Geotechnical Engineering Report

22-0008 Repair SWP129/SWP130 and Restore Wetlands

MCB Camp Lejeune, North Carolina

October 4, 2022

Prepared for:

Public Works Division

MCB Camp Lejeune, North Carolina

Prepared by:

CAPE FEAR ENGINEERING

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Project No. G2022-213

CAPE FEAR ENGINEERING

October 4, 2022

Commanding General
Attn: Public Works Division
Talia Prendergast, Project Manager
MCB, PSC Box 20004
Camp Lejeune, NC 28542-0004

RE: Geotechnical Engineering Report
22-0008 Repair SWP129/SWP130 and Restore Wetlands
MCB Camp Lejeune, North Carolina
Project No: G2022-213

Dear Ms. Prendergast:

Cape Fear Engineering, Inc. (CFE) has completed the geotechnical engineering services for the above referenced project. This report presents the results of the subsurface exploration and provides our geotechnical engineering recommendations.

We appreciate the opportunity to provide our services to you on this project. Should you have any questions or if we can be of further assistance, please contact us.

Respectfully Submitted,
Cape Fear Engineering

Glenn W. Hohmeier, P.E.
Senior Project Engineer
NC Reg. #033529

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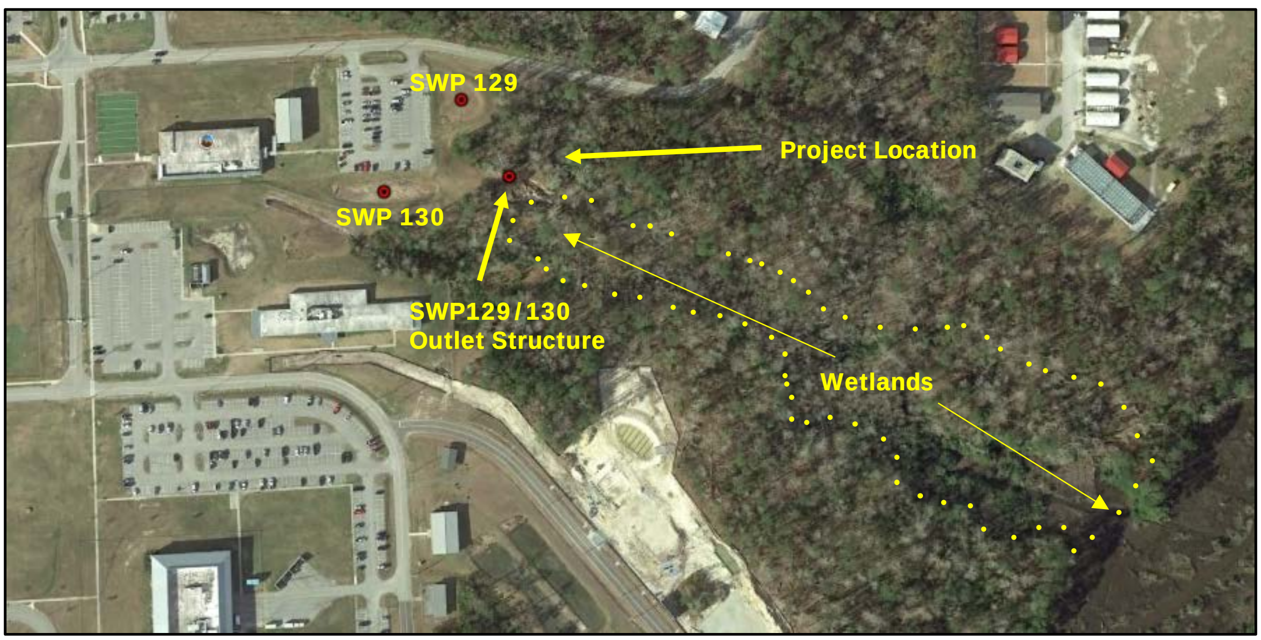
1.0 INTRODUCTION

1.1 Project Site Location and Description

Pursuant to the Request for Proposal under contract number N40085-22-D-0013, Cape Fear Engineering has completed our geotechnical engineering services for the Repair SWP129/SWP130 and Restore Wetlands project. The project site is a stormwater facility located within the MARSOC section of the MCB Camp Lejeune military installation in North Carolina. It is our understanding that the existing level spreader and vegetated filter strip serving this stormwater facility have failed and sediment from the failed areas have impacted downstream wetlands. The purpose of our geotechnical engineering evaluation was to provide design recommendations for the repair of the SWP129/SWP130 stormwater facility.

The project site currently consists of two dry stormwater ponds with grass vegetation, a wooden sedimentation weir, and a drainage overflow outlet that discharges into one outlet structure that outfalls to a wetland area. The current stormwater ponds SWP129 and SWP130 do not show any visual signs of erosion. The outlet structure which discharges to the wetland has signs of severe erosion with sloughing and tension cracks at and downstream of the outlet area. The erosion that has taken place has discharged and dispersed sediment throughout an adjacent wetland area. This wetland connects to an unnamed tributary that empties into Stone Bay.

A site vicinity map showing the project area is provided below.



Project Site General Vicinity

1.2 Scope of Services

The purpose of this investigation was to obtain information on the general subsurface conditions within the project area. The subsurface conditions were evaluated to provide our engineering assessments. For this project, the following items were evaluated to provide geotechnical engineering information and recommendations:

- ❖ General assessment of the soils revealed by hand auger borings performed at the project site.
- ❖ General location and description of any potentially deleterious materials encountered in the borings that may interfere with earthwork and construction of the facility design repair. Potential deleterious materials include existing fills, expansive soils, substantial organics, or other unsuitable materials.
- ❖ Interpretation of the soil test borings to provide earthwork design and construction recommendations, including requirements for fill, placement, and compaction.
- ❖ General location and depth of deposited sediments in the downstream wetland area.
- ❖ Interpretation of the soil test borings as it relates to stormwater pond facility repair and wetland impacts.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, hazardous or toxic material in the soil, bedrock, surface water, groundwater, or air on, below, or in the vicinity of the project site.

1.3 Project Authorization

The Geotechnical Engineering Services were conducted in general accordance with the Cape Fear Engineering fee proposal provided in response to the Request for Proposal (RFP) for this project. Authorization to proceed with our services was received from Ms. Talia Prendergast of the MCB Camp Lejeune Public Works Division.

2.0 FIELD EXPLORATION AND LABORATORY TESTING

2.1 Field Exploration

The general subsurface soil types were explored by completing Hand Auger borings in the areas noted in Table Ia. and Ib. below. The information obtained from our field exploration program was used to assist in developing the recommendations within this report.

Table Ia. – SWP129/SWP130 Boring Schedule

Boring Number	Boring Depth (feet)	Boring Location Description
SW Outlet	8.5	Accessible south-central portion of the study area within the extent of the existing pond outfall.
SW1-1	6.0	Accessible south-central portion of the study area within the existing SW130 pond.
SW1-2	7.0	Accessible northern portion of the study area within the existing SW129 pond.

Hand Augers borings related to the stormwater ponds were advanced to the depth of cave-in. A representative sample at each soil layer was collected, placed in a plastic bag, sealed, labeled, and returned to our laboratory for review.

Table Ib. – Wetland Boring Schedule

Boring Number	Sediment Depth (inches)	Boring Location Description
W-1	2.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-2	4.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-3	3.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-4	6.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-5	8.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-6	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-7	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-8	10.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-9	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-10	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-11	16.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-12	4.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-13	4.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-14	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).
W-15	12.0	Wetland hand auger boring (see attached Boring Location Exhibit).

Hand Auger borings were advanced in the wetland area as indicated on the attached Boring Location Exhibit. Soils recovered from the hand auger bucket were visually classified and depth of sediment was determined at each hand auger location.

The boring locations were initially established and staked in the field by a representative of Cape Fear Engineering. The approximate boring locations are shown on the attached "Boring Location Exhibit" (Appendix I), which was reproduced from a plan prepared by Cape Fear Engineering.

2.2 Laboratory Testing

Soil testing provided by Cape Fear Engineering was performed in accordance with American Society for Testing and Materials (ASTM) standards. All soil testing was performed in our Leland, North Carolina laboratory.

Representative portions of all soil samples collected during the field exploration were labeled, sealed in a plastic bag, and transferred to our laboratory in accordance with ASTM D4220 for classification and analysis. Soil descriptions on the boring logs are provided in general accordance with ASTM D2488 using the Unified Soil Classification System (USCS). Soil samples that were selected for testing were classified in general accordance with ASTM D2487. Some variation can be expected between samples classified using the visual-manual procedure (ASTM D2488) and the USCS (ASTM D2487). A summary of the soil classification system is provided in Appendix II.

As indicated above, representative soil samples were selected and subjected to natural moisture, No. 200 sieve wash, and Atterberg Limits testing to verify the visual classification. These test results are tabulated below in Table II – Summary of Laboratory Test Results. These results are also presented on the soil test log of borings provided in Appendix III. A generalized subsurface soil profile is also provided in Appendix IV.

Table II – Summary of Laboratory Test Results

Boring Number	Sample Type	Depth (feet)	Natural Moisture (%)	Passing No. 200 Sieve (%)	Atterberg Limits (LL/PL/PI)	USCS Classification
SWO	Bag Sample	0.67-1.0	10.8	17.2	Non-Plastic	Silty fine to medium SAND (SM)
SWO	Bag Sample	1.0-5.5	14.9	34.7	26/17/9	Clayey fine to medium SAND (SC)
SWO	Bag Sample	5.5-6.5	6.9	15.1	Non-Plastic	Silty fine to medium SAND (SM)
SWO	Bag Sample	6.5-8.0	8.4	16.3	Non-Plastic	Silty fine to medium SAND (SM)
SWO	Bag Sample	8.0-8.5	13.4	18.7	Non-Plastic	Silty fine to medium SAND (SM)
SW1-1	Bag Sample	0.0-2.0	5.5	1.6	Non-Plastic	Poorly Graded fine to medium SAND (SP) with trace Silt (Uncontrolled Earthfill)
SW1-1	Bag Sample	2.0-6.0	21.0	20.8	30/20/10	Clayey fine to medium SAND (SC)
SW1-2	Bag Sample	0.0-6.0	4.0	2.1	Non-Plastic	Poorly Graded fine to medium SAND (SP) with trace Silt (Uncontrolled Earthfill)
SW1-2	Bag Sample	6.0-7.0	15.6	41.3	Non-Plastic	Silty fine to medium SAND (SM)

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The project site lies within a major physiographic province of North Carolina called the Atlantic Coastal Plain. Numerous transgressions and regressions of the Atlantic Ocean have deposited marine, lagoonal, and fluvial (stream lain) sediments. The regional geology is very complex, and generally consists of interbedded layers of varying mixtures of sands, silts, and clays. Based on our review of existing geologic and soil boring data, the geologic stratigraphy encountered in our subsurface exploration generally consisted of marine deposited sands.

3.2 Subsurface Soil Conditions

A summary of the subsurface soil conditions encountered at the boring locations is presented in Table III.

Table III a. – Subsurface Soil Conditions (SW Outlet – Near Existing Outlet)

Average Depth (ft.)	Stratum	Description
0 to 0.67	Surficial	8 inches of Topsoil
0.67 to 8.5	I	Light brownish gray, grayish brown, light gray and yellowish brown, light gray, dark brown, SAND (SM, SC) with varying amounts of Silt and Clay.

Table III b. – Subsurface Soil Conditions (SW129/130 – Stormwater Basins)

Average Depth (ft.)	Stratum	Description
0.0 to 0.0-0.08	Surficial	0 to 1 inch of Topsoil
0.0-0.08 to 2.0-6.0	I	Light grayish brown, and Light brown and light yellowish brown SAND (SP) with varying amounts of Silt (Uncontrolled Earthfill).
2.0-6.0 to 6.5-7.0	II	Light brownish gray, Brown SAND (SM, SC) with varying amounts of Silt and Clay.

The subsurface descriptions are of a generalized nature and were provided to highlight the major soil strata encountered. The records of the subsurface exploration are included in Appendix III (Boring Log sheets) and in Appendix IV (Soil Profile), which should be reviewed for specific information as to the individual borings. The stratifications shown on the records of the subsurface exploration represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the transition may be gradual.

3.3 Groundwater

The initial groundwater level was not encountered at the hand auger borings to the depths explored. The boreholes were backfilled upon completion for safety considerations. Seasonal groundwater fluctuations of 2± feet or more are common in the project's area; however, greater fluctuations have been documented.

Perched groundwater conditions may be encountered at this site. The perched condition is anticipated to occur during periods of heavy precipitation and/or during the wet season in the areas where shallow subsurface clayey soils were encountered. These soils will act as a restrictive layer allowing excessive moisture to accumulate within the overlying granular soils. Perched groundwater, if encountered, can adversely affect construction activities. The Contractor should determine the actual groundwater levels and potential perched groundwater conditions at the time of construction to determine groundwater and potential perched groundwater impacts that may affect the construction procedures.

4.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

Our design and construction recommendations are based on the previously discussed project information, interpretation of the soil test borings, review of the provided scope of work documents, and observations during our site reconnaissance. If the proposed construction should vary from what was described, we request the opportunity to review our recommendations and make any necessary changes.

4.1 Design Repair SWP129/SWP130 Discussion

Stormwater SWP129/SWP130 Area

Due to the current severe erosion conditions that have taken place at and in the vicinity of the existing stormwater basin outlet area, significant amounts of the drainage basin will require redesign. This re-design will generally consist of re-grading the eroded area, provide Rip-Rap protection within various locations of the new design features, installation of new storm and level spreader structures, provide an underdrain system, along with other related stormwater basin design facilities.

Embankment and/or basin areas with severe erosion conditions should be over-excavated down to existing natural soil material (Sand). It is recommended that the over-excavation operations extend laterally at least 25 feet beyond the perimeter of the proposed construction areas. All over excavation operations shall be monitored on a full-time basis by the geotechnical engineer or their qualified representative. Slope re-construction within the eroded repair areas should include new berm and/or basin construction with side slopes no steeper than 2H:1V (horizontal to vertical). The fill placed for the embankment and/or basin repairs should be compacted to 95% of the Standard Proctor maximum dry density (ASTM D698). All new embankment and/or basin slopes should include Rip Rap protection lined with geotextile (such as a Mirafi 140N or equivalent). All new embankment fill shall meet the Unified Soil Classification System (USCS) classification CH, CL, or SC with a minimum of 35% fines. Embankment and/or basin fills tying into existing embankment areas shall be "benched" into the existing embankment every 2-vertical feet and benched horizontally back into the existing embankment a minimum of 2-feet.

In addition, all new outlet structures and level spreader structures shall rest on a minimum of 6 inches of NCDOT No. 57 stone. The soil backfill around the storm and level spreader structures should not be over compacted. The backfill around these structures should be compacted to 95% of the Standard Proctor maximum dry density (ASTM D698). The granular soils and/or gravel should be relatively clean, free draining, such as No. 57, 67, or 78 stone or Sand classified as SP-SM or better, containing less than 12% passing the No. 200 sieve. Final drainage area design shall be by the Civil Engineer of Record meeting the North Carolina Division of Environmental Quality standards for Stormwater Management.

As previously indicated, perched groundwater conditions may be encountered at this site. The perched condition is anticipated to occur during periods of heavy precipitation and/or during the wet season in the areas where shallow subsurface clayey soils were encountered. These soils will act as a restrictive layer allowing excessive moisture to accumulate within the overlying granular soils. Perched groundwater, if encountered, can adversely affect construction activities. The Contractor should determine the actual groundwater levels and potential perched groundwater conditions at the time of construction to determine groundwater and potential perched groundwater impacts that may affect the construction procedures.

Impacted Wetland downstream of SWP129/SWP130

Due to the SWP129/SWP130 stormwater facility failure, erosion of soil material the pond and embankment facilities was dispersed downstream into the adjacent wetlands. The eroded soil material ranges in depth from 2” to 16” across the downstream wetland. This eroded soil material in the wetland area does not pose a stability concern with regards to the repairs associated with the SWP129/SWP130 stormwater facility. The impacts to the wetlands are potentially an environmental concern and this report only documents the approximate depths of sedimented material which has potentially impacted the wetland area. Please refer to Table Ib. – Wetland Boring Schedule found in Section 2.0 of this report. Final remedial requirements addressing the potential wetland impacts shall be provided by the Civil Engineer of Record and the North Carolina Division of Environmental Quality.

4.2 Earthwork – Suitable Structural Fill, Placement, and Compaction Requirements

Any materials to be used for structural fill should be evaluated and tested by a qualified inspector and laboratory prior to placement to determine if the materials are suitable for the intended use. Suitable structural fill material should consist of sand or gravel containing less than 20% by weight of fines (SP, SP-SM, SM, SW, SW-SM, GP, GP-GM, GW, GW-GM), have a liquid limit less than 20 and plastic limit less than 6, and should be free of rubble, organics, clay, debris, and other unsuitable material.

All structural fill outside of pond facility areas should be compacted to a dry density of at least 95% of the Standard Proctor maximum dry density (ASTM D698). In general, the compaction should be accomplished by placing the fill in maximum 10-inch loose lifts and mechanically compacting each lift to at least the specified minimum dry density. A qualified inspector should perform field density tests on each lift as necessary to assure that adequate compaction is achieved.

Backfill material in utility trenches outside of pond facility areas and within the construction structural areas should consist of structural fill and be compacted to at least 95% of ASTM D698. This fill should be placed in 4 to 6-inch loose lifts when hand compaction equipment is used.

Care should be used when operating the compactors near existing structures, including the outlet structure, to avoid transmission of the vibrations that could cause settlement damage or disturb occupants. In this regard, it is recommended that large vibratory rollers remain at least 25 feet away from existing structures. Areas within 25 feet of existing structures should be compacted with small, hand-operated compaction equipment.

Based on the completed laboratory testing, the shallow subsurface SAND (SP, SM) appears to meet the criteria recommended in this report for reuse as structural fill. The SAND (SC) soils encountered at the boring locations do not appear to meet the criteria recommended in this report for reuse as structural fill; however, they may be used as fill in non-structural green areas or within the berm repair area.

At a minimum, further classification testing including natural moisture content, No. 200 sieve wash analysis, and Proctor testing should be performed at the time of construction to evaluate the suitability of the excavated soils for reuse as fill/structural fill.

4.3 Construction Considerations

Based on the results of this exploration, varying soil conditions and compositions are expected to be encountered throughout the project limits. Open-cut excavations will likely extend through natural soils that are relatively "clean" (i.e., soil that is relatively free of deleterious debris that may hinder excavation or installation). Debris typically considered unsuitable consists of wood, glass, organics, plastics, coal, brick, or any other material larger than 2 inches in diameter. Based on these characteristics, it is anticipated that some of the shallow subsurface materials encountered within the project alignment may be reusable as backfill. Soils containing appreciable amounts of deleterious debris should be discarded; however, an effort should be made during excavation to segregate potentially suitable in-situ fill soils for reuse.

Some of the shallow subsurface within the project limits is comprised of granular soils; however, the contractor should anticipate that some of these soils will have relatively little cohesion and have a high potential for caving. Additionally, water seepage at varying elevations should be expected within the side walls of the open cut areas, increasing the potential for caving.

Temporary Slopes

Due to the limited space for construction, temporary slopes may not be a feasible option. The contractor should be aware that temporary slope height, slope inclination, or excavation depths should in no case exceed those specified in local, state and/or federal safety regulations. Where temporary slopes are not feasible, shoring by means of sheeting and/or trench boxes may be appropriate. Where the stability of adjoining structures, pavements or other improvements are endangered by excavation operations, support systems such as shoring, bracing, or underpinning may be required to provide structural stability. Shoring, bracing, or underpinning required for this project (if required) should be designed by a professional engineer.

Shoring

Shoring design and installation should be the responsibility of the contractor. Shoring systems required for this project should be designed by a professional engineer. Shoring systems should be designed to provide positive restraint of trench walls to protect against lateral deformation that may result in ground cracks, settlement, and/or other ground movements that may affect adjacent underground utilities, pavements, structures, and surface improvements. The contractor should be made aware of this potential condition so that preventative or repair measures can be implemented.

Depending on the shoring system used, the removal process may create voids along the walls of the excavations. If these voids are left in place and are significant, backfill and/or the retained soil may shift laterally, resulting in settlement of overlying structures/pavements. As such, care should be taken to remove the shoring systems and backfill the trenches so that these voids are not created.

In all cases, the contractor should select an excavation and/or shoring scheme that will protect adjacent and overlying improvements, including below grade utilities.

Dewatering

It is expected that dewatering will be required for excavations that extend near or below the existing groundwater table. Dewatering above the groundwater-level can likely be accomplished by pumping from sumps. Dewatering at depths below the groundwater-level will likely require well pointing, deep well systems, or other suitable dewatering method and possibly shoring. Since temporary dewatering will impact construction and be dependent on construction methods and scheduling, we recommend the contractor be solely responsible for the design, installation, maintenance, and performance of all temporary dewatering systems. Where shoring is employed, the dewatering system should be compatible with the type of shoring to be used. We recommend the contractor verify groundwater conditions and evaluate dewatering requirements prior to construction.

Lowering the groundwater table during dewatering activities will result in an increase in effective stresses and may induce settlements of the soils underlying adjacent structures/pavements. Additionally, hydraulic compaction of granular soils (e.g., SP, SP-SM, SM soils) should be anticipated because of lowering the groundwater table. We recommend that the dewatering be performed so that the groundwater-level is lowered by no more than approximately 5 feet below the proposed excavation depth. It may be advantageous to install settlement monuments in areas where dewatering by means of well pointing is required.

Excavations

Federal regulation requires all excavations, whether they be utility trenches, basement excavation, or footing excavations, be constructed in accordance with (OSHA) guidelines.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's responsible person should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

5.0 REPORT LIMITATIONS

The recommendations submitted are based on the available soil information obtained by Cape Fear Engineering and the information supplied by the client and their consultants for the proposed project. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, Cape Fear Engineering should be notified immediately to determine if changes in the recommendations are warranted. If Cape Fear Engineering is not retained to perform these functions, Cape Fear Engineering cannot be responsible for the impact of those conditions on the geotechnical recommendations for the project.

The geotechnical engineer of record warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are completed, the geotechnical engineer of record should be provided the opportunity to review the final design plans and specifications to make sure our engineering recommendations have been properly incorporated into the design documents, in order that the provided stormwater pond and earthwork recommendations may be properly interpreted and implemented. At that time, it may be necessary to submit supplementary recommendations.

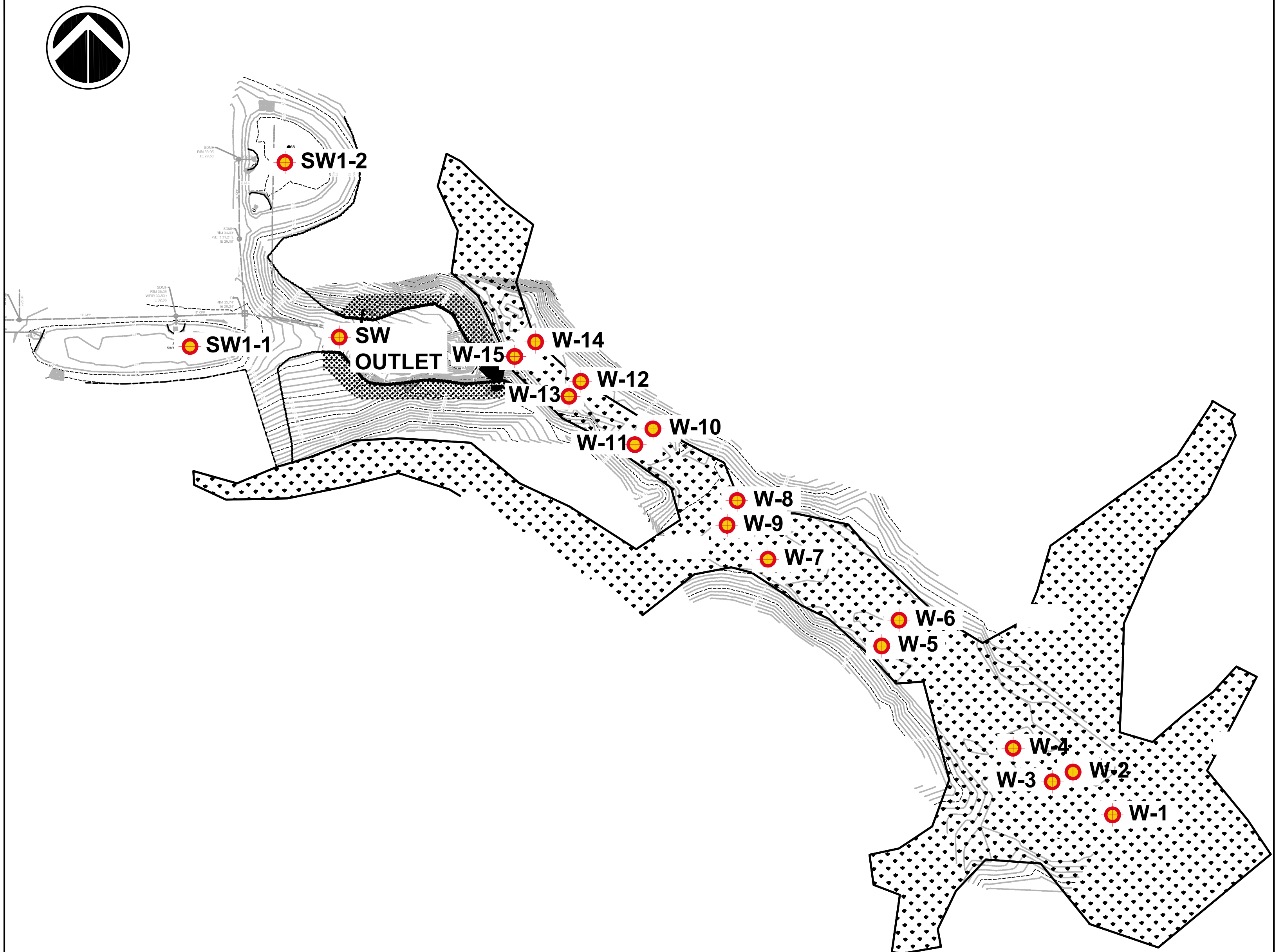
This report has been prepared for the exclusive use of the client and their designated agents for the specific application to the 22-0008 Repair SWP129/SWP130 and Restore Wetlands project located within the MARSOC portion of the MCB Camp Lejeune military installation in North Carolina.

APPENDICES

APPENDIX I	BORING LOCATION EXHIBIT
APPENDIX II	CLASSIFICATION SYSTEM FOR SOIL EXPLORATION
APPENDIX III	BORING LOGS
APPENDIX IV	SOIL PROFILE

APPENDIX I

BORING LOCATION EXHIBIT



VICINITY MAP
NOT TO SCALE

LEGEND

BORING LOCATIONS

NOTES

1. THIS BORING LOCATION EXHIBIT WAS REPRODUCED FROM A PLAN PROVIDED BY CAPE FEAR ENGINEERING.
2. THIS BORING EXHIBIT IS NOT TO SCALE.
3. ALL BORING LOCATIONS ARE APPROXIMATE.

PREPARED FOR:
MCB CAMP LELEUNE
PUBLIC WORKS DIVISION

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DATE: 9-02-2022
SCALE: NOT TO SCALE
DRAWN: JGC
APPROVED: GWH

22-0008 REPAIR
SWP129/SWP130
AND RESTORE WETLANDS
MCB CAMP LEJEUNE, NC

BORING LOCATION
EXHIBIT

JOB NUMBER
G2022-213

SHEET NUMBER
EX-01

APPENDIX II

CLASSIFICATION SYSTEM FOR SOIL EXPLORATION

CLASSIFICATION SYSTEM FOR SOIL EXPLORATION

Standard Penetration Test (SPT), N-value

Standard Penetration Tests (SPT) were performed in the field in general accordance with ASTM D 1586. The soil samples were obtained with a standard 1.4" I.D., 2" O.D., 30" long split-spoon sampler. The sampler was driven with blows of a 140 lb. hammer falling 30 inches. The number of blows required to drive the sampler each 6-inch increment (4 increments for each soil sample) of penetration was recorded and is shown on the boring logs. The sum of the second and third penetration increments is termed the SPT N-value.

NON COHESIVE SOILS

(SILT, SAND, GRAVEL and Combinations)

Relative Density

Very Loose	4 blows/ft. or less
Loose	5 to 10 blows/ft.
Medium Dense	11 to 30 blows/ft.
Dense	31 to 50 blows/ft.
Very Dense	51 blows/ft. or more

COHESIVE SOILS

(CLAY, SILT and Combinations)

Consistency

Very Soft	2 blows/ft. or less
Soft	3 to 4 blows/ft.
Medium Stiff	5 to 8 blows/ft.
Stiff	9 to 15 blows/ft.
Very Stiff	16 to 30 blows/ft.
Hard	31 blows/ft. or more

Particle Size Identification

Boulders	8 inch diameter or more	
Cobbles	3 to 8 inch diameter	
Gravel	Coarse	1 to 3 inch diameter
	Medium	$^{1}/_{2}$ to 1 inch diameter
	Fine	$^{1}/_{4}$ to $^{1}/_{2}$ inch diameter
Sand	Coarse	2.00 mm to $^{1}/_{4}$ inch (diameter of pencil lead)
	Medium	0.42 to 2.00 mm (diameter of broom straw)
	Fine	0.074 to 0.42 mm (diameter of human hair)
Silt		0.002 to 0.074 mm (cannot see particles)

Relative Proportions

Descriptive Term	Percent
Trace	0-5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Strata Changes

In the column "Description" on the boring log, the horizontal lines represent approximate strata changes.

Groundwater Readings

Groundwater conditions will vary with environmental variations and seasonal conditions, such as the frequency and magnitude of rainfall patterns, as well as tidal influences and man-made influences, such as existing swales, drainage ponds, underdrains and areas of covered soil (paved parking lots, side walks, etc.).

CLASSIFICATION SYMBOLS (ASTM D 2487 and D 2488)

Coarse Grained Soils

More than 50% retained on No. 200 sieve

GW - Well-graded Gravel
GP - Poorly graded Gravel
GW-GM - Well-graded Gravel w/Silt
GW-GC - Well-graded Gravel w/Clay
GP-GM - Poorly graded Gravel w/Silt
GP-GC - Poorly graded Gravel w/Clay
GM - Silty Gravel
GC - Clayey Gravel
GC-GM - Silty, Clayey Gravel
SW - Well-graded Sand
SP - Poorly graded Sand
SW-SM - Well-graded Sand w/Silt
SW-SC - Well-graded Sand w/Clay
SP-SM - Poorly graded Sand w/Silt
SP-SC - Poorly graded Sand w/Clay
SM - Silty Sand
SC - Clayey Sand
SC-SM - Silty, Clayey Sand

Fine-Grained Soils

50% or more passes the No. 200 sieve

CL - Lean Clay
CL-ML - Silty Clay
ML - Silt
OL - Organic Clay/Silt

Liquid Limit 50% or greater

CH - Fat Clay
MH - Elastic Silt
OH - Organic Clay/Silt

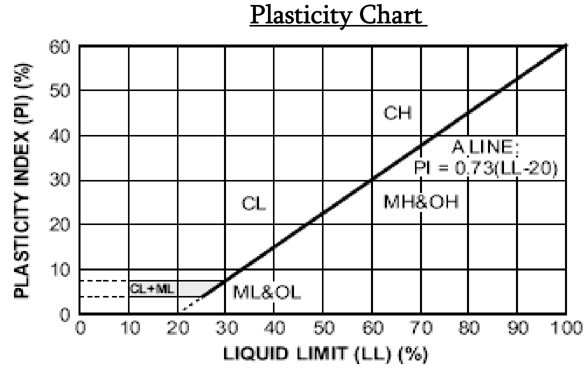
Highly Organic Soils

PT - Peat

Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent	GW, GP, SW,SP
More than 12 percent	GM, GC, SM, SC
5 to 12 percent	Borderline cases requiring dual symbols

Plasticity Chart



APPENDIX III

BORING LOGS

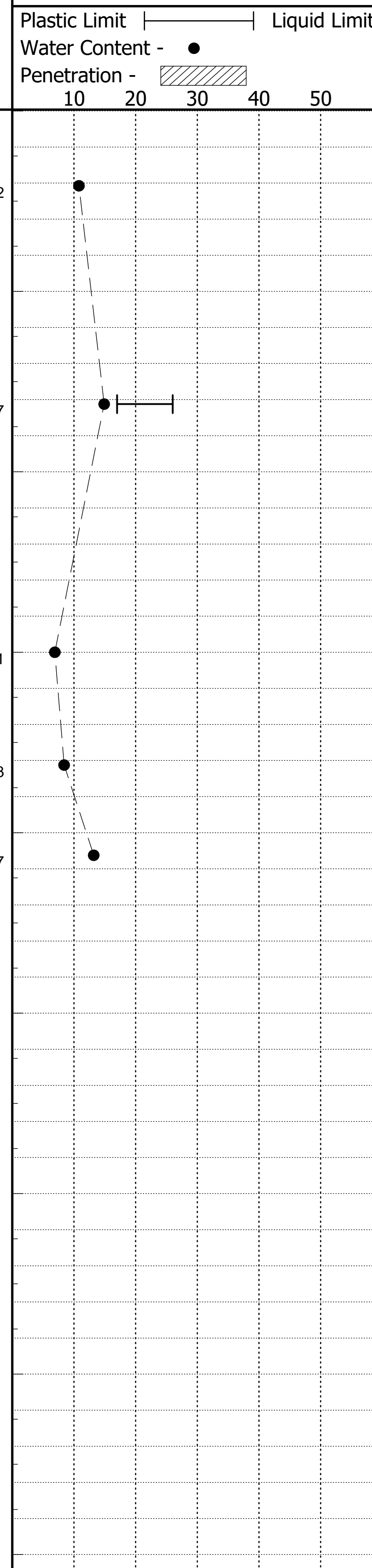
BORING LOG No. SWO

CAPE FEAR ENGINEERING

PROJECT:	22-0008 Repair SWP129/SWP130 and Restore Wetlands	**PROJECT NO.:**	G2022-213
CLIENT:	MCB Camp Lejeune Public Works Division	**NORTHING:**	
PROJECT LOCATION:	MCB Camp Lejeune, NC	**EASTING:**	
LOCATION:	See attached Boring Location Exhibit	**ELEVATION:**	
DRILLER:	Cape Fear Engineering	**LOGGED BY:**	MCR/JC
DRILLING METHOD:	Hand Auger	**DATE:**	8-3-2022
DEPTH TO - WATER> INITIAL:		**AFTER 24 HOURS:**	
CAVING>			

Depth (feet)	Description	Graphic	Sample No.	Blow Counts	N-Value	% < #200
0 – 0.67	8 inches of Topsoil					
0.67 – 1.0	Light brownish gray, moist, Silty fine to medium SAND (SM)					17.2
1.0 – 5.5	Grayish brown, moist, Clayey fine to medium SAND (SC)					34.7
5.5 – 6.5	Light gray and yellowish brown, moist, Silty fine to medium SAND (SM)					15.1
6.5 – 8	Light gray, moist, Silty fine to medium SAND (SM)					16.3
8 – 8.5	Dark brown, moist, Silty fine to medium SAND (SM)					18.7
	Boring terminated at 8.5 ft.					

TEST RESULTS



CAPE FEAR ENGINEERING

BORING LOG No. SW1-2

PROJECT: 22-0008 Repair SWP129/SWP130 and Restore Wetlands **PROJECT NO.:** G2022-213
CLIENT: MCB Camp Lejeune Public Works Division **NORTHING:**
PROJECT LOCATION: MCB Camp Lejeune, NC **EASTING:**
LOCATION: See Attached Boring Location Exhibit **ELEVATION:**
DRILLER: MCape Fear Engineering **LOGGED BY:** JC
DRILLING METHOD: Hand Auger **DATE:** 8-3-2022
DEPTH TO - WATER> INITIAL: **AFTER 24 HOURS:** **CAVING>**

Depth (feet)	Description	Graphic	Sample No.	Blow Counts	N-Value	% < #200	TEST RESULTS (Plastic Limit ├─┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50)
0–6	Light brown and light yellowish brown, moist, Poorly Graded fine to coarse SAND (SP) with trace Silt (Uncontrolled Earthfill)					2.1	
6–7	Brown, moist, Clayey fine to medium SAND (SC)					41.3	
7	Boring terminated at 7.0 ft.						

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16

BORING LOG No. SW1-1

CAPE FEAR ENGINEERING

PROJECT:	22-0008 Repair SWP129/SWP130 and Restore Wetlands	**PROJECT NO.:**	G2022-213
CLIENT:	MCB Camp Lejeune Public Works Division	**NORTHING:**	
PROJECT LOCATION:	MCB Camp Lejeune, NC	**EASTING:**	
LOCATION:	See Attached Boring Location Exhibit	**ELEVATION:**	
DRILLER:	Cape Fear ENgineering	**LOGGED BY:**	MCR
DRILLING METHOD:	Hand Auger	**DATE:**	8-3-2022
DEPTH TO - WATER> INITIAL:		**AFTER 24 HOURS:**	
CAVING>			

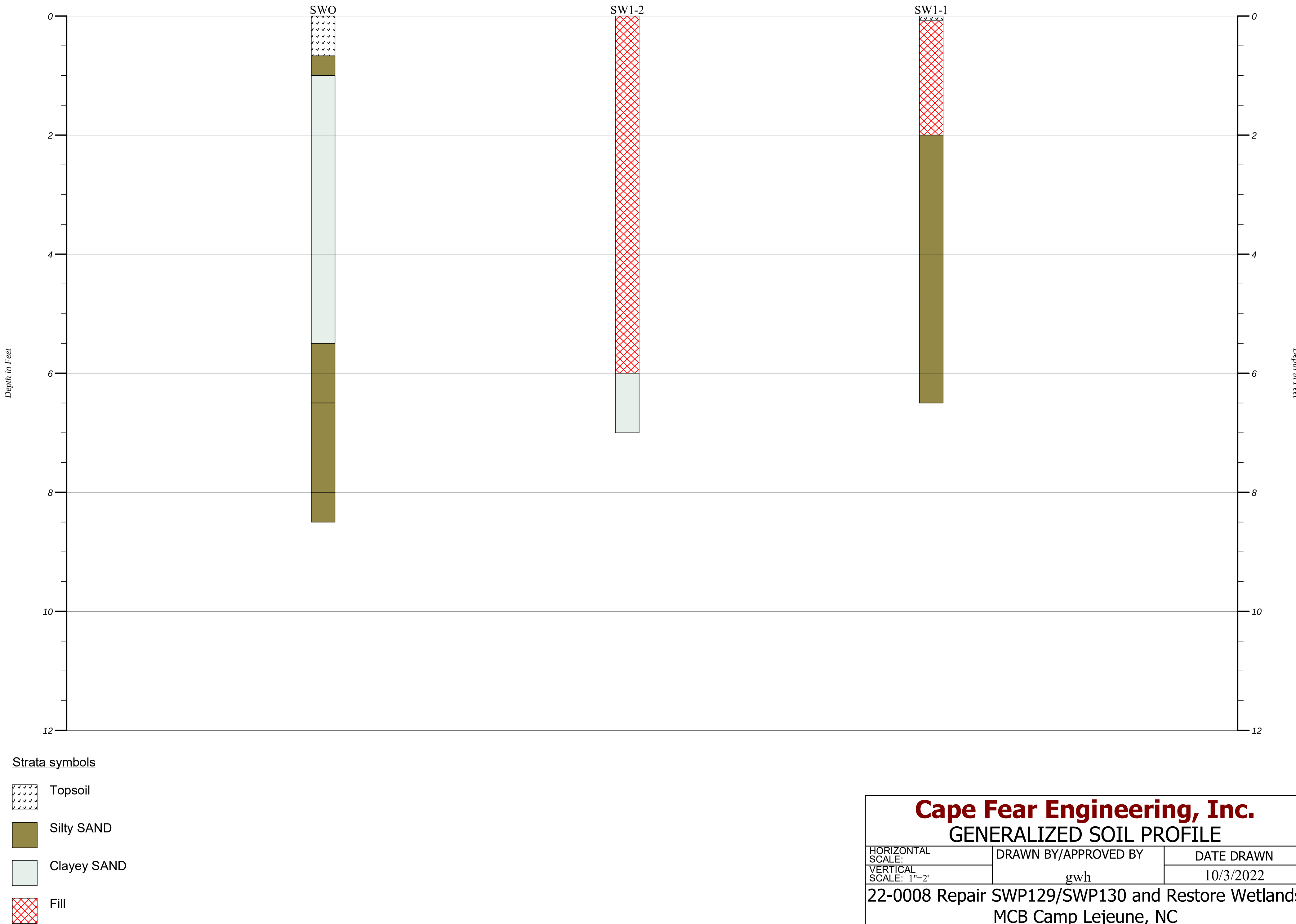
TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - (hatched bar); scale 10, 20, 30, 40, 50

Depth (feet)	Description	Graphic	Sample No.	Blow Counts	N-Value	% < #200	Water Content
0–0.08	1 inch of Topsoil						
0.08–2	Light grayish brown, moist, Poorly Graded fine to medium SAND (SP) with trace Silt (Uncontrolled Earthfill)					1.6	●
2–6.5	Light brownish gray, moist, Silty fine to medium SAND (SM)					20.8	●
6.5	Boring terminated at 6.5 ft.						

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16

APPENDIX IV

SOIL PROFILE



Cape Fear Engineering, Inc. GENERALIZED SOIL PROFILE		
HORIZONTAL SCALE: VERTICAL SCALE: 1"=2'	DRAWN BY/APPROVED BY gwh	DATE DRAWN 10/3/2022
22-0008 Repair SWP129/SWP130 and Restore Wetlands MCB Camp Lejeune, NC		
PROJECT NO. G2022-213		FIGURE NUMBER