. Stangland

FIGURE 13



LEGEND

This large portion of the State represents the area where the piezometric surface is at or above land surface and/or the clastic overburden is in excess of 100 feet thick. It appears to be the least probable area for sinkhole development.

This area is the portion of the State characterized by stable prehistoric sinkholes, usually flat bottomed, steep sided, both dry and containing water. Modifications in geology and hydrology may activate process again.

This portion of the State is characterized by limestones at or very near the surface. The density of sinkholes in this area is high, however, the intensity of surface collapse is moderate due to the lack of overburden. Exploration by drilling and geophysical methods for near-surface cavities can be realistically accomplished.

This portion of the State has moderate overburden overlying cavernous limestones and appreciable water use. These areas have histories of steep-walled, wider sinkhole collapse but require more detailed study. A thick overburden or high water table present within these areas lessen the probability of sinks occurring.

SINKHOLE REGIONS IN FLORIDA

ROBERT O. VERNON, FLORIDA GEOLOGICAL SURVEY
SPECIAL PUBLICATION #16, PG 19, 1972

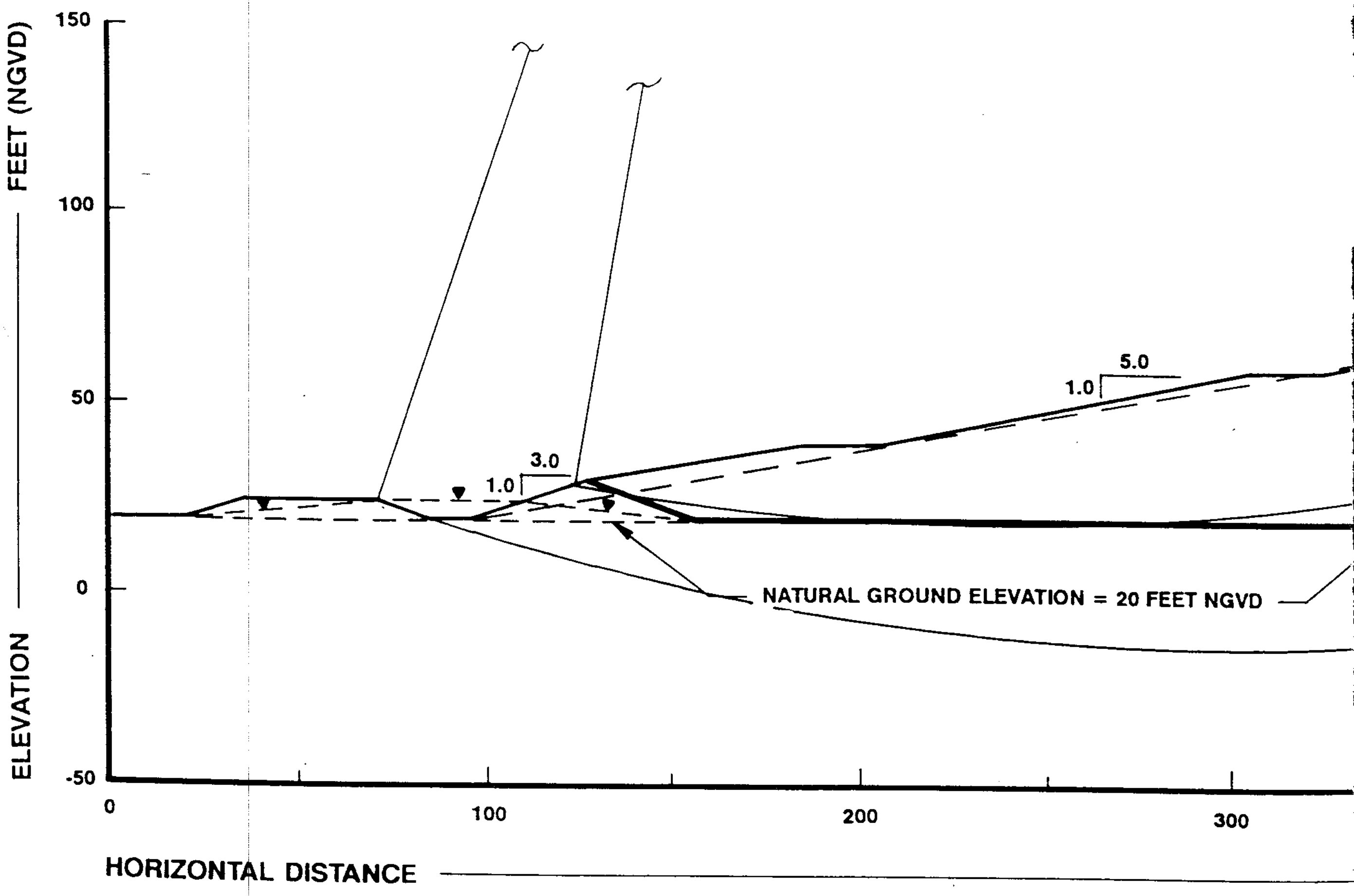
Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Material Testing

HYDROGEOLOGICAL SURVEY
SARASOTA CENTRAL LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

DRAWN BY: SEF	CHECKED BY:	DATE: 05/18/90
FILE NO. 89-135	APPROVED BY:	

K&E 19-1353

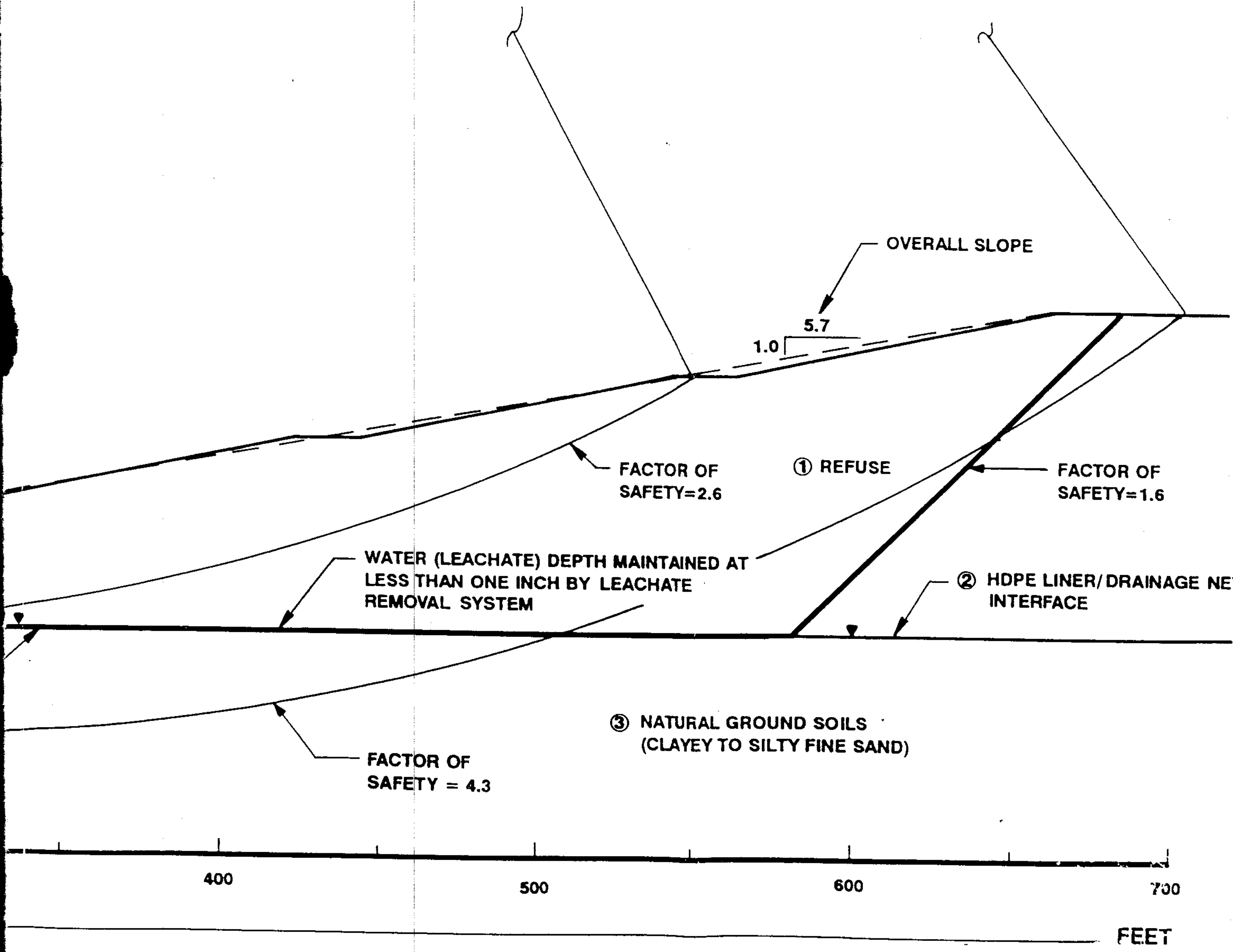
FIGURE 14



N56815

TELEDYNE POST

MATERIAL	UNIT WEIGHT pcf	EFFECTIVE COHESION psf	EFFECTIVE FRICTION ANGLE
1 REFUSE	45 (TOTAL)	0	26°
2 HDPE LINER/DRAINAGE NET INTERFACE	—	0	8°
3 CLAYEY TO SILTY FINE SAND	65 (SUBMERGED) 130 (TOTAL)	0	30°



STABILITY ANALYSES

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HYDROGEOLOGIC SURVEY
SARASOTA CENTRAL
COUNTY LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

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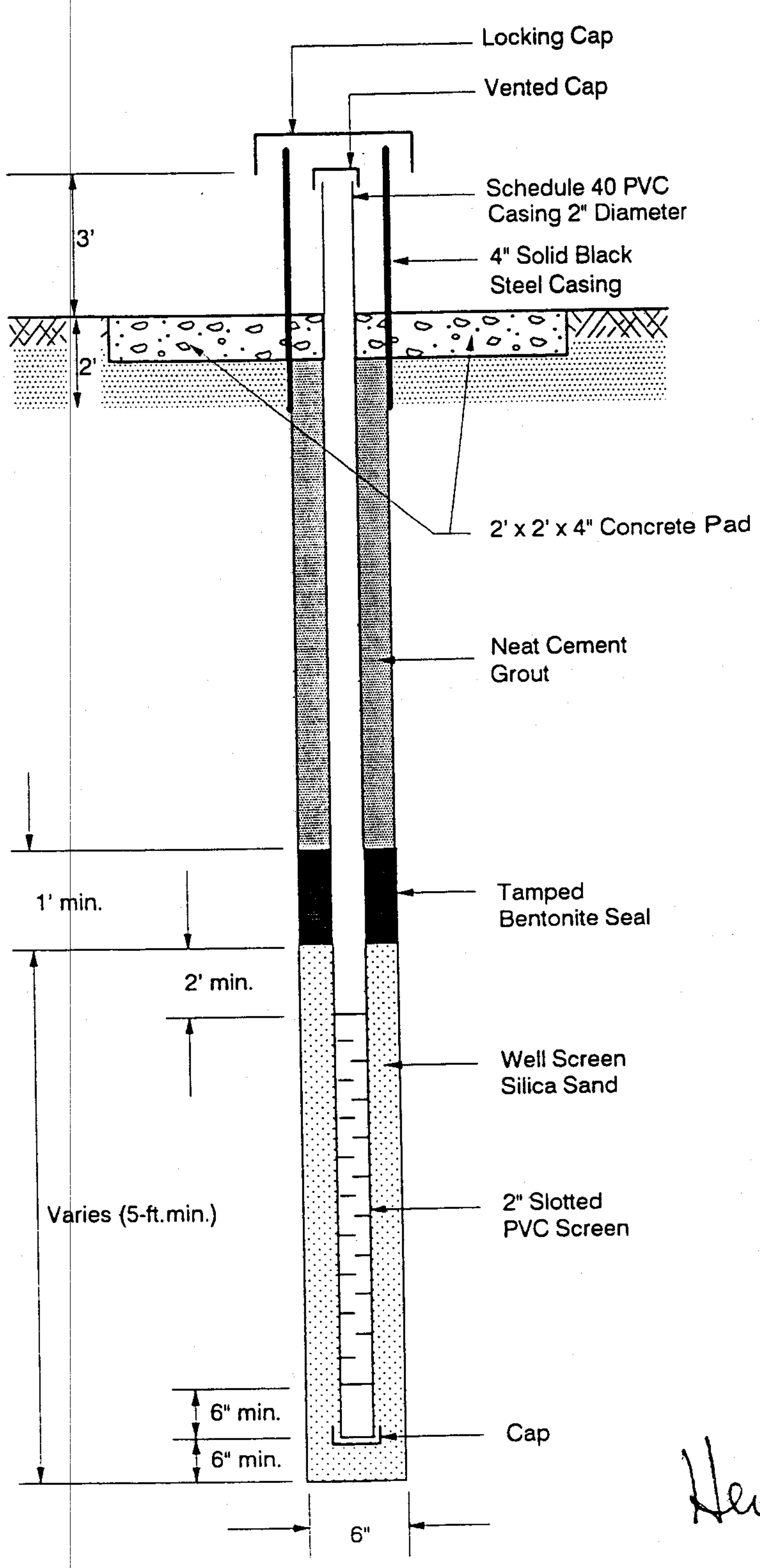
FIGURE 16



SCHEMATIC OF MONITORING WELL INSTALLATION

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

HYDROGEOLOGIC SURVEY
SARASOTA CENTRAL
COUNTY LANDFILL COMPLEX
SARASOTA COUNTY, FLORIDA

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