



**SUBSURFACE EXPLORATION
AND GEOTECHNICAL ENGINEERING
EVALUATION
REPORT
PROPOSED MIDWAY PARK RESIDENTIAL
DEVELOPEMENT
CAMP LEJEUNE MARINE CORPS BASE
JACKSONVILLE, NORTH CAROLINA**

F&R PROJECT NO. D66-293G

Prepared For:

GREENHORNE AND O'MARA, INC.

5565 Centerview Drive, Suite 107
Raleigh, North Carolina 27606

Prepared By:

FROEHLING & ROBERTSON, INC.

310 Hubert Street
Raleigh, North Carolina 27603
Phone: (919) 828-3441 • Fax: (919) 828-5751

April 16, 2003



TABLE OF CONTENTS

	<u>PAGE</u>
1.0 PURPOSE AND SCOPE OF SERVICES.....	1
1.1 Purpose of Study.....	1
1.2 Scope of Services.....	1
2.0 PROPOSED PROJECT DATA.....	1
3.0 EXPLORATION PROCEDURES.....	2
3.1 Field Exploration.....	2
3.2 Laboratory Testing.....	3
4.0 SITE AND SUBSURFACE CONDITIONS.....	3
4.1 Site Conditions.....	3
4.2 Regional Geology.....	4
4.3 Subsurface Conditions.....	4
4.4 Groundwater Conditions.....	5
5.0 ENGINEERING EVALUATION & RECOMMENDATIONS.....	6
5.1 General Development Considerations.....	6
5.2 Site Preparation.....	7
5.3 Structural Fill Placement and Compaction.....	8
5.4 Cut and Fill Slopes.....	8
5.5 Foundations.....	9
5.6 Settlement.....	10
5.7 Seismic Design Criteria.....	11
5.8 Floor Slabs.....	11
5.9 Pavements.....	12
5.10 Temporary Excavation Recommendations.....	12
6.0 CONSTRUCTION QUALITY CONTROL.....	13
7.0 LIMITATIONS.....	14
APPENDIX I SITE VICINITY MAP, FIGURE No. 1 BORING LOCATION PLAN, FIGURE No. 2 SUBSURFACE PROFILE, FIGURE No.'s 3 & 4	
APPENDIX II KEY TO SOIL CLASSIFICATION CHART BORING LOGS	
APPENDIX III LABORATORY TESTING RESULTS	



1.0 PURPOSE AND SCOPE OF SERVICES

1.1 PURPOSE OF STUDY

The purpose of the subsurface exploration and geotechnical engineering evaluation was to explore the subsurface conditions at the site and to provide geotechnical design recommendations for foundation design, as well as recommendations for site preparation, earthwork and quality control measures related to these design aspects.

1.2 SCOPE OF SERVICES

F&R's scope of services included the following:

- Completion of 19 soil test borings (B-1 through B-17, B-11M and B-14A) to depths ranging from 9 to 45 feet;
- Performing geotechnical laboratory testing on representative soil samples;
- Preparation of typed Boring Logs and development of Subsurface Profiles;
- Performing a geotechnical engineering evaluation of the subsurface conditions with regard to their suitability for the proposed construction;
- Preparation of this geotechnical report by professional engineers.

2.0 PROPOSED PROJECT DATA

The project site is an existing residential development that will be razed and re-developed. The proposed buildings will be one and two-story wood-frame residential structures. Based on our conversation with Mr. Dan Donochod, P.E. of Greenhorne & O'Mara, the proposed structures may be founded on shallow foundations with crawl spaces or may be slab-on-grade construction including turned-down foundations. The site grading plans are not yet available to F&R; however, it is anticipated that cuts and fills will be minimal (less than 2 feet) to establish the finished grades. Specific structural loading information is not available at this time, but we anticipate that maximum column and wall loads will be 25 kips and 3 kips per linear foot, respectively.



3.0 EXPLORATION PROCEDURES

3.1 FIELD EXPLORATION

A total of 19 soil test borings (B-1 through B-17, B-11M and B-14A) were performed at the project site as part of this exploration (see Figure No. 2 Boring Location Plan in Appendix I). The borings were located in the field by an F&R representative by taping measurements from known site features (e.g. existing buildings and parking lots). The ground surface elevations at the boring locations are based on interpolation of the topographic information indicated the plans provided to F&R. Given the method of determination, the boring locations and ground surface elevations should only be considered approximate.

The test borings were advanced with a track-mounted CME 750 drill rig, using hollow stem augers for borehole stabilization. Representative soil samples were obtained within the soil test borings using a standard two-inch outside diameter (O.D.) split barrel sampler in general accordance with ASTM D 1586, Penetration Test and Split-Barrel Sampling of Soils (Standard Penetration Test). The number of blows required to drive the split barrel sampler three consecutive 6-inch increments is recorded and the blows of the last two 6-inch increments are added to obtain the Standard Penetration Test (SPT) N-values representing the penetration resistance of the soil. Standard Penetration Tests were performed at frequent intervals to evaluate the consistency and general engineering properties of the subsurface soils.

Representative portions of the soil samples obtained from each SPT interval were sealed in a container, labeled and transported to our laboratory for final classification by a geotechnical engineer. The soil samples were visually classified in general accordance with the Unified Soil Classification System (USCS), using visual-manual identification procedures (ASTM D 2488). The Boring Log for each test boring is presented in Appendix II.

Soft/loose compressible material was encountered near the surface at several of the borings performed in the southeastern portion of the site including boring B-14. An offset boring, B-14A, was performed for the purpose of retrieving relatively undisturbed samples for laboratory testing. Two Shelby Tube samples were obtained from the loose and very soft soils in B-14A at depths between 3.5 and 7.5 feet.



Test boring B-11M, an offset boring of B-11, was advanced with mud rotary drilling to equalize groundwater seepage forces that may have been affecting the results of the SPT test N-values. A 2-15/16-inch drag bit was advanced, and the borehole was filled with a bentonite mud. SPT sampling was performed in the same manner described previously. SPT N-values, obtained in boring B-11M were similar to those obtained in boring B-11 indicating that groundwater seepage was not affecting the SPT N-values, and that continued mud drilling was not necessary.

3.2 LABORATORY TESTING

Two consolidation tests were performed on the relatively undisturbed Shelby Tube samples retrieved from boring B-14A. Routine geotechnical laboratory index testing was also performed on these, and on 5 other selected samples to aid in the classification process. The routine laboratory testing consisted of Atterberg Limits, natural moisture content and sieve analysis. The samples were tested in general accordance with the applicable ASTM standards. Results of the laboratory tests are presented in Appendix III. Detailed information about the consolidation tests is included in Section 5.6.

4.0 SITE AND SUBSURFACE CONDITIONS

4.1 SITE CONDITIONS

Midway Park is currently a residential neighborhood of 1-story houses mostly arranged around two small paved streets, which are concentric and circular. The houses have relatively flat and grass covered yards. Undeveloped areas in the center of the subdivision, and around its perimeter, are occupied by dense woods. Based on topographic information provided by Greenhorne and O'Mara, higher elevations occur within the central undeveloped portion of the site and gently descend towards the perimeter of the project site.



4.2 REGIONAL GEOLOGY

Based on our review of the Geologic Map of North Carolina (Brown, 1985), the project site is located in the Coastal Plain Physiographic Province of North Carolina. The Coastal Plain is characterized by flat land to gently rolling hills and valleys. The Coastal Plain is a wedge of mostly marine sediments that gradually thickens to the east. More specifically, the site is located in the Belgrade Formation, which consists of gray to brown, fossiliferous clayey sand.

4.3 SUBSURFACE CONDITIONS

Subsurface Profiles have been prepared from the boring data to graphically illustrate the subsurface conditions encountered at the site. The Subsurface Profiles are presented in Figure Numbers 3 and 4 in Appendix I. Strata breaks designated on the Boring Logs and Subsurface Profiles represent approximate boundaries between soil types. The actual transition from one soil type to another may be gradual or occur between soil samples. The generalized subsurface conditions at the site are described below. For more detailed soil descriptions and stratifications at a particular boring location, the respective Boring Log, supplied in Appendix II, should be reviewed.

In the majority of the borings, a topsoil/grass root mat layer was encountered at the surface ranging from 1 to 10 inches in thickness with a majority of the locations having a thickness of 2 to 3 inches. A pavement section consisting of approximately 1 to 2.5 inches of asphalt and 5 to 8 inches of Aggregate Base Course (ABC) stone was encountered at the surface at boring locations B-4, B-5 and B-14. Borings B-10, B-12, B-15 and B-17, an asphalt layer ranging from 2.5 to 11 inches was encountered at the surface.

Beneath the surface material described above, coastal plain deposits generally consisting of very loose to medium dense, silty sand and sand, (USCS –SM and SP) were encountered to depths ranging from 2.0 to 13.5 feet. N-values obtained in this soil stratum varied from 1 to 19 bpf with a majority in excess of 5 bpf. Underlying this stratum, layers of high to low plasticity, silty and fine sandy clays (USCS –CL and CH) were encountered. N-values ranged from 0 to 10 in the clayey soil, and were encountered to depths ranging from 24 feet to 30. Softer layers, N-values between 0 and 2, were generally encountered in the south-central portion of the site, in Borings



B-6, B-11, B-12, and B-14, B-15 and B-16. In Boring B-6, sands and silty sands (USCS –SM, SP), with occasional shells were encountered at 27 feet and extended to boring termination at 45 feet.

4.4 GROUNDWATER CONDITIONS

Soil samples obtained from the borings were generally moist near the surface and became wet or saturated with depth. In Borings B-6 and B-11 to B-17, wet or saturated soils were encountered at depths of 1 to 3.5 feet and extended for the full depth of the borings. In the remaining borings, wet or saturated soils were generally encountered at depths of 6 to 13 feet and extended to termination.

Groundwater was observed in Borings, B-3, B-6, B-7, B-8, B-13, B-15 and B-17 when measurements were attempted at the termination of drilling, at depths ranging from 10.0 to 33.0 feet below the existing ground surface. After a 24-hour stabilization period, groundwater measurements were taken in PVC standpipes installed in Borings B-3, B-8, B-11 and B-16. Groundwater depths measured were variable, ranging from 3.3 to 28.0 feet below the ground surface. Based on the presence of clayey soils, it is possible that sufficient time was not allowed to obtain stabilized water levels. Considering the obtained groundwater readings and observed soil moisture conditions, F&R anticipates that groundwater will generally be encountered at depths 4 to 10 feet, or less in perched conditions, across most of the site. The shallowest groundwater levels are anticipated on the southern portion of the site.

If proposed grades are at or above existing grades, then we do not anticipate that groundwater should be a problem during a majority of the mass grading or foundation installation at this site. Due to the presence of shallow groundwater, some areas may require temporary dewatering measures while establishing final grades. In addition, deep utility excavations that penetrate the water table will also require groundwater control measures and trench excavation slopes may require shoring or flattening back depending on the depth of excavation. F&R recommends that a minimum separation of at least 4 feet be maintained between stable high water levels and finished subgrades. Once a grading and utility plan is available, F&R should be provided an



opportunity to review it in its early stages with regard to site conditions and provide any additional recommendations if needed.

It should be noted, however, that groundwater elevations tend to fluctuate with seasonal and climatic variations, as well as with some types of construction operations. Therefore, the elevation of the groundwater table may be different at other times of the year, and vary in different parts of the site, from the elevations presented in this report.

5.0 ENGINEERING EVALUATION & RECOMMENDATIONS

5.1 GENERAL DEVELOPMENT CONSIDERATIONS

The conclusions and recommendations contained in this section of the report are based upon the results of the 19 soil test borings, site observations, laboratory test results and information provided regarding the proposed development. It is our opinion that the subsurface conditions encountered on the project site are suitable for the proposed development provided the following measures are considered and recommendations presented in subsequent sections of this report are followed throughout the design and construction phases of this project.

- A. Variable density silty sand and sand was encountered sporadically across the site within the upper 10 feet. F&R recommends that when structural and paved areas are known, a thorough field evaluation should be performed. Any areas that exhibit loose or soft conditions should attempt to be densified prior to fill placement, foundation installation of pavement construction. The field evaluation may include proofrolling, test pit excavations and hand auger borings with Dynamic Cone Penetrometer (DCP) testing. As previously mentioned, the near surface soils appeared moist and became wet to saturated with depth. If at the time of construction the near surface sandy material (upper 2 to 4 feet) is dry to slightly moist, attempts should be made to densify them with a medium to large capacity (8 to 10 ton) vibratory smooth drum roller. Soft or loose areas that fail to improve or contain sufficient fines (clay or silt) or of high moisture content may require undercutting and replacement with drier material as a method of repair.



- B. Soft, compressible soils are present beneath the near surface sandy soils particularly in the south central portion of the site. Due to the presence of this material, F&R recommends, if possible, that proposed grades not be planned below existing grades. If site grading requires excavations within structural areas (buildings and paved areas) then there is an increased risk that excessive settlement will occur that may cause building and pavement distress and possible structural damage. If soft compressible materials are encountered during site grading, they should be evaluated by the geotechnical engineer and repaired as directed. We anticipate that repair of soft compressible soil conditions will include undercutting and replacement with suitable structural fill and may include the use of geosynthetics.
- C. As previously indicated, given the preliminary stage of this project, F&R should be afforded the opportunity to review site grading, layout and structural plans once these plans have been developed to determine if additional or modified recommendations are needed.

5.2 SITE PREPARATION

The building and pavement areas should be stripped of all concrete (old foundations), asphalt pavement, topsoil, trash, debris and other organic or deleterious materials to a minimum of 10 feet outside the structural, and 5 feet outside pavement limits. Upon the completion of the stripping operations, the exposed subgrade in areas to receive fill should be proofrolled with a loaded dump truck or similar pneumatic tired vehicle (minimum loaded weight of 20 tons) under the observation of a geotechnical staff engineer or a senior soils technician. The proofrolling procedures should consist of four passes of the exposed areas, with two of the passes being a direction perpendicular to the preceding ones. Any areas that deflect, rut or pump excessively during proofrolling should be repaired as directed by the geotechnical engineer.

Based on our past experience, soft/unstable conditions are commonly discovered on previously developed sites where demolition activities (including removal of old foundations and utilities) were performed. All existing utility lines within the proposed development area that are to be abandoned (i.e. storm water lines, water lines, sanitary sewer lines, etc.) should be removed. The resulting excavations should be backfilled with controlled structural fill placed in accordance



with the recommendations presented in this report. Open pipes or conduits, if any, left in-place should be bulkheaded and grouted as they might serve as a conduit for subsurface erosion.

5.3 STRUCTURAL FILL PLACEMENT AND COMPACTION

All fill used for site grading operations should consist of a clean (free of organics and debris), low plastic sandy/granular soil ($PI < 25$). The proposed fill should have a maximum dry density of at least 100 pounds per cubic foot as determined by a Standard Proctor compaction test, ASTM D 698. All fill should be placed in loose lifts not exceeding 8 inches in thickness (12 inches for very sandy material) and compacted to a minimum of 95 percent of its Standard Proctor maximum dry density. We recommend that field density tests, including one-point Proctor verification tests, be performed on the fill as it is being placed at a frequency determined by the geotechnical engineer to verify the compaction criteria.

Based on the results of the soil test borings performed and our past experience with similar type materials, the on-site sandy soils, except for the high plastic material, can be used as structural fill. Some aeration may be required prior to the re-use as structural fill so that adequate compaction can be achieved.

We would like to point out that the on-site silty and clayey soils can be moisture sensitive and may become unstable during normal construction traffic and activities when wet. During earthwork and construction activities, surface water runoff should be drained away from the construction areas to prevent water from ponding on or saturating the soils within excavations or on subgrades. Earthwork construction during seasonally wet times of the year (typically November to April) may result in soft subgrade conditions, difficulties in properly placing and compacting the on-site soils and possible undercutting in excess than would otherwise be expected.

5.4 CUT AND FILL SLOPES

Site grading plans were not available to F&R for this report, and we do not anticipate large cut and fill slopes. If slopes are planned, they should be designed to be 3 horizontal to 1 vertical or flatter. The tops and bases of all slopes should be located a minimum of 10 feet from structural limits and a minimum of 5 feet from pavement limits. The fill slopes should be compacted as



outlined in this report and should be vegetated as soon as possible to prevent surface sloughing and erosion. If sloughing or erosion occurs, the use of a vegetation mat or geotextile and large stone may be required to stabilize the slopes. A swale or shallow ditch should be constructed near the top of slopes to prevent surface water from flowing onto the slopes. We recommend that all cut and fill slopes be observed by a geotechnical engineer or his representative during construction. Additional slope drainage and protection measures may be required in certain areas depending upon conditions observed at the time of slope construction.

5.5 FOUNDATIONS

For satisfactory performance, the foundation for any structure must satisfy two independent design criteria. First, it must have an acceptable factor of safety against bearing failure of the foundation bearing soils under the maximum design loads. Second, the settlement of the foundations due to consolidation/compression of the underlying soils should be within tolerable limits for the proposed structures. Settlement considerations will be discussed in the following section, 5.6.

Based on the results of the soil test borings performed, the proposed structures can be adequately supported on shallow foundation bearing on competent near surface sandy soils, on approved adequately densified sandy soils or on properly compacted structural fill placed over an approved subgrade provided the site preparation and fill placement procedures outlined in this report are implemented.

Minimum wall and column footing dimensions of 18 and 24 inches, respectively, should be maintained to reduce the possibility of a localized, punching-type shear failure. Exterior foundations and foundations in unheated areas should be designed to bear at least 12 inches below finished grade for frost protection.

The bearing materials can be sensitive to moisture variations; therefore, foundation excavations should be opened for a minimum amount of time, particularly during inclement weather. If the soils are exposed to moisture variations, they could become disturbed and undercutting may be necessary. We recommend that foundations be installed shortly after the subgrade has been evaluated. If precipitation occurs after the evaluation, a re-evaluation may be necessary.

We recommend that all foundation excavations and bearing grades be evaluated by a qualified



geotechnical engineer or his representative. Should soft or variable density soils be present, then densification, undercutting or widening of the foundation may be required. The locations requiring densification or undercutting should be determined by the project geotechnical engineer based on the results of our observations and field evaluation. The field evaluation should include probing with a steel probe rod and performing hand auger borings with DCP testing of the foundation bearing materials. If soft or loose soils are encountered, they should be repaired as directed by the geotechnical engineer. A net allowable bearing pressure of 1500 pounds per square foot may be used for design of shallow foundations bearing on approved bearing materials (noted earlier in this section).

5.6 SETTLEMENT

As previously discussed, bearing capacity and settlement are primary concerns in foundation design. In general, large or differential settlements can cause distress or structural damage to buildings and roadways including increased long-term maintenance.

Due to the presence of compressible soils near the surface and at depth, two relatively undisturbed samples of the compressible material were retrieved and returned to our laboratory for consolidation testing. The samples were obtained using Shelby Tube samplers advanced into an offset boring (B-14A) adjacent to Boring B-14 at depths between 3.5 and 7.5 feet below the existing ground surface. Results from the consolidation testing are included in Appendix III for your review.

A settlement analysis was performed utilizing the consolidation data, empirical relationships and our past experience with similar type soils for shallow foundations designed for bearing pressures not exceeding 2000 psf. Tabulated below are the calculated total and differential settlements expected for the loading conditions analyzed.

Foundation Type	Total Settlement (in.)	Differential Settlement (in.)
Column	$\frac{1}{2}$ to 1	$\frac{1}{4}$ to $\frac{1}{2}$
Wall	$\frac{1}{2}$ to $\frac{3}{4}$	$\frac{1}{4}$ to $\frac{1}{2}$



Should a monolithic type turned-down-slab be considered, we recommend that additional reinforcement (rebar) be extended from the turned-down footing into the slab to help reduce the potential for cracking that may occur in the slab near the turned-down footing. In addition, interior turned-down footings should be incorporated into the slab coincidental to the location of load bearing walls. Additional reinforcement should be provided for interior turned-down footings. A structural engineer should be consulted with regard to reinforcement design.

5.7 SEISMIC DESIGN CRITERIA

F&R has evaluated the data obtained from the soil test borings performed with regard to the International Building Code (IBC) and Building Officials & Code Administrators (BOCA) for assignment of Seismic Site Classification of this site. A weighted average of the conditions in the upper 100 feet of the site was performed with the assumption that stiff to soft soils ($N < 15$ blows per foot) are present below the depth of our exploration. Based upon the subsurface conditions encountered, this site has an IBC Site Classification of **F** and a BOCA Site Coefficient of **1.5**. If the site is governed by the IBC code, then a dynamic site response analysis may be required to determine spectral response accelerations for the site.

5.8 FLOOR SLABS

The building ground floors may be designed as a slab-on-grade. We recommend that a modulus of subgrade reaction (k) of 150 pounds per cubic inch (pci) be used for slab design. The subgrade soils for support of floor slabs should be prepared as outlined in previous sections of this report. Utility and other construction excavations performed in the prepared floor slab subgrade should be backfilled in accordance with previously referenced structural fill criteria to aid in providing uniform floor support. The floor slab should be supported on at least 4 inches of ABC stone to provide a uniform well-compacted material immediately beneath the slab. The floor slab should be underlain by a vapor barrier to minimize the potential for floor slab dampness. Vapor barrier construction should be performed in accordance with applicable ACI guidelines. Floor slab design and construction should incorporate isolation joints around columns, utility penetrations, and along bearing walls to allow for differential movement to occur without damage to the floor.



5.9 PAVEMENTS

Subgrade preparation in paved areas should also be performed as outlined in previous sections of this report, including proofrolling of subgrade and base course materials. Exposed pavement subgrades should be re-compacted to at least 100 percent of the standard Proctor maximum dry density just prior to base stone placement.

As per the proposal, no site-specific pavement design was created for this site. We recommend that local, municipal standards be observed. F&R would be pleased to make pavement design recommendations for this project if they are needed in the future.

5.10 TEMPORARY EXCAVATION RECOMMENDATIONS

Temporary excavations should be shored, braced or flattened (laid back) to obtain a safe working environment. Utility excavations and other excavations required for construction of this project must be performed in accordance with the United States Department of Labor, Occupational Safety and Health Administration (OSHA) guidelines (29 CFR 1926, Subpart P, Excavations) or other applicable jurisdictional codes for permissible temporary side-slope ratios and/or shoring requirements. The OSHA guidelines require daily inspections of excavations, adjacent areas and protective systems by a “competent person” for evidence of situations that could result in cave-ins, indications of failure of a protective system, or other hazardous conditions. The on-site soils may be unstable even with less than a 1 (vertical) to 2 (horizontal) slope due to a lack of cohesion, even when moist. The “competent person” should verify slope stability in the field during construction. Excavated soils and equipment should not be placed within a distance equal to the excavation depth from the tops of slopes. The contractor is usually solely responsible for site safety. This information is provided as a service and under no circumstances should F&R be assumed to be responsible for construction site safety.



6.0 CONSTRUCTION QUALITY CONTROL

As previously discussed, the Geotechnical Engineer of record should be retained to monitor and test earthwork activities, and subgrade preparations for foundations, floor slabs and pavements. It should be noted that the actual soil conditions at the various subgrade levels and footing bearing grades will vary across this site and thus the presence of the Geotechnical Engineer and/or his representative during construction will serve to validate the subsurface conditions and recommendations presented in this report. We also stress the importance of conducting hand auger borings and DCP testing in the footing excavations in order to confirm the anticipated subsurface conditions and define footings that should be undercut and repaired as outlined in this report.

We recommend that F&R be employed to monitor the earthwork and foundation construction, and to report that the recommendations contained in this report are completed in a satisfactory manner. Our continued involvement on the project will aid in the proper implementation of the recommendations discussed herein. The following is a recommended scope of services:

- Review of project plans and construction specifications to verify that the recommendations presented in this report have been properly interpreted and implemented;
- Observe the earthwork process to document that subsurface conditions encountered during construction are consistent with the conditions anticipated in this report;
- Observe the subgrade conditions before placing structural fill including proofroll observations;
- Observe the densification or undercut and replacement of soft fill, placement and compaction of any structural fill and backfill, and perform laboratory and field compaction testing of the fill;
- Observe all foundation excavations and footing bearing grades for compliance with the recommended design soil bearing capacity.



7.0 LIMITATIONS

This report has been prepared for the exclusive use of Greenhorne and O'Mara for specific application to the referenced property in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. These conclusions and recommendations do not reflect variations in subsurface conditions that could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, we reserve the right to re-evaluate our conclusions and recommendations based upon on-site observations of the conditions. In the event changes are made in the proposed construction plans, the recommendations presented in this report shall not be considered valid unless reviewed by our firm and conclusions of this report modified or verified in writing. Prior to final design, F&R should be afforded the opportunity to review the site grading and layout plans to determine if additional or modified recommendations are necessary.

Important Information About Your Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one—not even you—*should apply the report for any purpose or project except the one originally contemplated.

Read the full report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report* that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when

it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,

- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions *only* at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject To Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the

report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time to perform additional study.* Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations", many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any *geoenvironmental* findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own *geoenvironmental* information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.



8811 Colesville Road Suite G106 Silver Spring, MD 20910

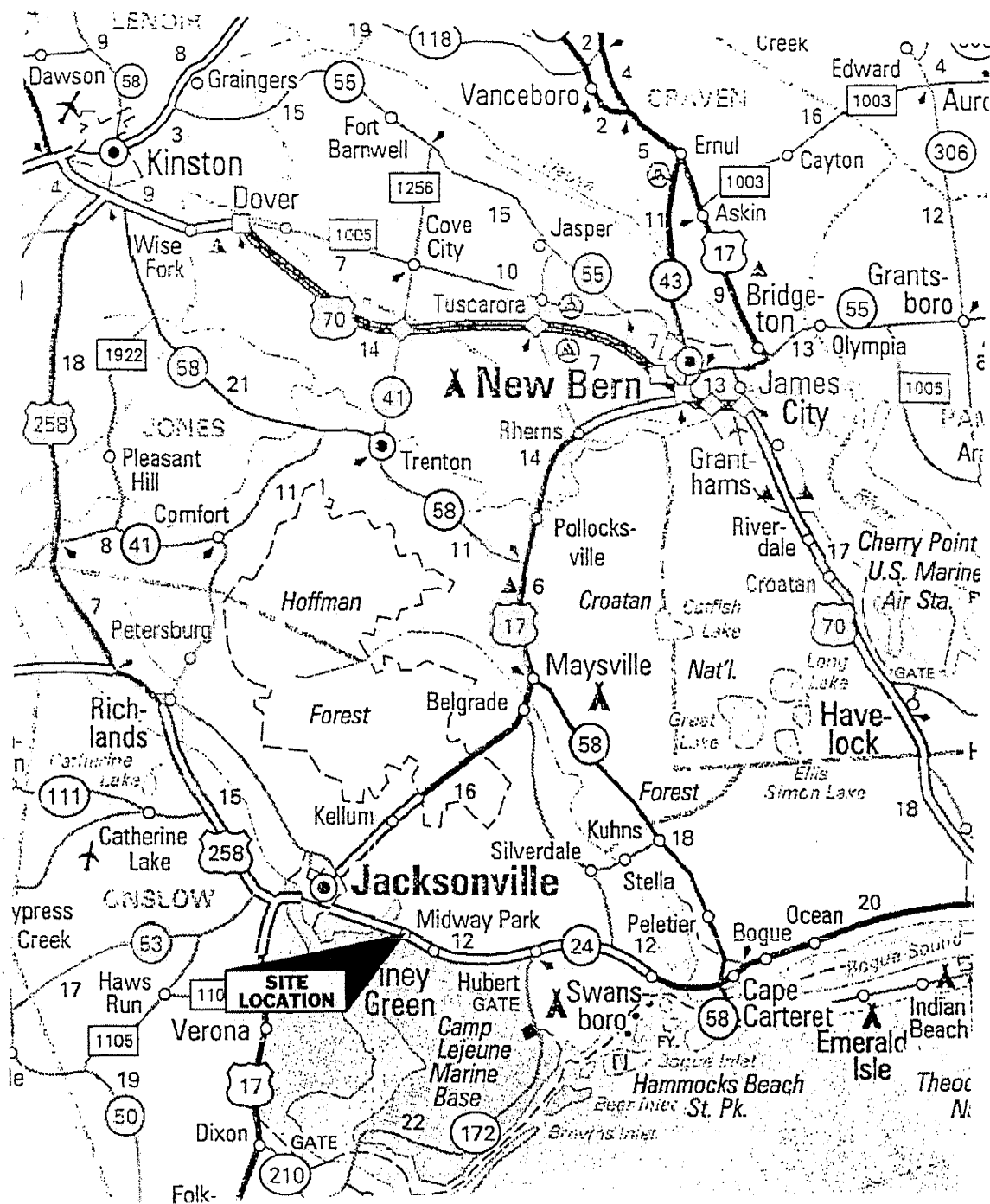
Telephone: 301-565-2733 Facsimile: 301-589-2017

email: info@asfe.org www.asfe.org



APPENDIX I

FIGURES

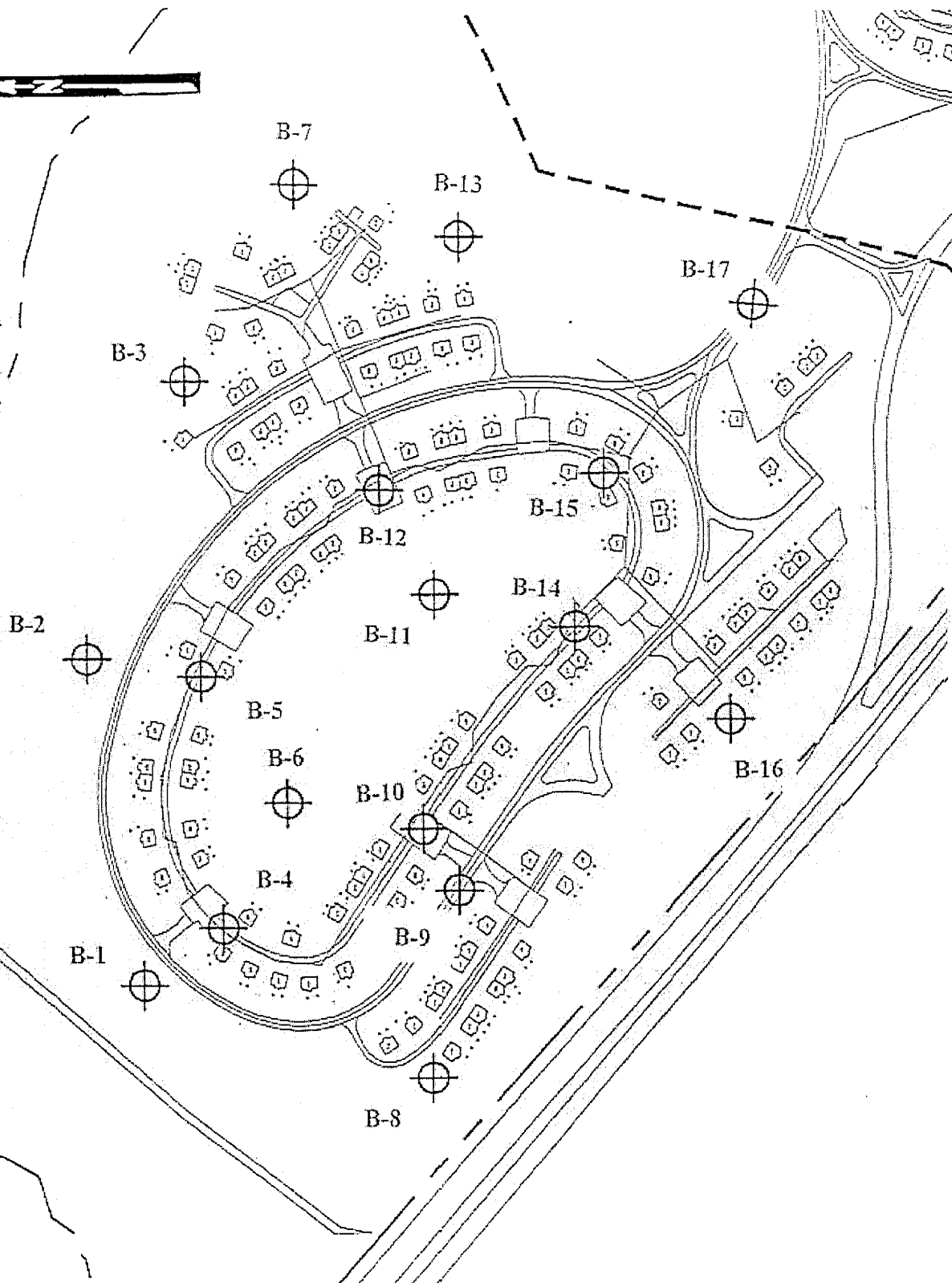


SITE VICINITY MAP



SINCE
FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"
 310 Hubert Street

CLIENT: Greenhorne & O'Mara
 PROJECT: Midway Park
 LOCATION: Camp LeJeune, NC



LEGEND

— APPROX. F&R BORING LOCATION

BORING LOCATION PLAN

ADAPTED FROM PHASE I DRAWING MPIOI BY GREENHORNE & O'MARA, INC. AND NOT DATED



SINCE 1904 FROEHLING & ROBERTSON, INC.

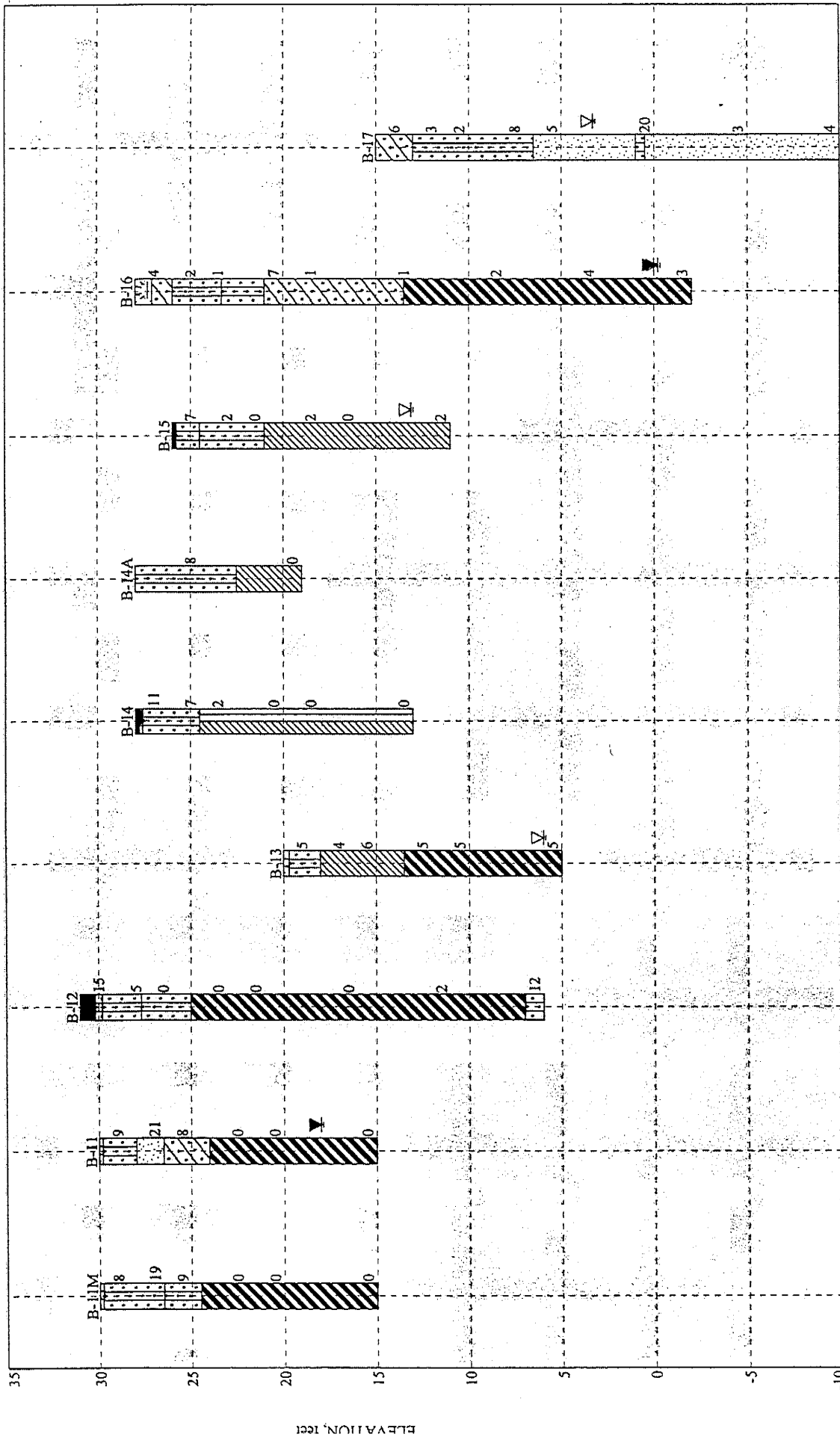
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES

"OVER ONE HUNDRED YEARS OF SERVICE"
310 Hubert Street

CLIENT: Greenhorne & O'Mara

PROJECT: Midway Park - Camp LeJeune

LOCATION: Jacksonville, NC



CLIENT: Greenhome & O'Mara
 PROJECT: Midway Park
 LOCATION: Camp Lejeune, NC
 DATE: April 17, 2003

FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"



SUBSURFACE PROFILE FIGURE No. 4

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISION					TYPICAL NAMES
	GRAVELS More than 50% of coarse fraction larger than No. 4 sieve	CLEAN GRAVEL (little or no fines)		GW	Well graded gravels
				GP	Poorly graded gravels
		GRAVELS with fines		GM	Silty gravels
				GC	Clayey gravels
	SANDS More than 50% of coarse fraction smaller than No. 4 sieve	CLEAN SAND (little or no fines)		SW	Well graded sands
				SP	Poorly graded sands
		SAND with fines		SM	Silty sands, sand/silt mixtures
				SC	Clayey sands, sand/clay mixtures
	SILTS AND CLAYS Liquid Limit is less than 50			ML	Inorganic silts, sandy and clayey silts with slightly plasticity
				CL	Sandy or silty clays of low to medium plasticity
				OL	Organic silts of low plasticity
	SILTS AND CLAYS Liquid Limit is greater than 50			MH	Inorganic silts, sandy micaceous or clayey elastic silts
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic clays of medium to high plasticity
	HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils
	MISCELLANEOUS MATERIALS				PWR (Partially Weathered Rock)
				Rock	
				Asphalt	
				ABC Stone	
				Concrete	
				Topsoil	



APPENDIX II

BORING LOGS



KEY TO SOIL CLASSIFICATION

Correlation of Penetration Resistance with Relative Density and Consistency

<u>Sands and Gravels</u>		<u>Silts and Clays</u>	
No. of Blows, N	Relative Density	No. of Blows, N	Relative Density
0 - 4	Very loose	0 - 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Firm
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		30 - 50	Hard
		Over 50	Very hard

Particle Size Identification (Unified Classification System)

Boulders:	Diameter exceeds 8 inches
Cobbles:	3 to 8 inches diameter
Gravel:	<u>Coarse</u> - 3/4 to 3 inches diameter <u>Fine</u> - 4.76 mm to 3/4 inch diameter
Sand:	<u>Coarse</u> - 2.0 mm to 4.76 mm diameter <u>Medium</u> - 0.42 mm to 2.0 mm diameter <u>Fine</u> - 0.074 mm to 0.42 mm diameter
Silt and Clay:	Less than 0.07 mm (particles cannot be seen with naked eye)

Modifiers

The modifiers provide our estimate of the amount of silt, clay or sand size particles in the soil sample.

<u>Approximate Content</u>	<u>Modifiers</u>
≤ 5%:	Trace
5% to 12%:	Slightly silty, slightly clayey, slightly sandy
12% to 30%:	Silty, clayey, sandy
30% to 50%:	Very silty, very clayey, very sandy

<u>Field Moisture Description</u>
Saturated: Usually liquid; very wet, usually from below the groundwater table
Wet: Semisolid; requires drying to attain optimum moisture
Moist: Solid; at or near optimum moisture
Dry: Requires additional water to attain optimum moisture



SPLIT SPOON SAMPLING

The borings were made in accordance with ASTM Specifications D-1586. The borings were advanced using either hollow stem augers or the rotary drill method using a bentonite slurry. The drill method employed depends upon the subsurface conditions and our experience in the general area. After cleaning all loose cuttings from the boring, the soil is sampled with a split barrel sampler. The sampler is driven to a depth of 18 inches or to a blow count of 100 blows with a 140-pound hammer falling 30 inches. The number of blows required for driving each 6-inch increment is recorded. The first 6-inch increment is required to seat the sampler below the disturbed zone, the second and third increments are added to yield blows per foot. This value is the standard penetration resistance, N. This is recorded on the attached logs of borings per each 6-inch increment of penetration. The "N" value, when properly evaluated, is an index to the in-place density strength and foundation support capacity.

Representative portions of each soil sample, obtained from the split tube sampler, were placed in glass jars, sealed and transported to our Raleigh, North Carolina laboratory. The soils are classified in accordance with ASTM Specification D-2488, "Visual--Manual Classification of Soils for Engineering Purposes", based on the Unified Classification System. The Unified Group Symbol is shown on the logs for each distinct stratum, and is described briefly on the attached chart.

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. D66-293

Date: April 2003

Client: **Greenhorne & O'Mara**

Project: **Midway Park, Camp LeJeune, NC**

Boring No.: **B-1** (1 of 1) Total Depth **15.0'** Elev: **20.0 ±** Location:

Type of Boring: **2.25" ID HSA** Started: **3/27/03** Completed: **3/27/03** Driller: **D. Tignor**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
19.8	0.2	TOPSOIL	1-1-1	0.0	2	GROUNDWATER DATA: 0 HRS.: Dry inside HSA 24 HRS.: Dry inside PVC
		Very loose to loose, moist, greenish-brown, fine SAND (SM), with fine roots.		1.5		
			1-2-2	2.0	4	
16.5	3.5	Firm, moist, light brown, fine sandy SILT (ML), with trace fine roots.	3-3-4	3.5	7	
15.0	5.0	Soft to firm, moist, light gray & yellow, fine sandy CLAY (CL).		5.0		
			2-2-2	6.5	4	
				8.0		
			2-2-2	8.5	4	
				10.0		
			1-2-3		5	
5.0	15.0	Boring terminated at 15.0 feet.				

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. **D66-293**

Date: **April 2003**

Client: Greenhorne & O'Mara						
Project: Midway Park, Camp LeJeune, NC						
Boring No.: B-2		(1 of 1)	Total Depth 15.0'	Elev: 17.0 ±	Location:	
Type of Boring: 2.25" ID HSA			Started: 3/31/03	Completed: 3/31/03	Driller: D. Tignor	
Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
16.8	0.2	TOPSOIL	1-0-1	0.0	1	GROUNDWATER DATA: 0 HRS.: Dry inside HSA 24 HRS.: Dry
		Very loose to loose, moist, light brown & orangish-brown, silty fine SAND (SM).		1.5		
			2-2-4	2.0	6	
			4-5-4	3.5	9	
				5.0		
10.5	6.5	Firm to stiff, moist, light greenish-brown, fine very sandy CLAY (CL).	3-2-4	6.5	6	
				8.0		
			3-4-6	8.5	10	
				10.0		
5.0	12.0	Firm, moist, dark gray, silty CLAY (CH).				
			2-2-4		6	
2.0	15.0	Boring terminated at 15.0 feet.				

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: **D66-293**

Date: **April 2003**

Client: **Greenhorne & O'Mara**

Project: **Midway Park, Camp LeJeune, NC**

Boring No.: **B-3 (1 of 1)** Total Depth **15.0'** Elev: **15.0 ±** Location:

Type of Boring: **2.25" ID HSA** Started: **3/27/03** Completed: **3/27/03** Driller: **D. Tignor**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
14.8	0.2	TOPSOIL	2-3-3	0.0	6	GROUNDWATER DATA: 0 HRS.: 14.1' inside HSA 24 HRS.: 8.7' inside PVC
13.7	1.3	Loose, moist, dark gray, silty fine SAND (SM), with fine roots.	2-2-1	1.5 2.0	3	
11.8	3.2	Very loose, moist, light brown, silty fine SAND (SM), with organic material.	2-2-3	3.5	5	
		Firm, moist, light gray & orange, fine sandy CLAY (CL/CH).		5.0		
			2-2-3	6.5	5	
				8.0 8.5	4	
			1-2-2	10.0		
1.5	13.5	Soft, wet, dark gray, silty CLAY (CH).	2-1-3	13.5	4	
0.5	14.5	Loose, moist, orangish-brown, clayey fine to medium SAND (SC).		15.0		
0.0	15.0	Boring terminated at 15.0 feet.				

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. D66-293

Date: April 2003

Client: Greenhorne & O'Mara						
Project: Midway Park, Camp LeJeune, NC						
Boring No.: B-5		(1 of 1)	Total Depth 15.0'	Elev: 28.0 ±	Location:	
Type of Boring: 2.25" ID HSA			Started: 3/28/03	Completed: 3/28/03	Driller: D. Tignor	
Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
27.8	0.2	ASPHALT	4-4-5	0.0	9	GROUNDWATER DATA: 0 HRS.: Dry inside HSA
27.3	0.7	ABC STONE		1.5		
		Loose to medium dense, moist, gray & orange, silty fine SAND (SM).	3-4-5	2.0	9	
			4-4-7	3.5	11	
				5.0		
22.0	6.0	Firm to very soft, saturated, dark gray, fine sandy SILT (MH).	4-3-2	6.5	5	
				8.0		
			2-1-0	8.5	1	
				10.0		
16.0	12.0	Very soft, saturated, dark gray, silty CLAY (CH).				
			1-1-0		1	
13.0	15.0	Boring terminated at 15.0 feet.				

F&R GDT 4/15/03

25

BORING LOG

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D. 1.25" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-6 (1 of 1) Total Depth 45.0' Elev: 32.0 ± Location:
 Type of Boring: 2.25" ID HSA Started: 3/31/03 Completed: 3/31/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
31.8	0.2	TOPSOIL	2-3-3	0.0	6	GROUNDWATER DATA: 0 HRS.: 33.0' inside HSA Boring backfilled upon completion.
		Loose to medium dense, wet to saturated, dark brown, silty fine SAND (SM).		1.5		
			4-7-11	2.0	18	
			7-10-9	3.5	19	
				5.0		
25.5	6.5	Very loose, saturated, gray, silty fine SAND (SM).	1-2-2	6.5	4	
23.5	8.5			8.0		
		Very soft, saturated, gray, fine sandy CLAY (CL).	0-0-1	8.5	1	
				10.0		
				13.5	0	
			0-0-0	15.0		
				18.5	0	
			0-0-0	20.0		
				23.5	0	
			0-0-0	25.0		
5.0	27.0	Loose, saturated, light gray, medium SAND (SP).		28.5	6	
			2-3-3	30.0		
-1.5	33.5	Loose, saturated, light gray & orange, silty fine to medium SAND (SM).	1-2-4	33.5	6	
				35.0		
-6.5	38.5	Medium dense, saturated, light gray, silty fine to medium SAND (SM), with shell fragments.	3-6-10	38.5	16	
				40.0		
-11.5	43.5	Very dense, saturated, gray, silty fine to medium SAND (SM).	21-25-31	43.5	56	
-13.0	45.0			45.0		
		Boring terminated at 45.0 feet.				

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-7 (1 of 1) Total Depth 15.0' Elev: 18.0 ± Location:

Type of Boring: 2.25" ID HSA Started: 3/28/03 Completed: 3/28/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
17.8	0.2	TOPSOIL	1-2-2	0.0	4	GROUNDWATER DATA: 0 HRS.: 13.5' inside HSA 24 HRS.: Dry
16.0	2.0	Very loose, moist, dark brown, silty fine SAND (SM).		1.5		
			2-2-4	2.0	6	
		Firm, moist, yellowish-brown & orange, fine sandy CLAY (CL), with fine roots.				
			2-3-4	3.5	7	
				5.0		
			2-3-4	6.5	7	
				8.0		
			2-2-4	8.5	6	
				10.0		
4.5	13.5	Loose, saturated, light brown, silty SAND (SM).	2-4-4	13.5	8	
3.0	15.0			15.0		

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG

SINCE



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-8 (1 of 1) Total Depth 15.0' Elev: 24.0 ± Location:

Type of Boring: 2.25" ID HSA Started: 3/27/03 Completed: 3/27/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
23.9	0.1	TOPSOIL	3-3-3	0.0	6	GROUNDWATER DATA: 0 HRS.: 10.0' inside HSA 24 HRS.: 3.3' inside PVC
		Loose and very loose, moist, black & light gray, silty fine SAND (SM).	1-1-2	1.5	3	
			3-3-4	1.5	7	
				5.0		
18.0	6.0	Loose, moist, light gray & orange, clayey fine SAND (SC), with organic material.	4-3-2	6.5	5	
16.0	8.0	Very soft, saturated, gray, silty CLAY (CH), with salty odor.	0-0-0	8.5	0	
				10.0		
12.0	12.0	Very loose, saturated, gray, very silty fine SAND (SM), with salty odor.	1-1-1		2	
9.0	15.0	Boring terminated at 15.0 feet.				

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. **D66-293**

Date: **April 2003**

Client: **Greenhorne & O'Mara**

Project: **Midway Park, Camp LeJeune, NC**

Boring No.: **B-9** (1 of 1) Total Depth **15.0'** Elev: **32.0 ±** Location:

Type of Boring: **2.25" ID HSA** Started: **4/1/03** Completed: **4/1/03** Driller: **D. Tignor**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
31.9	0.1	TOPSOIL	5-6-4	0.0	10	GROUNDWATER DATA: 0 HRS.: 10.0' inside HSA Boring backfilled upon completion.
		Medium dense to loose, moist, dark gray, silty fine SAND (SM). Becomes saturated at 2.0'.		1.5		
			4-5-8	2.0	13	
			4-4-4	3.5	8	
				5.0		
25.5	6.5	Very loose to loose, wet, gray, very silty fine SAND (SM).	4-4-4	6.5	8	
			3-2-2	8.0		
				8.5	4	
				10.0		
20.0	12.0	Very soft, saturated, gray, silty CLAY (CH).				
			0-0-0	13.5	0	
17.0	15.0	Boring terminated at 15.0 feet.		15.0		

BORING LOG



GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-10 (1 of 1) Total Depth: 15.0' Elev: 32.0 ± Location:

Type of Boring: 2.25" ID HSA Started: 3/31/03 Completed: 3/31/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
31.1	0.9	ASPHALT	4-5-6	0.0	11	GROUNDWATER DATA: 0 HRS.: Dry inside HSA
		Loose and medium dense, moist, black, fine SAND (SP).		1.5		
			6-4-4	2.0	8	
			4-8-8	3.5	16	
				5.0		
25.0	7.0	Loose to very loose, saturated, gray, silty fine SAND (SM), with salty odor.	2-3-3	6.5	6	
				8.0		
			1-0-1	8.5	1	
				10.0		
18.5	13.5	Very soft, saturated, gray, silty CLAY (CH), with organic odor.	0-0-0		0	
17.0	15.0					
		Boring terminated at 15.0 feet.				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG



GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-11 (1 of 1) Total Depth 15.0' Elev: 30.0 ± Location:

Type of Boring: 2.25" ID HSA Started: 3/27/03 Completed: 3/27/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
29.8	0.2	TOPSOIL	3-4-5	0.0	9	GROUNDWATER DATA: 0 HRS.: Dry inside HSA 24 HRS.: 12.0' inside PVC
28.0	2.0	Loose, moist, dark brown, silty fine SAND (SM).		1.5		
				2.0	21	
26.5	3.5	Medium dense, wet, gray, fine SAND (SP).	9-11-10	3.5	8	
		Loose, wet, gray, clayey fine SAND (SC).	5-4-4	5.0		
24.0	6.0	Very soft, saturated, gray, fine sandy CLAY (CH).		6.5	0	
			0-0-0	8.0		
				8.5	0	
			0-0-0	10.0		
				13.5	0	
15.0	15.0	Boring terminated at 15.0 feet.		15.0		

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-11M (1 of 1) Total Depth 15.0' Elev. 30.0 ± Location:

Type of Boring: Mud Rotary Started: 3/28/03 Completed: 3/28/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
29.8	0.2	TOPSOIL	1-4-4	0.0	8	GROUNDWATER DATA:
		Loose to medium dense, wet, dark brown, silty fine SAND (SM).		1.5		
			8-9-10	2.0	19	
26.5	3.5	Loose, wet, gray, silty fine SAND (SM).	5-4-5	3.5	9	
24.5	5.5	Very soft, saturated, gray, sandy silty CLAY (CH).		5.0		
			0-0-0	6.5	0	
				8.0		
			0-0-0	8.5	0	
				10.0		
			0-0-0	13.5	0	
15.0	15.0	Boring terminated at 15.0 feet.			15.0	

BORING LOG 4/15/03 J.A.F. GDI

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D. 1 3/4" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

Report No.: D66-293



FROEHLING & ROBERTSON, INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"

Date: April 2003

Client: **Greenhorne & O'Mara**

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-12	(1 of 1)	Total Depth	25.0'	Elev:	31.0 ±	Location:
------------------	----------	-------------	-------	-------	--------	-----------

Type of Boring: 2.25" ID HSA	Started: 3/27/03	Completed: 3/27/03	Driller: D. Tignor
------------------------------	------------------	--------------------	--------------------

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
30.2	0.8	ASPHALT	6-8-7	0.0	15	GROUNDWATER DATA: 0 HRS.: Dry inside HSA
29.8	1.2	Medium dense, moist, dark brown, silty fine SAND (SM).	4-3-2	1.5	5	
27.7	3.3	Loose, wet, gray, silty fine SAND (SM).	0-0-0	2.0	0	
		Very soft, saturated, gray, very silty fine SAND (SM), with salty odor.		3.5		
25.0	6.0	Very soft, saturated, gray, silty CLAY (CH).		5.0		
			0-0-0	6.5	0	
				8.0		
			0-0-0	8.5	0	
				10.0		
			0-0-0	13.5	0	
				15.0		
			0-1-1	18.5	2	
				20.0		
7.0	24.0		2-4-8	23.5	12	
6.0	25.0	Medium dense, wet, dark gray, silty fine SAND (SM).		25.0		
		Boring terminated at 25.0 feet.				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

CORRECTION : , PERIOD 4, 703

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-13 (1 of 1) Total Depth: 15.0' Elev: 20.0 ± Location:
 Type of Boring: 2.25" ID HSA Started: 3/28/03 Completed: 3/28/03 Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
19.7	0.3	TOPSOIL	2-2-3	0.0	5	GROUNDWATER DATA: 0 HRS.: 14.0' inside HSA 24 HRS.: Dry
18.0	2.0	Loose, moist, light brown, silty fine SAND (SM).		1.5		
		Soft to firm, wet, yellowish-brown, fine sandy CLAY (CL), with organic material.	2-2-2	2.0	4	
			3-3-3	3.5	6	
13.5	6.5	Firm, wet, gray & yellow, fine sandy CLAY (CH).		5.0		
			1-2-3	6.5	5	
			1-2-3	8.0	5	
				8.5		
5.0	15.0		1-2-3	10.0		
				13.5	5	
				15.0		

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D. 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. **D66-293**

Date: **April 2003**

Client: **Greenhorne & O'Mara**

Project **Midway Park, Camp LeJeune, NC**

Boring No. **B-14** (1 of 1) Total Depth **15.0'** Elev: **28.0 ±** Location:

Type of Boring: **2.25" ID HSA** Started: **4/1/03** Completed: **4/1/03** Driller: **D. Tignor**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
27.8	0.2	ASPHALT	5-6-5	0.0	11	GROUNDWATER DATA: 0 HRS.: Dry inside HSA
27.6	0.4	ABC STONE		1.5		
		Loose to medium dense, moist, dark brown, silty fine	5-5-2	2.0	7	
24.5	3.5	SAND (SM).		3.5	2	
		Very soft, saturated, gray, fine sandy silty CLAY (CL/ML).	0-1-1	5.0		
			0-0-0	6.5	0	
			0-0-0	8.0	0	
				10.0		
			0-0-0	13.5	0	
13.0	15.0	Boring terminated at 15.0 feet.				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. **D66-293**

Date: **April 2003**

Client: **Greenhorne & O'Mara**

Project: **Midway Park, Camp LeJeune, NC**

Boring No.: B-14A (1 of 1)	Total Depth: 9.0'	Elev.: 28.0 ±	Location:
Type of Boring: 3.25" ID HSA	Started: 4/1/03	Completed: 4/1/03	Driller: D. Tignor

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
		Loose, moist, dark brown, silty SAND (SM).				GROUNDWATER DATA:
			3-5-3	2.0	8	
				3.5		
22.5 -	5.5	Very soft, saturated, gray, sandy CLAY (CL).				
			0-0-0		0	
19.0 -	9.0	Boring terminated at 9.0 feet.				

4/1/03 4/ 6603

BY

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No. **D66-293**

Date: **April 2003**

Client: **Greenhorne & O'Mara**

Project: **Midway Park, Camp LeJeune, NC**

Boring No. **B-15** (1 of 1) Total Depth **15.0'** Elev: **26.0 ±** Location: _____
 Type of Boring: **2.25" ID HSA** Started: **3/26/03** Completed: **3/26/03** Driller: **D. Tignor**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
25.8	0.2	ASPHALT	4-4-3	0.0	7	GROUNDWATER DATA: 0 HRS.: 12.9' inside HSA
24.5	1.5	Loose, moist, dark brown, silty fine SAND (SM). Very loose, wet to saturated, dark brown, silty fine SAND (SM), with organic staining.	1-1-1	1.5	2	
			0-0-0	3.5	0	
21.0	5.0	Very soft, wet to saturated, gray, fine sandy CLAY (CL).		5.0		
			0-1-1	6.5	2	
				8.0		
			0-0-0	8.5	0	
				10.0		
			0-1-1	13.5	2	
11.0	15.0	Boring terminated at 15.0 feet.				

F&R 4/17/03

BORING LOG

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the

BORING LOG



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

Report No.: D66-293

Date: April 2003

Client: Greenhorne & O'Mara

Project: Midway Park, Camp LeJeune, NC

Boring No.: B-17 (1 of 1) Total Depth 25.0' Elev: 15.0 ± Location:

Type of Boring: 2.25" ID HSA Started: 4/1/03 Completed: 4/1/03 Driller: D. Tignor

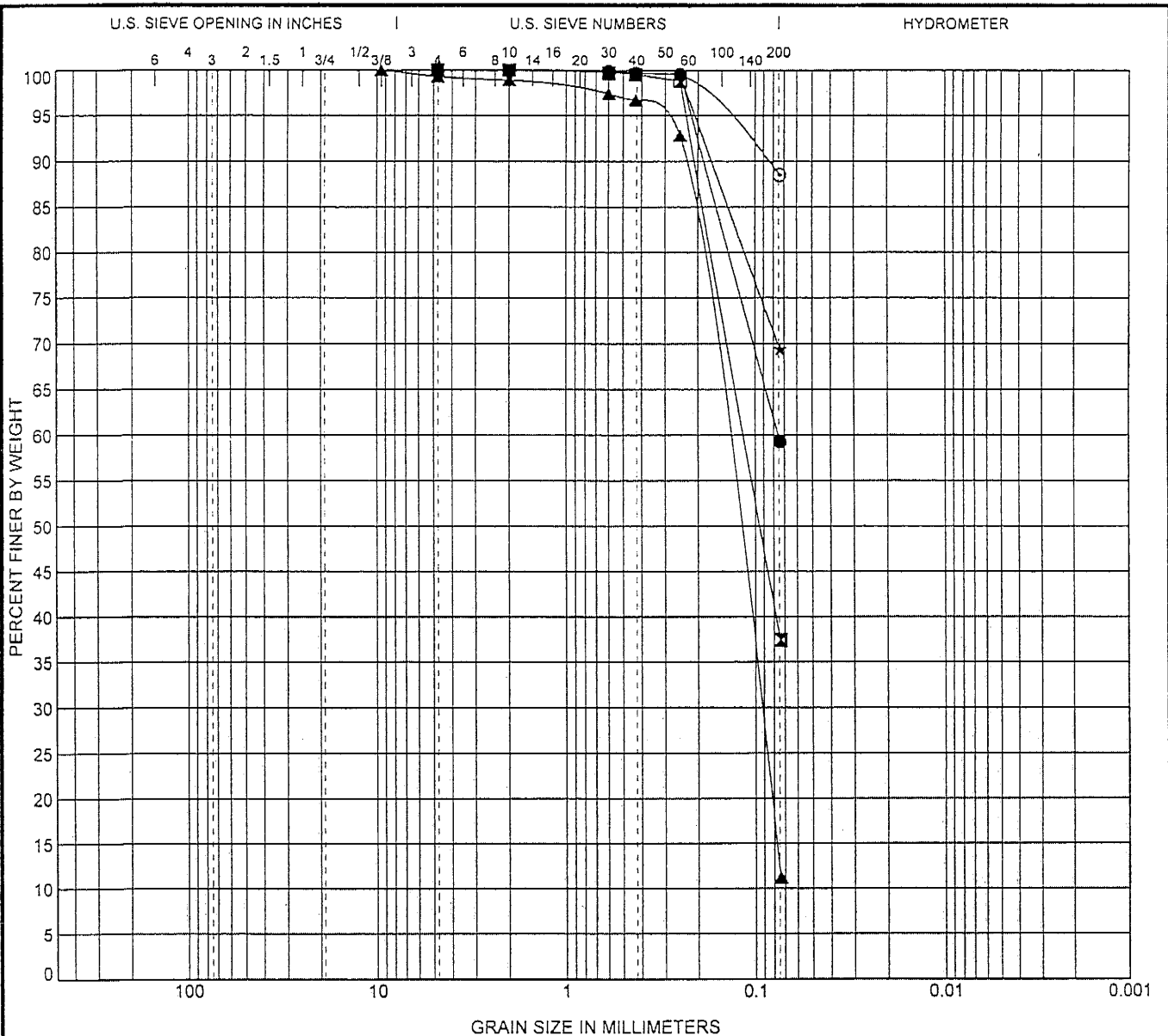
Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ft)	REMARKS
13.0	2.0	Loose, moist, light brown, clayey SAND (SC).	4-3-3	0.0	6	GROUNDWATER DATA: 0 HRS.: 11.7' inside HSA
				1.5		
		Very loose to loose, wet, dark to light brown, silty fine SAND (SM).	2-2-1	2.0	3	
			0-0-2	3.5	2	
				5.0		
			1-3-5	6.5	8	
6.5	8.5	Loose, saturated, orange, fine SAND (SP).	3-4-1	8.0	5	
				10.0		
1.0	14.0		1-7-13	13.5	20	
0.5	14.5	Medium dense, moist, dark brown, silty SAND (SM), with organic material.		15.0		
		Medium dense to very loose, saturated, gray, sorted SANDS (SP).				
			0-1-2	18.5	3	
				20.0		
			1-1-3	23.5	4	
-10.0	25.0	Boring terminated at 25.0 feet.		25.0		

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the



APPENDIX III

LABORATORY TEST RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring No.				Depth	Classification				LL	PL	PI	Cc	Cu
●	B-14	at	3.5	SANDY SILTY CLAY (CL-ML)				25	21	4			
⊠	B-16	at	2.0	SILTY SAND (SM)				31	NP	NP			
▲	B-4	at	2.0	SILTY SAND (SM)				25	NP	NP			
★	B-4	at	6.5	SANDY CLAY (CL)				29	19	10			
◎	B-5	at	13.5	CLAY (CH)				60	18	42			
Boring No.				Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay	
●	B-14	at	3.5	4.76	0.076			0.0					
⊠	B-16	at	2.0	4.76	0.116			0.0					
▲	B-4	at	2.0	9.52	0.153	0.098		0.7					
★	B-4	at	6.5	4.76				0.0					
◎	B-5	at	13.5	4.76				0.0					

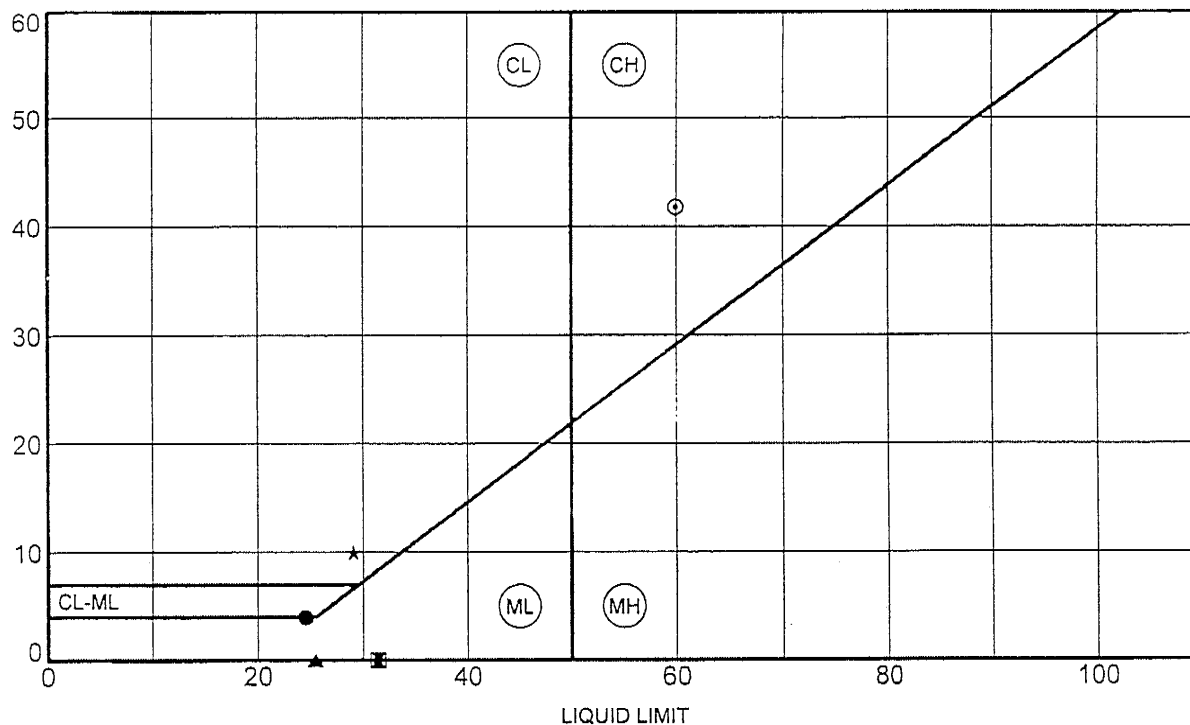


FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

GRAIN SIZE DISTRIBUTION

Report No.: D66-293
 Client: Greenhorne & O'Mara
 Project: Midway Park
 Location: Camp LeJeune, NC
 Date: April 2003

PLASTICITY INDEX



Boring No.	Depth	LL	PL	PI	Fines	Classification	Natural Moisture Content
● B-14	at 3.5	25	21	4		SANDY SILTY CLAY (CL-ML)	29.8%
⊠ B-16	at 2.0	31	NP	NP		SILTY SAND (SM)	36.9%
▲ B-4	at 2.0	25	NP	NP		SILTY SAND (SM)	22.6%
★ B-4	at 6.5	29	19	10		SANDY CLAY (CL)	33.7%
⊙ B-5	at 13.5	60	18	42		CLAY (CH)	48.0%

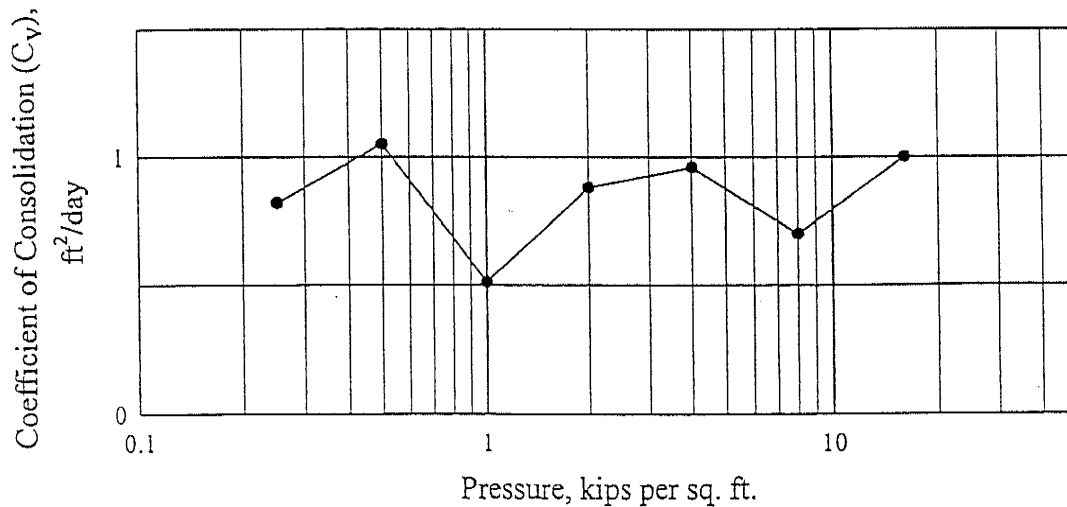
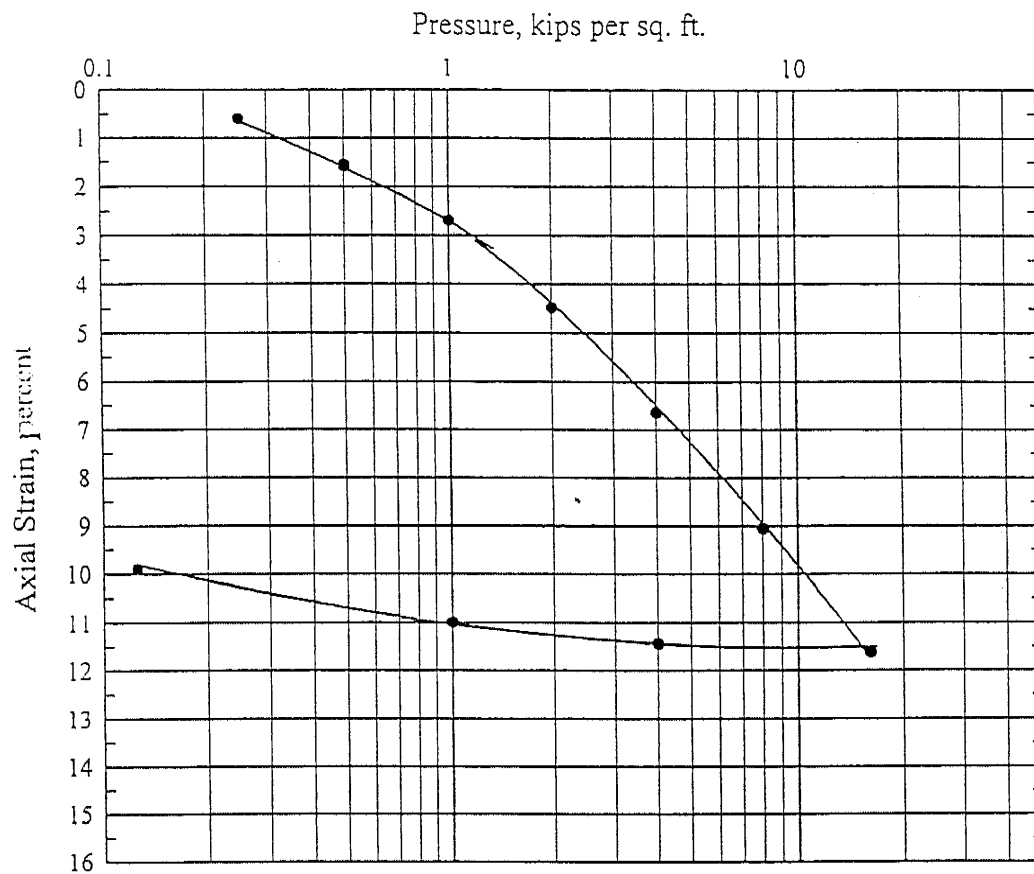
SINCE



FROEHLING & ROBERTSON, INC.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
 ENGINEERS • LABORATORIES
 "OVER ONE HUNDRED YEARS OF SERVICE"

ATTERBERG LIMITS' RESULTS

Report No.: D66-293
 Client: Greenhorne & O'Mara
 Project: Midway Park
 Location: Camp LeJeune, NC
 Date: April 2003



Boring No.: B-14A

Depth: 3.5 ft. - 5.5 ft.

Sample No.: ST-1

Soil Description: Gray, silty clayey SAND (SM/SC)

Specimen Type: Undisturbed

Specific Gravity: 2.65 (assumed)

Wet Unit Weight: 124.5 pcf

Dry Unit Weight: 95.6 pcf

Initial Void Ratio: 0.93

Compression Index (C_c): 0.15

Compression Ratio (C_{cc}): 0.08

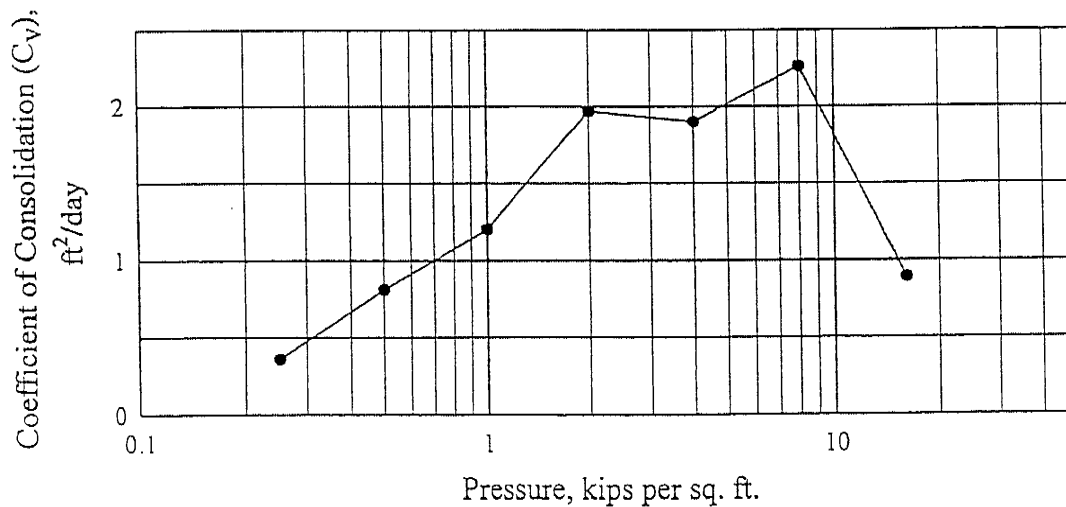
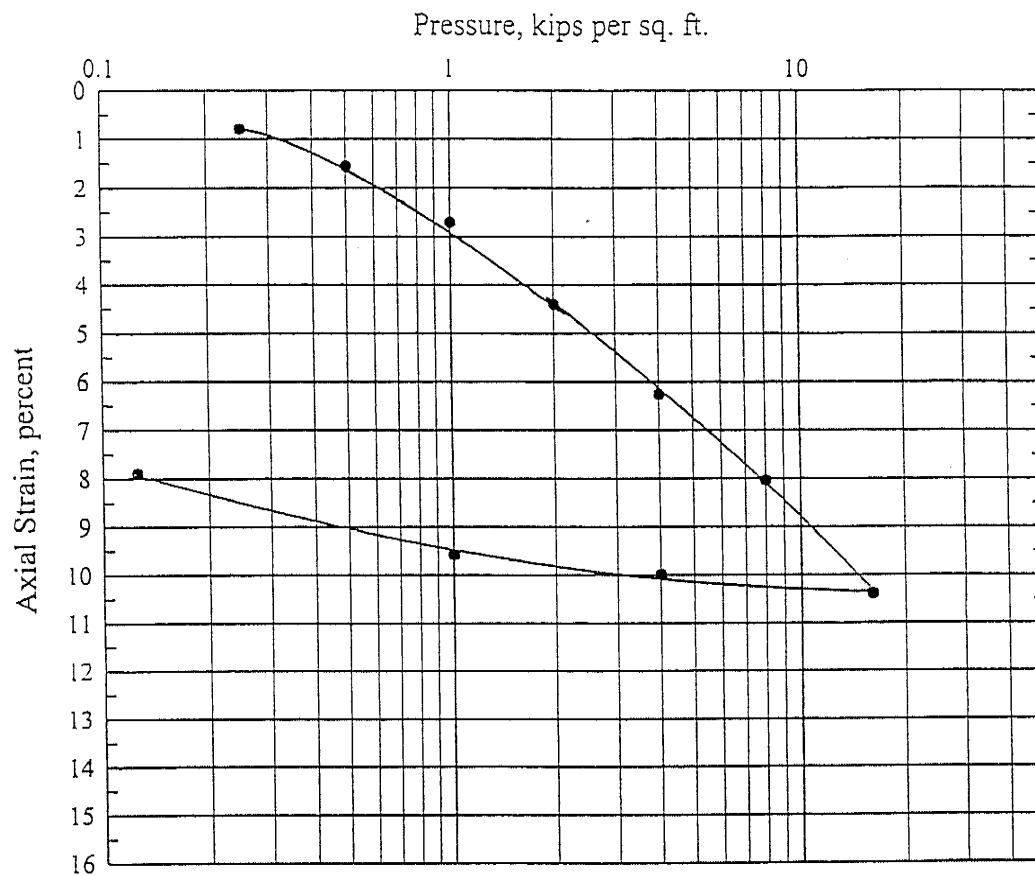
Natural Moisture Content: 30.2%



Froehling & Robertson, Inc.

Geotechnical - Environmental - Materials
Engineers - Laboratories
Raleigh, NC

Consolidation Test
Greenhorne & O'Mara
Camp LeJeune - Midway Park



Boring No.: B-14A

Depth: 5.5 ft. - 7.5 ft.

Sample No.: ST-2

Soil Description: Gray, silty clayey SAND (SM/SC)

Specimen Type: Undisturbed

Specific Gravity: 2.65 (assumed)

Wet Unit Weight: 123.7 pcf

Dry Unit Weight: 95.2 pcf

Initial Void Ratio:

Compression Index (C_c): 0.13

Compression Ratio (C_{cc}): 0.07

Natural Moisture Content: 29.9%



Froehling & Robertson, Inc.

Geotechnical - Environmental - Materials
Engineers - Laboratories
Raleigh, NC

Consolidation Test
Greenhorne & O'Mara
Camp LeJeune - Midway Park



PARTICLE SIZE ANALYSIS OF SOILS

Purpose: The grain size data are often used to aid in the classification of soils and in the estimation of properties such as permeability, compressibility and strength.

Procedure: The test samples can be prepared using either the dry method or wet method as described in the various references. After preparation, the test can be divided into two parts, the determination of the size and distribution of the coarse fraction and the determination of the size distribution of the fines. The division between the two tests is the No. 200 sieve. The coarse fraction is tested using the sieve method whereas the fines are tested using the hydrometer method. If both tests are performed, the test is referred to as the combined analysis.

In the sieve analysis of the coarse fraction, the soil is passed through a series of sieves, and the weight retained on each sieve is determined. The distribution of weights is then computed and the percent passing is plotted for display.

In the hydrometer method, the particle size is determined by Stoke's equation. The soil is mixed in a heavy slurry and the rate of sedimentation is measured with hydrometer. This data can then be reduced to a distribution of particle size and percent finer as in the sieve analysis.

References: ASTM Specification D 421-58, "Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants."

ASTM Specification D 422-63, "Standard Method for Particle Size Analysis of Soils."

ASTM Specification D 2217-66, "Standard Method for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants."



ATTERBERG LIMITS

Purpose: Atterberg limits tests (liquid and plastic limits) are performed to determine the soil classification and plasticity properties of the soil specimen. These properties can be correlated with approximate values for compressibility, strength, shrinkage (swell) and permeability.

Procedure: The liquid limit of a soil is the water content, expressed as a percentage of the weight of the oven dry soil, at the boundary between the liquid and plastic states. The plastic limit is the water content expressed as a percentage of the weight of the oven dry soil, at the boundary between the plastic and semi-solid states. The difference between these two values is the Plasticity Index (PI).

The liquid limit is determined by obtaining the water content at which the soil will flow under a specified dynamic force. The soil is wetted, placed in a special liquid limit device and grooved into two halves. The device is then dropped a specified distance 25 times. The liquid limit is defined as the water content at which the two halves will flow together over a specified distance.

The plastic limit is determined by obtaining the water content at which the soil can be rolled into thin threads by hand, on a ground-glass or non-absorbent paper. The plastic limit is defined as the moisture content at which the soil cannot be rolled into threads smaller than 1/8 inch in diameter.

Reference: ASTM Specification D 4318-84, "Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils."



TIME CONSOLIDATION TEST

Purpose: Consolidation tests are performed on undisturbed soil samples in order to determine the settlement resulting from the imposed loading conditions. The time required for consolidation can also be predicted from this test data.

Procedure: An undisturbed sample is trimmed to fit the consolidometer by using a cutting ring. The sample after trimming has a diameter of 2.5 inches and a height of 1.0 inch. The soil sample is confined within the brass consolidometer and sandwiched between porous plates. A seating pressure of 1/16 tsf is applied and the micrometer dial gauge is adjusted to zero. Pressures are then placed on the soil sample beginning with 1/8 tsf and increasing to 1/4, 1/2, 1, 2, 4, 8 tsf, etc. Loading of the sample should increase until a linear plot of strain versus log pressure becomes a straight line. The test results are presented in the form of a pressure versus strain.

References: ASTM Specification D-2455, "One-Dimensional Consolidation Properties of Soils."

Engineering Properties of Soils & Their Measurements by Joseph E. Bowles, McGraw-Hill, Inc., "Consolidation Test."



MOISTURE CONTENT

Purpose: The purpose of the moisture content test is to determine what percentage of the weight of a given soil is water as opposed to the weight of solid particles of the soil sample. This percentage in the case of in-situ soils indicates the extent to which the soil in question is saturated. For controlled fill placement the moisture content is critical in achieving maximum compaction.

Procedure: A sample of soil is weighed in the wet condition, then placed in a drying oven and is dried to constant weight. The dry weight is then determined. The moisture content in percent is the ratio of the weight of moisture to the weight of dry soil multiplied by 100.

Reference: ASTM Specification D 2216, "Standard Method of Laboratory Determination of Moisture Content of Soil."