# A. TOBLIN STAFF EXHIBIT 10

# NIRS/PC EC-1

# GEOTECHNICAL INVESTIGATION

# AND

# ENGINEERING ANALYSIS

# FOR

WASTE CONTROL SPECIALISTS INC.

LANDFILL PROJECT

ANDREWS COUNTY, TEXAS

REPORT FOR:

AM ENVIRONMENTAL, INC.

2525 WALLINGWOOD, SUITE 701

AUSTIN, TEXAS 78746

FILE NO.: 10-25792

12 MARCH 1993

JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

TABLE OF CONTENTS



APPENDIX

GEOTECHNICAL INVESTIGATION

ENGINEERING ANALYSIS

FOR

WASTE CONTROL SPECIALISTS INC.

LANDFILL PROJECT

ANDREWS COUNTY, TEXAS

## INTRODUCTION

A Geotechnical Investigation and Engineering Analysis for the above referenced project located in Andrews County, Texas was authorized by Mr. Allen Messenger of A.M. Environmental, Austin, Texas on 15 October 1992. The purpose of the investigation was to determine subsurface soil conditions and materials at the site and to obtain samples for laboratory testing. Based on our boring logs and laboratory tests an engineering analysis was performed to determine foundation stability, slope stability and soil permeability as well as other design parameters for the proposed hazardous waste landfill.

## SCOPE

The scope of the project included the following:

1. Reconnaissance of the project site to observe physical features, vegetation and access to the property.

2. Surveying grid system on the site on 500 foot intervals and obtaining elevations at each grid point. Topographic survey of entire site and areas outside the site for a distance of 1000 feet.
3. Mobilization and demobilization of office trailer, storage building, electrical service, equipment, van truck, logging trailers, water tank and drill rigs to the site.
4. Drilling, logging and sampling 55 soil borings using air rotary and air coring to depths of 100 feet to 300 feet.
5. Drilling, logging and sampling 12 soil borings to depths of 45 feet to obtain rock cores.
6. Wrapping and packaging core samples in core boxes and properly storing on site prior to shipping to laboratory. Transporting samples to the laboratory in Austin, Texas.
7. Laboratory testing including but not limited to Unified Soils Classifications, Moisture Contents, Unit Weights, Atterberg Limits, Unconfined Compression Tests, Permeabilities, Triaxial Tests, Consolidation Tests, Moisture/Density Relationships and Direct Shear Tests.
8. Installation of eight monitor wells (4 inch PVC) and six piezometers (2 inch PVC) and coordinating the installation of wells with Terra Dynamics, Inc.
9. Monitoring groundwater levels in open bore holes prior to plugging and in water wells and piezometers.
10. Plugging of all bore holes with cement bentonite slurry.



JACK H. HOLT PH.D. & ASSOCIATES INC.
2200 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

11. Preparing a written engineering report with grid survey, topographic survey, boring location plan, soil boring logs, laboratory test results and water level data. Preparing engineering analyses including soil permeability, slope stability, foundation stability, settlement analyses and recommendations for landfill design.

LOCATION AND SITE DESCRIPTION

The proposed landfill site is located in Andrews County, Texas approximately 34 miles west of Andrews, Texas on State Highway 176 (see location on State Highway Map - Figure 1). The site is located approximately 0.5 miles north of the Highway on the Flying "W" Diamond Ranch. The initial grid survey area consists of approximately 485 acres of undeveloped ranch land. The landfill area will be 100 acres in size with approximate dimensions of 1100 feet by 4000 feet. The terrain consists of gently sloping grass covered ranch land with scattered small mesquite trees. The proposed landfill site is bordered by a gravel ranch road on the west that parallels the Texas-New Mexico state line. An oil well location exists approximately 2500 feet south of the landfill site. An overhead power line borders the site on the east. The site slopes gradually from north to south changing in surface elevation from approximately 3480 feet to 3440 feet above mean sea level.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2200 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

Several surface depressions exist on the landfill site and are locally referred to as buffalo wallows. These depressions are believed to have been formed by the dissolution of the carbonaceous caliche deposits near the surface or from natural depressions in the Triassic red bed clay formation below.

SITE SURVEY AND GRID LAYOUT

The project site was selected by Mr. Allen Messenger after preliminary borings indicated shallow depths to red bed clay in the area. Grid layout with approximate size of 6000 feet by 4500 feet was surveyed by Mr. James E. Tompkins, (R.P.S.) Engineering and Surveying of Andrews, Texas. Grid points were staked on the site at 500 foot intervals. Grid points were lettered from north to south A through J and numbered from east to west 1 through 13. The Texas-New Mexico State line running north to south has a bearing of N 0° 0'0"W. The grid lines A through J have a bearing of S 65° 0' 0" E. The grid lines 1 through 13 have a bearing of S 25° 0'0" W.

Additional surveying was performed by Tompkins Engineering and Surveying to provide adequate topographical information both inside and outside the grid to depict surface physical features on a one foot contour interval. The benchmark for the project is located at the state line marker located 1600 feet north of State Highway 176 with an elevation of 3484.75 feet MSL. A Grid Survey and Topography Map is shown in Figure III.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

## FIELD INVESTIGATION

The drilling and sampling was accomplished with a 1974 Model Midway 1300 and 1977 Model Midway 1500 owned and operated by Scarborough Drilling, Inc. from Lamesa, Texas. These truck mounted rigs are equipped with direct rotary table, 550 CFM air compressors, mud pump, 2 7/8 inch diameter drill stem, 3 1/2 inch drill stem, tri-cone roller bits, drag bits, 3 foot core barrel and 10 foot core barrels.

Initially all holes were continuously sampled by air coring with 4 3/4 inch O.D. Christian Core barrels producing 2 1/8 inch diameter core samples. Where bit wear was excessive in hard limestone or conglomerate then tri-cone roller bits were used until hard layers were penetrated. Where soft layers were encountered and recovery using air coring was poor, split spoon (1.4 inch diameter) samples were obtained using rig pull-down.

The investigation consisted of drilling, logging and sampling a total of 55 bore holes (see Generalized Boring Location Plan - Figure IV). Of the 55 holes a total of 14 holes were continuously air cored in the upper caliche (hard limestone and sandstone deposits) to depths ranging from 9 feet to 53 feet deep. The remaining holes were drilled with straight air rotary in the upper caliche layers and cuttings were continuously sampled, logged and visually classified. All 55 holes were continuously sampled (air coring) from the top of the red bed (Triassic) using both split spoon samples and 2 1/8 I.D.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

Christianson core barrels. Continuous coring intervals varied from lengths of 4 feet to 10 feet depending on the type of soils encountered.

The initial investigation consisted of drilling and continuous air coring all bore holes to depths of 100 feet with selected holes extended to depths of 200 feet. At six piezometers and three monitor well locations the bore holes were extended to depths ranging from 260 feet to 300 feet and either continuously cored or air rotary drilled and cuttings were logged to accurately describe the geology and classify the soils. These nine holes were also used for geophysical logging that was coordinated by Terra-Dynamics, Austin, Texas. The geophysical logs and core logs were then compared and correlated by Terra-Dynamics. A total of 12 holes were drilled with a CME 55 Rig equipped with a mud rotary NXB Christianson Wireline system (1.875 diameter core) for the purpose of obtaining rock cores from the upper limestone (caliche) formation. These holes varied in depth from 12 feet to 36 feet below the existing grade. The total recovery as well as Rock Quality Designation (RQD) is shown on the individual boring logs. All rock cores were visually classified and logged in the field and samples were wrapped with plastic and stored in wooden core boxes and transported to the lab. A table depicting boring numbers, grid locations, boring depth and date of boring is shown in the Soil Boring Summary in Appendix II.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

All core samples were examined and visually classified, logged in the field prior to wrapping and placing in cardboard core boxes. Grab samples from air rotary cuttings were also visually classified and logged and placed in ziploc plastic bags and stored in cardboard boxes. All core boxes were properly labeled with boring number and grid location, date, sample intervals and transported to the laboratory of Jack H. Holt & Associates, Inc. in Austin, Texas for testing and storage.

## LABORATORY TESTING

The laboratory testing program included tests to determine the engineering characteristics and properties of the soil and rock samples obtained from the drilling and sampling program. These tests include soil classification, shear strength, plasticity, density, moisture, grain size analysis, and permeability. All laboratory tests were run in strict accordance with ASTM Standards using up-to-date calibrated testing equipment and apparatus as required by those standards. The laboratory testing program was performed under the supervision and direction of Dr. Jack H. Holt, Ph.D., P.E. Listed below is a list of the specific laboratory tests and their appropriate ASTM Designation:

1. Classification of soils according to the "Unified Soil Classification System" (ASTM D2487-90).
2. Sieve Analysis of soils including Minus No. 200 Mesh Sieve and Hydrometer Analysis (ASTM D-422-63).



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

3. Moisture Content of Soils (ASTM D-2216-90).
4. Unit Weight Tests.
5. Atterberg Limits Tests including Liquid Limits, Plastic Limits (ASTM D-4318-84).
6. Unconfined Compressive Strength - clay soils (ASTM D-2166-91).
7. Unconfined Compression Tests - rock specimens (ASTM D-2938-68).
8. Triaxial Tests.
9. Permeability Tests using both flexible wall and rigid permeameters (ASTM D-5084-90).
10. Moisture-Density Relationship Tests using Modified Proctor (ASTM D-1557-91) and Standard Proctor (ASTM D-698-91).
11. Consolidation Tests.

The results of all laboratory tests can be found in Appendix I. Laboratory test results are also shown on the individual boring logs at the appropriate depth.

SUBSURFACE CONDITIONS

The subsurface soil conditions are described in more detail by the attached Logs of Borings found in Appendix II. In general the soil conditions consist of a thin (one foot or less) layer of brown organic sandy silt overlying a formation of white or tan caliche. The caliche consists of crumbly to very hard cemented sand, conglomerate limestone rock, sandy silt and



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

gravel. At the base of the caliche strata lies a sand and gravel layer that varies in thickness from 0 feet to 20 feet. The depth of the caliche layer including the sand and gravel strata below ranges from approximately 9 feet to 53 feet across the investigated area.

Below the caliche lies a formation of reddish brown silty clay (red bed clay) that extends to termination of the borings at 100 feet to 300 feet below the existing grade. The red bed clay consists of a highly consolidated impervious mottled reddish brown-gray clay, purple-gray silty clay, and yellowish brown-gray silty clay. Siltstones and sandstones are found at various depths and thicknesses across the grid area and vary in color from red, tan, gray, pink and yellow. The depth to the top of the red bed (Triassic-Dockum Group) varies across the site from 9 feet (B-24) to 53 feet (B-1) and generally averages 12 feet to 30 feet deep through the center of the grid area between Grid Lines C and E.

The red, reddish brown or purple silty clay soils range in moisture content from 2.5% to 25% and generally average 8% to 12% in most of the borings.

Dry density of the clay soils range from 116 PCF to 145 PCF and average 132 PCF.

Liquid Limits of the clays range from 35% to 55%. Plasticity indices vary from 24 to 38. The clays vary in percent passing the #200 Mesh Sieve from 87% to 99.8%.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

A total of 36 vertical permeabilities and 6 horizontal permeabilities were run on the reddish brown silty clays, sandstones and siltstones. Vertical permeabilities range from <1.00x $10^{-9}$ cm/sec to 1.76 x $10^{-8}$ cm/sec for the clays. Horizontal permeabilities range from 1.63 x $10^{-9}$ cm/sec to 1.10 x $10^{-8}$ cm/sec. The siltstones and sandstones found at depths of 56 feet to 90 feet range in vertical permeability from 2.58 x $10^{-8}$ cm/sec to 1.93 x $10^{-6}$ cm/sec. The horizontal permeability averages 6.53 x $10^{-7}$ cm/sec. The siltstone at a depth of 208 feet has a permeability of 2.06 x$10^{-8}$. The permeability tests were run according to ASTM D-5084-90 using a flexible wall permeameter under a constant head. De-aired tap water and a .005N Ca $SO_4$ solution was used for the permeant liquid. The permeabilities were calculated on both the inflow and outflow and then averaged for the final result. The plot of Q x L vs T x A x H for selected tests are shown graphically in the Steady State Permeability Plots in Appendix I. Shown in each graph is the plot for both inflow and outflow through the sample. The slope of straight line is the permeability in cm/sec. A summary of permeability test results including boring number, grid location, soil classification, depth are shown in Permeability Test Results, Appendix I.

Unconfined compression test on the clay soils range from 13.9 TSF to 49.7 TSF with an average of 30 TSF.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

## GROUNDWATER

Water level measurements were made on open bore holes at 24 hours and 48 hours after completion. All borings were found to be dry with the exception of B-7, B-4, B-10, B-20, B-30, B-20, B-41 and B-41S. Groundwater was found at a shallow depths only in borings B-41 and B-41S at 26 feet and 32.4 feet respectively. Groundwater or damp sandstone/siltstone was encountered during the drilling operation only in Borings B-7, B-21 and B-48 at depths ranging from 200 feet to 220 feet below the existing grade.

Piezometers (2 inch PVC pipe) were installed at four locations (B-4, B-7, B-10 and B-20) with screened intervals ranging in depths from 170 feet to 257 feet below the existing grade. Water level measurements ranged from 149.8 feet to 187.8 feet below the existing grade on 14 January 1993.

Additional piezometers were installed at boring B-30 and boring B-39 . These holes were dry at the time of this report. Monitor wells were installed at grid locations 4-G, 9-G, and 6-B to better define saturated zones and obtain hydrological data for various zones. Details on construction of these wells are depicted in the State of Texas Well Reports in Appendix III. Water level measurements for all piezometers and wells are found in the Water Level Measurements, Appendix III. The groundwater hydrology is discussed in more detail in the Terra Dynamics Report.



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

FOUNDATION STABILITY

The landfill floor elevation will be established at 3,40( feet. Maximum depth of the waste material will be 76 feet. A 16.5 foot thick cap is planned for the crest section which slopes at 3% grade back to the containment dike. The clay cap will be covered with a filter fabric and 2 feet of top soil. An 8 foot thick liner system will be placed between the waste material and the impervious clay formation. A typical landfill Section is shown below.

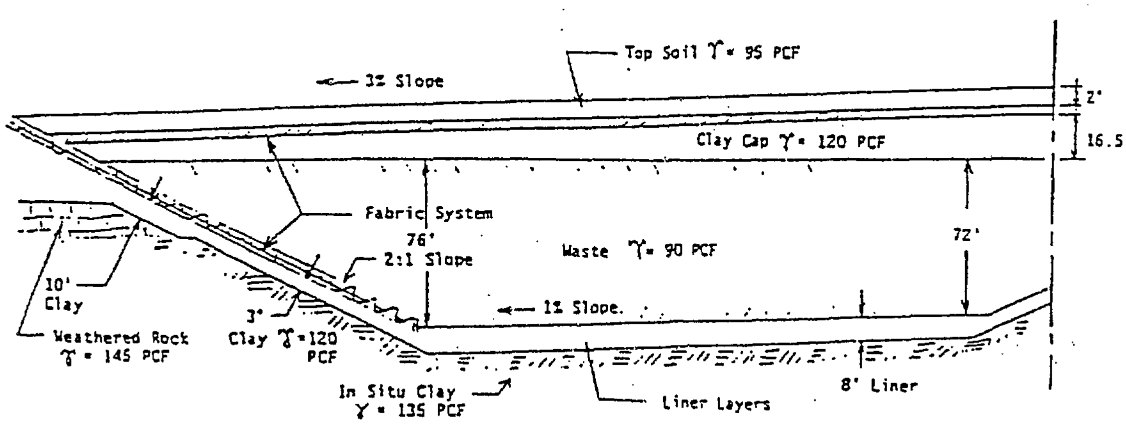


FIGURE VI
Typical Landfill Section



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8165

1.5:1 and a slope of 1:1. Computations for stability were based on the following criteria developed from laboratory tests using conservative results.

SLOPE CRITERIA

| DEPTHS (FT.) | $\sigma'_3$ | $\sigma'_1$ | $\frac{\sigma'_1 + \sigma^1_3}{2}$ | $\frac{\sigma'_1 - \sigma'_3}{2}$ |
|---|---|---|---|---|
| 29 - 30 | 34.5 | 132.0 | 83.3 | 48.8 |
| | 51.0 | 208.0 | 129.5 | 78.5 |
| 23 - 25 | 34.5 | 154.0 | 94.3 | 59.8 |
| | 51.0 | 200.0 | 125.5 | 74.5 |

WHERE:
$\sigma'$ = Normal Stress (PSI)
$\sigma_3$ = Confining Stress (PSI)

Design parameters:

1. Friction Angle ($\phi$) = 36°
2. Unit Weight $\gamma$ = 135 PCF
3. Effective Cohesive Shear Strength $C'$ = 260 PSF

The slope stability analysis was made using the computer program (PC STABL 5M) adopted by the Federal Public Road Administration. This program was developed by the University of Purdue under a federal grant program and is widely used throughout the U.S.A.

The computer analysis calculates the ten most critical failure circles based on the selected slope, friction angle $\phi$, cohesion and whether or not a compacted clay liner is considered. The analysis computes the factor of safety for each



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

failure circle. A graphical analysis depicting 10 failure circles for each of the failure planes at various slopes are shown in Appendix IV. The most critical condition is highlighted by arrows. Slope conditions were considered without the clay liner and omitting the effects of the cohesive strength of the clays. Listed below in Table II are the results of the analysis.

**TABLE II**

**SUMMARY OF SLOPE STABILITY ANALYSIS**

| COMPUTER NO. RUN | SLOPE (H:V | $\phi$ | C′ (PSF) | WITH LINER W/O LINER | MINIMUM FACTOR OF SAFETY |
|---|---|---|---|---|---|
| 1 | 1:1 | 36° | 260 | With Liner | 1.54 |
| 2 | 1.5:1 | 36° | 260 | W/O Liner | 1.52 |
| 3 | 1.5:1 | 36° | 260 | With Liner | 1.73 |
| 4 | 2:1 | 36° | No Cohesion | W/O Liner | 1.47 |
| 5 | 2:1 | 36° | No Cohesion | With Liner | 1.90 |
| 6 | 2:1 | 36° | 260 | W/O Liner | 2.36 |

C′ = Effective Cohesive Shear Strength

All of the computer analysis were run with an internal friction angle ($\phi$) of 36°. This is considered to be a conservative figure based on laboratory tests of the insitu clays. The analysis clearly shows that a 2:1 slope with or without the compacted clay liner will provide a safe stable condition with a safety factor of 2.36. Computer run number 4



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

and 5 indicate even under saturated conditions the 2:1 slope would be stable.

B. Settlement Analysis - The groundwater table at the most shallow depth is 150 feet below existing ground surface (as of 2/15/93) and is not a consideration for calculation of settlement. Therefore only elastic settlement is considered and consolidation is not a factor. Since the waste repository is considered as a flexible foundation and therefore the elastic settlement is given by:

$$S_e = C_d\, qB\, (1 - \mu^2{}_s/E_s)$$

Where
$S_e$ = elastic settlement
$C_d$ = a parameter accounting for the shape of the load area
$q$ = distributed load
$B$ = width of the foundation
$\mu_s$ = Poisson's ratio of the soil
$E_s$ = Young's modulus of the soil

Based on the unit weights given in Figure VI, page 12, the maximum elastic settlement (Se) at the center of the waste repository when the complete landfill is loaded is calculated to be 2.45 inches (see Appendix IV for our calculations).

BORE HOLE GROUTING

All bore hoes were grouted with a cement/bentonite slurry. The bore holes were grouted after all water level measurement were made and drilling was completed on the site. Because of the hard dry clays and the absence of groundwater bore holes generally remained open and there was little or no problem with



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166

caving or sloughing. Each hole was measured prior to grouting to verify the depth was within one foot of the original drilling depth. If not, the holes were redrilled with air rotary and the bore hole was grouted immediately by pumping grout through a 2 inch PVC tremmie pipe from bottom to surface.

The grout mixture consisted of a ratio of 94 pounds portland cement per 5 pounds bentonite per 12 gallons of water. The grout was mixed at a local concrete redi-mix company within 2 miles of the site. The grout was poured into the open bore hole from the chute of the redi-mix truck. Where caving or sloughing of holes was a problem than centrifugal pump and tremmie line was used to ensure that grout was forced from bottom to top of the hole.

The original bore hole depth, the depth prior to grouting, date grouted, truck number and amount of cement/bentonite used was recorded by the technician.

REMARKS

This report has been prepared in order to aid in the evaluation of this property and to assist the architect and engineer in the design of the project. It is intended for use with regard to specific projects discussed in general herein and any substantial changes in locations or grades should be brought to our attention so that we may determine how this may affect our conclusions. If during the proposed construction, the soil strata are found to differ from that reported here, we should be notified immediately. This report contains soil boring logs which are for the purpose of arriving at foundation criteria and are not to be used by the excavation contractor in arriving at rock hardness or rock depth. The procedures, tests and recommendations of this investigation and report have been conducted and furnished in accordance with generally accepted professional engineering practices in the field of foundations, engineering soil mechanics and engineering geology. No other warranty is either expressed or implied.

STATE OF TEXAS
JACK HASTON HOLT
35732
REGISTERED PROFESSIONAL ENGINEER

Jack H. Holt
Ph.D., P.E.

JHH/mco



JACK H. HOLT Ph.D. & ASSOCIATES INC.
2220 BARTON SKYWAY
AUSTIN, TEXAS 78704
PH. 512/447-8166