REPORT OF SUBSURFACE INVESTIGATION AND GEOTECHNICAL ENGINEERING SERVICES

Bulkhead Failure Replacement
Corova, North Carolina

G E T Project No: EC20-121G
March 24, 2020

PREPARED FOR:

Coastal ENGINEERING & SURVEYING
STRUCTURAL • HOME DESIGN • CIVIL • SITE DEVELOPMENT

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March 24, 2020

TO: **Coastal Engineering and Surveying, Inc.**
4425 N. Croatan Highway
Kitty Hawk, NC 27949

Attn: Mr. Carlos Gomez, PE

RE: Report of Subsurface Exploration and Geotechnical Engineering Services
Bulkhead Failure Replacement
Corova, North Carolina
G E T Project No: EC20-121G

Dear Mr. Gomez:

In compliance with your instructions, we have completed our Subsurface Exploration and Geotechnical Engineering Services for the above referenced project. The results of this study, together with our recommendations, are presented in this report.

Often, because of design and construction details that occur on a project, questions arise concerning subsurface conditions. **G E T Solutions, Inc.** would be pleased to continue its role as Geotechnical Engineer during the project implementation.

We appreciate the opportunity to work with you on this project. We trust that the information contained herein meets your immediate need, and should you have any questions or if we could be of further assistance, please do not hesitate to contact us.

Respectfully Submitted,
G E T Solutions, Inc.

Gerald W. Stalls Jr., P.E.
Senior Project Engineer
NC Reg. # 034336

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Principal Engineer
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EXECUTIVE SUMMARY

The project site is located at 2100 Ocean Pearl Road in Corova, North Carolina. The site was previously developed (Corova Beach Park and Boat Ramp) including a recreational area, restroom building, and a boat ramp that accesses the existing canal north of the site. The development also included an existing vinyl sheet bulkhead with a boardwalk/dock along the north side of the site. A portion of the existing bulkhead has recently experienced rotational failure with its head migrating into the canal. This project will include the construction of a new bulkhead which is anticipated to consist of vinyl sheeting with tie backs and deadman anchors.

Our field exploration and sampling program performed within the proposed construction areas included three (3) 30-foot deep Standard Penetration Test (SPT) borings performed along the upland side of the existing bulkhead alignment. Additionally, sixteen (16) soundings with probing were performed along the canal side of the existing bulkhead, where accessible. The initial groundwater level was measured to occur at depths ranging from 2.5 to 3 feet below the existing grades at the boring locations. The mudline was measured along the north side of the existing bulkhead and boardwalk/deck, where accessible, to occur at depths ranging from 4.2 to 6 feet below the deck elevation of the existing boardwalk/dock which generally coincided with the existing site grade elevations immediately to the south. The existing site grade elevations were unknown at this time. As such, the groundwater and mudline elevations occurring at this site could not be estimated. A summary of the subsurface soil and groundwater conditions encountered at the boring and sounding locations is presented in Section 3 of this report.

The following evaluations and recommendations were developed based on our field exploration and laboratory-testing program:

- A field testing program during construction is recommended, which should include compaction testing.

- The subsurface Organic laden and/or Cohesive soils do not meet the criteria recommend for reuse as structural fill. However, these may be used as fill within green areas, when encountered and provided they meet the criteria specified by the Civil Engineer of Record and/or owner. The surficial and shallow subsurface soils encountered at the explored locations and classified as SAND (SP, SP-SM, SM) appear to meet the criteria recommended in this report for reuse as structural fill. However, moisture manipulation will be required as these soils occur in proximity to the encountered ground water level.

- Estimated soil design parameters associated with the design of the new bulkhead are provided herein.

- Based on the information obtained at the boring locations (to a maximum depth of 30 feet) and our experience within the vicinity of the project site, it is our opinion that this site may be classified as a Site Class “D” in accordance with Table 20.3-1 of ASCE 7-10 as referenced by the 2015 International Building Code (IBC).

This summary briefly discusses some of the major topics mentioned in the attached report. Accordingly, this report should be read in its entirety to thoroughly evaluate the contents.

1.0 PROJECT INFORMATION

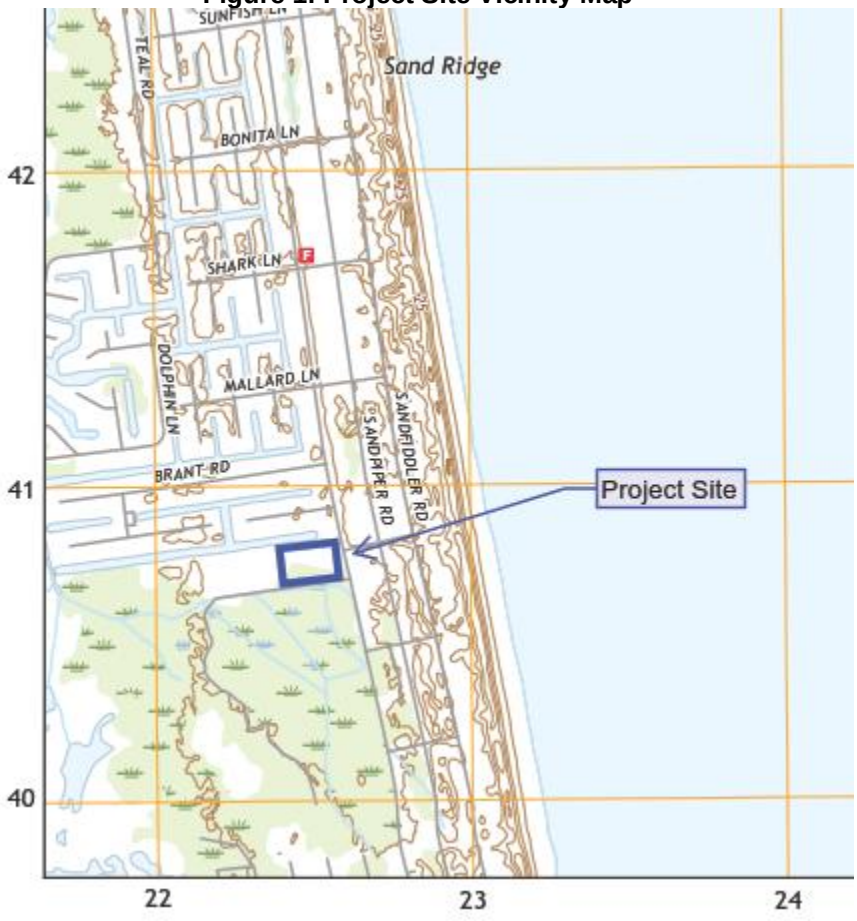
1.1 Project Authorization

G E T Solutions, Inc. has completed our subsurface exploration and geotechnical engineering services for the proposed Bulkhead Failure Replacement project located at 2100 Ocean Pearl Road in Corova, North Carolina. The geotechnical engineering services were conducted in general accordance with the scope presented in **G E T** Proposal No. PEC20-102G. Authorization to proceed with our services was received from the client in the form of an email received on the date of February 11, 2020.

1.2 Project Site Location and Description

The project site is located at 2100 Ocean Pearl Road in Corova, North Carolina. The site was previously developed (Corova Beach Park and Boat Ramp) including a recreational area, restroom building, and a boat ramp that accesses the existing canal along the north side of the site. The development also included an existing vinyl sheet bulkhead with a wood framed boardwalk/dock along the north side of the site. A portion of the bulkhead has recently experienced rotational failure with its head migrating into the canal. The existing site grade elevations at this site were unknown at the time of our subsurface exploration and reporting procedures. A site vicinity map is provided in Figure 1.

Figure 1: Project Site Vicinity Map



1.3 Project Construction Description

The proposed construction at this site is planned to consist of building a new bulkhead. The bulkhead will be of vinyl sheet design with tie backs and deadman anchors. Finally, it is understood that the existing site grade elevations will not require any cut or fill to establish the design grade elevations.

If any of the noted information is incorrect or has changed, please inform G E T Solutions, Inc. so that we may amend the recommendations presented in this report, if appropriate.

1.4 Purpose and Scope of Services

The purpose of this study was to obtain information on the general subsurface conditions along the proposed bulkhead alignment at the proposed project site. The subsurface conditions encountered were then evaluated with respect to the available project characteristics. The limited scope of work provided at this time did not include an assessment of the existing bulkhead as-built construction as well as the in-situ soils as it relates to the recent failure. In this regard, engineering assessments for the following items were formulated:

1. General assessment of the soils revealed by the borings performed at the proposed development.

2. General location and description of potentially deleterious material encountered in the borings that may interfere with construction progress or structure performance, including existing fills or surficial/subsurface organics.

3. Estimated soil design parameters required for the design of the new bulkhead.

4. Seismic site class determination in accordance with the 2015 International Building Code as well as liquefaction potential analysis.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands or hazardous or toxic material in the soil, bedrock, surface water, groundwater or air, on or below or around this site. Prior to development of this site, an environmental assessment is advisable.

2.0 FIELD AND LABORATORY PROCEDURES

2.1 Field Exploration

In order to explore the general subsurface soil types and to aid in developing associated design parameters and recommendations, the following exploration program was performed:

- Three (3) 30-foot deep SPT borings (designated as B-1 through B-3) were drilled adjacent to the existing bulkhead.

- Sixteen (16) soundings and probing were performed in the existing canal to determine the mudline depth adjacent to the existing bulkhead and boardwalk/dock, where accessible.

Standard Penetration Tests were performed in the field in general accordance with ASTM D 1586. The tests were performed continuously from the existing ground surface to depths of 10 to 12 feet, and at 5-foot intervals thereafter, starting at a depth of 13 feet below grade. 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, using a safety hammer. The number of blows required to drive the sampler each 6-inch increment 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 (uncorrected for automatic hammer and overburden pressure). A representative portion of each disturbed split-spoon sample was collected with each SPT, placed in a sealed glass jar, and returned to our laboratory for review. Following the exploration procedures, the borings were backfilled with a neat cement grout mix in accordance with NCDENR requirements for aquifer protection.

The boring locations were established and staked in the field by a representative of **G E T Solutions, Inc.** by measuring from corroborating and identifiable landmarks. Additionally, the sounding locations were determined in the field and were established by measuring from identifiable landmarks. Approximate soil boring and sounding locations are shown on the attached "Boring and Sounding Location Plan" (Appendix I) which was developed using Google Earth imagery. In the event that the alignment of the bulkhead will change from the existing bulkhead alignment and from that depicted in Appendix I, **G E T Solutions, Inc.** should be consulted to determine if any additional field explorations are deemed warranted.

2.2 Field and Laboratory Testing

Soil testing provided by **G E T Solutions, Inc.** was performed in accordance with American Society for Testing and Materials (ASTM) standards. All soils and materials tests were performed in our AASHTO re:source (formally AMRL) certified Elizabeth City laboratory.

2.2.1 Soil Classification and Index Testing

Representative portions of all soil samples collected during drilling operations were labeled, preserved and transferred to our laboratory in accordance with ASTM D4220 for classification and analysis. Soil descriptions on the boring logs are provided using visual-manual methods in general accordance with ASTM D2488 using the Unified Soil Classification System (USCS). Soil samples that were selected for index testing were classified in general accordance with ASTM D2487. It should be noted that 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.

Six (6) representative split-spoon soil samples were selected and subjected to natural moisture, Atterberg Limits, and/or #200 sieve wash testing in order to corroborate the visual classification. These test results are presented in Appendix III and/or on the soil test boring logs provided in Appendix IV. Generalized subsurface soil profiles are provided in Appendix V.

3.0 SITE AND SUBSURFACE CONDITIONS

3.1 Site Geology

The project site lies within a major physiographic province 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 explorations generally consisted of marine deposited Clays and Sands.

3.2 Recent Land Reclamation and Site Development

Based on a review of historical United States Geological Survey (USGS) topographic maps of Edenton, North Carolina produced between the years of 1954 and 2019, the project site does not appear to be within a reclaimed area. However, the site was previously developed including the existing bulkhead and boardwalk/dock. As such, excavations to remove the existing tie backs and deadmen are anticipated.

3.3 Subsurface Soil Conditions

The surficial and subsurface soils encountered at the explored locations generally consisted of SAND (SP, SP-SM, SM) having varying amounts of Silt and Clay. The granular soils encountered at boring B-1 from 23 to 28 feet and at B-2 from 6 to 7 feet were noted to contain trace amounts of Organics. Finally, 1- to 2-foot thick deposits of very soft to soft CLAY (CL) were encountered at borings B-1 and B-3 at depths ranging from 6 to 8 feet. A summary of the subsurface soil conditions encountered at the boring locations is presented in Table I.

Table I – Subsurface Soil Conditions

Average Depth (ft)	Stratum	Description	Ranges of SPT(1) N-Values
0 to 8 – 13	I	Ø Tan, Gray, or Brown SAND (SP, SP-SM, SM) with varying amounts of Silt The granular soils encountered at boring B-2 from 6 to 7 feet contained 0.4% Organics	3 – 9
6 – 8 to 7 – 10	Deposit I.A(2)	Ø Dark Gray CLAY (CL)	W.O.H.(3) – 4(4)
8 – 13 to 30	III(5)	Ø Gray, Dark Gray, or Dark Gray-Brown SAND (SP, SP-SM) The granular soils encountered at boring B-1 from 23 to 28 feet were noted to contain trace amounts of Organics	11 – 50

Note(s): (1) SPT = Standard Penetration Test, N-Values in Blows-per-foot (uncorrected)
(2) Encountered at Borings B-1 and B-3 only
(3) W.O.H. = Weight of Hammer
(4) N-value estimated given the depth of the deposit and SPT sampling interval
(5) All Borings terminated in this stratum

The subsurface descriptions are of a generalized nature provided to highlight the major soil strata encountered. The records of the subsurface exploration are included in Appendix IV (Boring Log sheets) and in Appendix V (Generalized 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.

In addition to the SPT explorations completed at this site, a total of sixteen (16) soundings and probing were performed along the north side of the existing bulkhead and boardwalk/dock in order to estimate the existing mudline depth as well as to estimate the depth to the bottom of the surficial silt/muck and/or very loose Sand soils. These depths can be affected by tidal fluctuations, stormwater runoff, boat activity, and/or storm related events. As such, these depths are estimates, may vary along the bulkhead alignment and/or at unexplored locations, as well as may change over time. The results of these soundings and probing are provided in Table II below. The approximate location of the soundings is provided in Appendix I on the "Boring and Sounding Location Plan".

Table II – Mudline Depths

Sounding ID	Mudline Depth (ft)(1)	Estimated Depth to Bottom of Surficial Silt/Muck and/or Very Loose Sand(1,2)
S-1	4.2	6
S-2	4.8	12
S-3	4.9	10
S-4	5.3	6.5
S-5	5.6	6.5
S-6	5.8	10
S-7	5.8	10.5
S-8	6	11.5
S-9	5.9	7.5
S-10	6	8.5
S-11	5.9	7.5
S-12	5.8	8
S-13	5.9	9
S-14	5.8	8.5
S-15	5.5	1.5
S-16	4.8	2

Note(s): (1) Depths noted above are referenced from beneath the finished deck elevation of the boardwalk/dock.
(2) These depths noted above are qualitative estimates based on the penetration resistance of our hand operated equipment.

3.4 Groundwater Discussion

The groundwater level was recorded at the boring locations and as observed through the relative wetness of the recovered soil samples during the drilling operations. The initial groundwater level was measured to occur at depths ranging from approximately 2.5 to 3 feet below the existing grades at the SPT boring locations. The existing site grade elevations were unknown at the time of our field explorations and reporting procedures. As such, the ground water elevations could not be estimated.

Drilling fluids (water) are introduced into the bore holes during the drilling operations impairing the ability to accurately determine the groundwater levels. In addition, as subsurface soils begin to dry, moisture moves upwards through the soil profile by means of capillary action. The near surface soils containing generally less than 10% fines (Silt) are relatively porous soils within an active Coastal Environment that can affect groundwater levels from tidal fluctuations including wind driven tides. As such, the reported initial groundwater levels may not be indicative of the static groundwater level. The SPT boreholes were backfilled upon completion for safety considerations as well as in accordance with NCDENR requirements for aquifer protection.

Groundwater conditions will generally vary with environmental variations and seasonal conditions, such as the frequency and magnitude of rainfall patterns, as well as man-made influences, such as existing swales, drainage ponds, underdrains and areas of covered soil (paved parking lots, sidewalks, etc.). In the project's area, seasonal groundwater fluctuations of +/-2 to 3 feet or more are common; however, greater fluctuations have been documented. We recommend that the Contractor determine the actual groundwater levels at the time of the construction to determine groundwater impact on the construction procedures, if necessary.

4.0 EVALUATIONS AND RECOMMENDATIONS

Our recommendations are based on the previously discussed project information, our interpretation of the soil test borings and laboratory data, and our 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 Suitability of On-site Soils

Based on the laboratory testing program, the surficial and/or shallow subsurface soils classified as SAND (SP, SP-SM) encountered at the boring locations generally extending from the surface to depths ranging from 6 to 8 feet, and identified to be free of Organics, appear to meet the criteria recommended in this report for reuse as structural fill. These soils should be segregated from Organic laden soils and/or CLAY (CL) deposits where encountered during excavating. Finally, moisture manipulation is expected as the majority of these soils are located near or below the groundwater table. This manipulation will likely require stockpiling of wet soils and placing the material in thin layers. Conversely, those soils excavated above the groundwater table may require the addition of water for compaction purposes. The goal of these methods is to dry the soils to within ±2 percentage points of their optimum moisture at the time of compaction.

The subsurface CLAY (CL) and/or Organic laden SAND (SP, SP-SM) soil deposits encountered at the boring locations do not meet the criteria recommended in this report for reuse as structural fill; however, may be used as fill in green areas provided they meet the criteria specified by the Civil Engineer of Record and/or owner.

Further classification testing (natural moisture content, gradation analysis, and Proctor testing) should be performed in the field during construction to evaluate the suitability of excavated soils for reuse as structural fill. The project's budget should include an allowance for imported structural fill.

4.2 Estimated Soil Design Parameters for Bulkhead Design

The estimated soil design parameters and recommendations presented herein are based solely on the soil conditions encountered at the completed landside boring locations. As directed by the Engineer of Record, borings were not performed within the open water areas along the face of the bulkhead. As such, the subaquatic soil conditions occurring along the face of the bulkhead remain unknown.

The bulkhead should be designed and analyzed with hydrostatic pressures occurring at the ground surface considering the potential for elevated water levels to occur from wind driven tides as well as for quick draw-down conditions. Finally, it is noted that erosion/scour along the bulkhead face should be accounted for.

The backfilling of any excavations required to complete the replacement procedures specified by the Engineer of Record should include suitable structural fill. Any material to be used for structural fill should be evaluated and tested by **G E T Solutions, Inc.** prior to placement to determine if they are suitable for the intended use. Suitable structural fill material should consist of sand or gravel containing less than 12% by weight of fines (SP, SM, SW, GP, GW) and should be free of rubble, organics, clay, debris and other unsuitable material.

The compaction of the structural fill behind these walls should be in the range of 95% to 97% of the Standard Proctor maximum dry density (ASTM Specification D 698). The soils in this zone should not be over-compacted. In order to minimize the potential for wall damage due to excessive compaction, hand operated mechanical tampers should be used to compact the granular materials. Heavy compaction equipment should not be allowed within five feet of the bulkhead. Filter fabric should be installed on the inside (upland) face of the bulkhead to prevent backfill material from seeping through any joints or through wall penetrations.

With regard to the analysis and design of the bulkhead, and in order to resist lateral earth pressures, the estimated soil parameters presented in Table III on the following page can be used. However, this project site is susceptible to deposits of Organic laden granular and/or very soft Cohesive soils having varying depths and thicknesses as well as slightly varying compositions. As such and in the event that it is deemed warranted by the Engineer of Record, additional SPT borings should be performed to more accurately identify the presence of Organic and/or very soft Cohesive soil conditions occurring at currently unexplored locations.

TABLE III - Estimated Soil Design Parameters

Soil Type	SAND (SP, SP-SM, SM)[2]	CLAY (CH) [3]	SAND (SP, SP-SM)[2]	On Site Excavated or Imported Structural Backfill[4]
Stratum	I	I	II	-
Approximate/Average Depths Below Grade (ft)[1]	0 to 10	7 to 9	10 to 30	-
Average SPT N-value	6	W.O.H.[5]	20	-
Estimated Moist Unit Weight (pcf)	110	105	115	110
Estimated Saturated Unit Weight (pcf)	115	110	120	115
Estimated Buoyant Unit Weight (pcf)	53	48	58	53
Friction Angle (f') (degrees)	30	0	34	30
Cohesion (c') (psf)	0	200	0	0
Active Coefficient of Lateral Earth Pressure, K_a	0.33	1	0.28	0.33
At-rest Coefficient of Lateral Earth Pressure, K_o	0.50	1	0.44	0.50
Passive Coefficient of Lateral Earth Pressure, K_p	3.00	1	3.54	3.00

Note(s): (1) Depths noted above are referenced from below existing site grade elevations at the time of the subsurface exploration procedures.
(2) The granular soils within these strata at borings B-1 and B-2 encountered at depths ranging from 23 to 6 feet (respectively) were noted to contain trace amounts of Organics (i.e. less than 1%). As such, the presence of the minimal amount of Organics is anticipated to be inconsequential.
(3) This stratum is applicable to borings B-1 and B-3 only
(4) The estimated soil design parameters for suitable structural backfill is contingent upon achieving the recommended compaction noted in Section 4.2 of this report
(5) W.O.H. = Weight Of Hammer

4.3 Seismic Evaluation

Based on our experience in the vicinity of the project site and the composition of the soils recovered within the upper 30 feet (maximum explored depth) at the boring locations, it is our opinion that the site characteristics are indicative of a Site Class “D” in accordance with Table 20.3-1 of ASCE 7-10 as referenced by the 2015 International Building Code (IBC); however, the seismic evaluation requires soils information associated with the upper 100 feet. If the site classification is critical to the structural design, it will be necessary to perform a 100-foot deep Cone Penetration Test (SCPTu) boring with shear wave velocity testing to substantiate this site classification.

The USGS Earthquake Hazards Program (US Seismic Design Maps) and the 2015 International Building Code indicate the following seismic site characteristics:

Latitude/Longitude – 36.509651°N, -75.865668°W
United States Seismic Zone – 1
Maximum Considered Earthquake Ground Motion for 0.2 sec. Spectral Response S_s – 0.084g
Maximum Considered Earthquake Ground Motion for 1.0 sec. Spectral Response S_1 – 0.045g
Site Coefficient F_a – 1.6
Site Coefficient F_v – 2.4
Maximum Considered Earthquake Spectral Response Acceleration S_{MS} – 0.134g
Maximum Considered Earthquake Spectral Response Acceleration S_{M1} – 0.108g
Design Spectral Response Acceleration S_{DS} – 0.089g
Design Spectral Response Acceleration S_{D1} – 0.072g

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Anticipated Excavation Characteristics

Based on the results of this exploration, generally uniform soil conditions and compositions are expected to be encountered throughout the project limits. Open-cut excavations will extend through natural soils that are considered to be 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 the majority of the surficial and subsurface materials within the project area and extending to depths of about 6 to 8 feet may be reusable as backfill. Soil deposits classified to consist of CLAY (CL) and/or SAND (SP-SM) with trace organics are not recommended to be reused as backfill. Soils containing appreciable amounts of Organics and/or deleterious debris should be discarded; however, an effort should be made during excavation to segregate potentially suitable in-situ soils for reuse. Information pertaining to backfill criteria was provided previously in Section 4.3.

5.2 Excavation Stability

The subsurface soils within the project limits are comprised of relatively porous, granular soils of which have relatively no cohesion and have a significant 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. Based on these mentioned characteristics, it is recommended that all subsurface soils be considered Type C in accordance with Occupational Safety and Health Administration (OSHA) criteria.

Temporary Slopes

In Federal Register, Volume 54, No. 209 (October, 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better ensure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that all excavations, whether they be utility trenches, basement excavations, or footing excavations, be constructed in accordance with the new (OSHA) guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the Contractor could be liable for substantial penalties.

Temporary slopes may not be a feasible option. 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, as defined in 29 CFR Part 1926, 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.

Where temporary slopes are not feasible, shoring by means of sheeting and/or trench shields may be appropriate. Where the stability of adjoining structures, pavements, or other improvements is 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 in an effort to protect against lateral deformation that may result in ground cracks, settlement, and/or other ground movements that may affect adjacent underground utilities and pavements as well as surface improvements. The Contractor should be made aware of this potential condition in order that preventative measures can be implemented, or repair measures provided for.

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 in a manner as to not create these voids.

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

We are providing this information solely as a service to our client. **G E T Solutions, Inc.** is not assuming responsibility for construction site safety or the Contractor's activities; such responsibility is not being implied and should not be inferred.

5.3 Dewatering

It is expected that dewatering will be required for excavations that extend near or below the existing groundwater table (approximate depths of 2.5 to 3 feet). As an exception, dewatering perched water levels within structural fill and/or slightly below existing grades should be expected following inclement weather and/or during the wet season. Dewatering above the groundwater level could probably be accomplished by pumping from sumps. Dewatering at depths below the groundwater level will require well pointing 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 predominately granular soils (e.g. SP, SP-SM soils) should be anticipated as a result of lowering the groundwater table. We recommend that the dewatering be performed such that the groundwater level is lowered 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.

5.4 Site Utility Installation

The base of the utility trenches should be observed by a qualified inspector prior to the pipe placement to verify the suitability of the bearing soils. It is expected that the utilities will be located near or below the groundwater level (at the time of this reporting 2.5 to 3 feet below current grades), bearing in moist to wet granular soils. In these instances, the bearing soils may require some stabilization to provide suitable bedding. This stabilization is commonly accomplished by adding 6 to 12 inches or more of bedding stone (Type NCDOT No. 57). The resulting excavations should be backfilled with structural fill, as described in Section 4.2 of this report. As mentioned previously, some of the shallow subsurface materials encountered within the project site may be suitable for reuse as backfill. Soils containing appreciable amounts of fines or deleterious debris should be discarded. Imported fill should be included in the construction budget for backfilling the utility excavations within the construction areas.

6.0 REPORT LIMITATIONS

The recommendations submitted are based on the available soil information obtained by **G E T Solutions, Inc.** and the information supplied by the client and their designated agents 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, **G E T Solutions, Inc.** should be notified immediately to determine if changes in the foundation recommendations are required. If **G E T Solutions, Inc.** is not retained to perform these functions, **G E T Solutions, Inc.** can not be responsible for the impact of those conditions on the geotechnical recommendations for the project.

The Geotechnical Engineer 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 more complete, the Geotechnical Engineer 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 earthwork and foundation 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 Bulkhead Failure Replacement project located at 2100 Ocean Pearl Road in Corova, North Carolina.

APPENDICES

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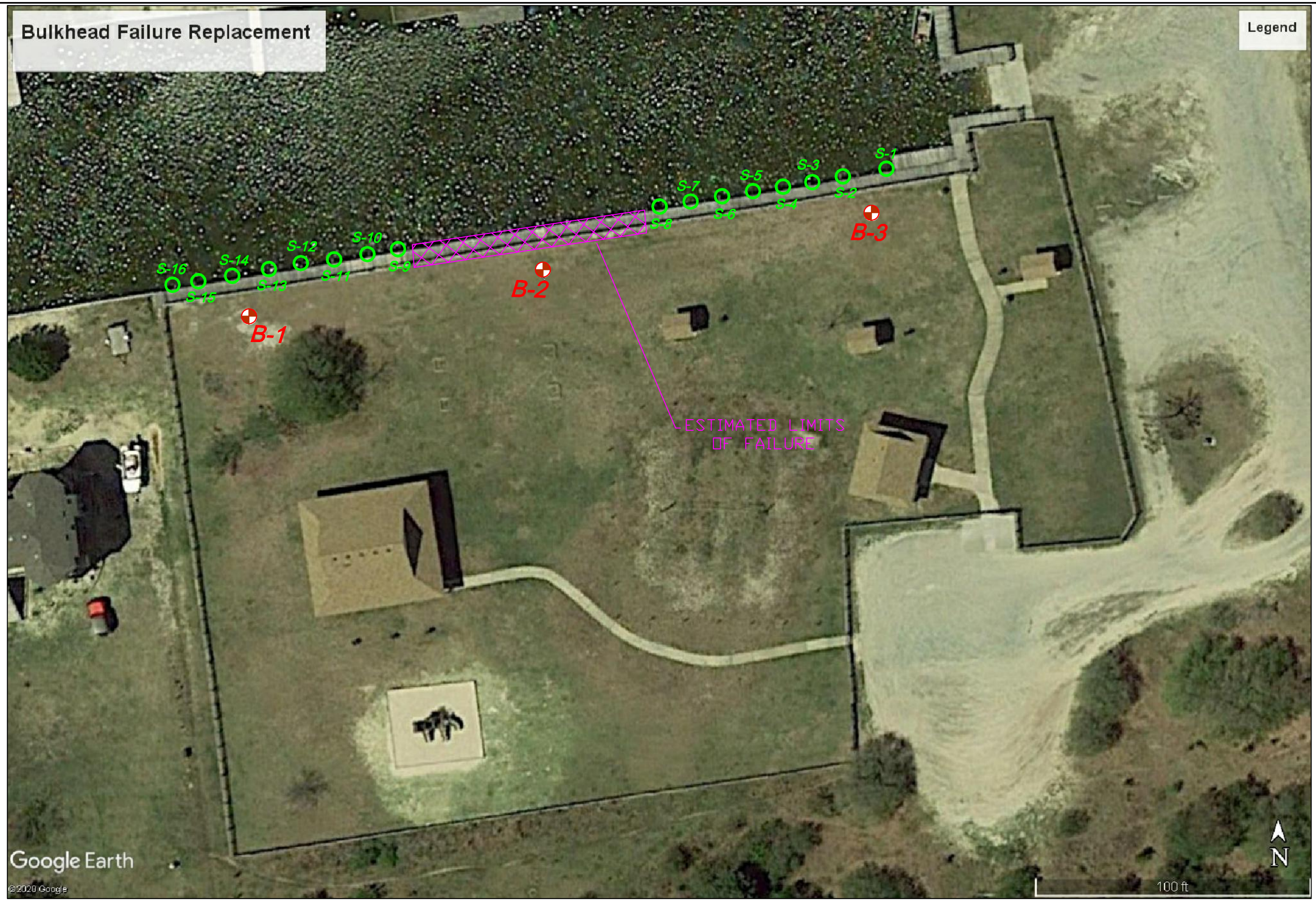
APPENDIX I

BORING LOCATION PLAN



LEGEND
— APPROXIMATE BORING LOCATION
— APPROXIMATE SOUNDING LOCATION

GET Solutions, Inc.
Geotechnical • Environmental • Testing

Project Name:
BULKHEAD FAILURE REPLACEMENT
COROVA, NORTH CAROLINA

Project No.: EC20-121G	Drawn By: GWS
Date: 3/24/2020	Figure No.: 1

BORING AND SOUNDING LOCATION PLAN

SCALE:
NOT TO SCALE

APPENDIX II

CLASSIFICATION SYSTEM FOR SOIL EXPLORATION

Project: Bulkhead Failure Replacement
Project Location: Corova, Currituck County, North Carolina
Project Number: EC20-121G

GET Solutions, Inc.
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Key to Soil Symbols and Terms

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No. 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests.

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests.

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very stiff	200 to 400	15 to 30
Hard	> 400	> 30

GENERAL NOTES

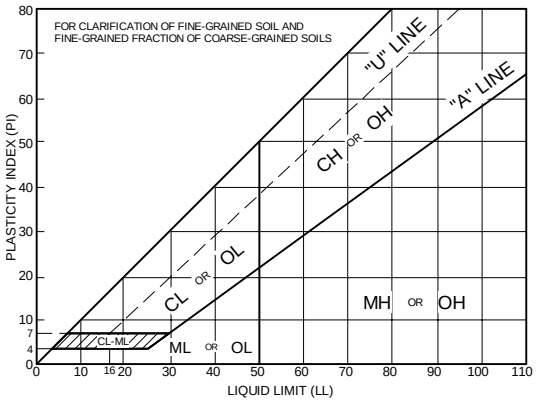
1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

2. Surface elevations are based on topographic maps and estimated locations.

3. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made. They are not guaranteed to be representative of subsurface conditions at other locations or times.

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW
		Gravel with fines (Appreciable amount of fines)	GM* d / u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4; Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-silt mixtures	Atterberg limits above "A" line or P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4; Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line or P.I. greater than 7
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 60)		ML	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and Clays (Liquid limit greater than 60)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, organic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity, organic silts	
	Highly Organic Soils		Pt	Peat and other highly organic soils	

Determine percentages of sand and gravel from grain size curve, Depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows:
Less than 5 percent..... GW, GP, SW, SP
More than 12 percent..... GM, GC, SM, SC
6 to 12 percent..... Borderline case4s requiring dual symbols**



Plasticity Chart

Particle Size		
Material	Sieve sizes	mm
Silt or clay	< #200	< 0.074
Sand	#200 to #40	0.074 to 0.42
Fine	#40 to #10	0.42 to 2.00
Medium	#10 to #4	2.00 to 4.76
Coarse	#4 to 3/4 in.	4.76 to 19.1
Gravel	3/4 in. to 3 in.	19.1 to 76.2
Cobble	3 in. to 12 in.	76.2 to 304.8
Boulders	12 in. to 36 in.	304.8 to 914.4

* Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg Limits: suffix d used when L.L. is 23 or less and the P.I. is 6 or less; the suffix is used when L.L. is greater than 26.

** Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

KEY TO MATERIAL GRAPHICS

GET Solutions, Inc.

CLIENT Coastal Engineering and Surveying, Inc.

PROJECT NAME Bulkhead Failure Replacement

PROJECT NUMBER EC20-121G

PROJECT LOCATION Corova, Currituck County, North Carolina

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

CL: USCS Low Plasticity Clay

SAND WITH ORGANICS: Topsoil

SM: USCS Silty Sand

SP: USCS Poorly-graded Sand

SP-SM: USCS Poorly-graded Sand with Silt

APPENDIX III

SUMMARY OF LABORATORY CLASSIFICATION RESULTS

GET Solutions, Inc.

SUMMARY OF LABORATORY RESULTS

GET Solutions, Inc.

CLIENT Coastal Engineering and Surveying, Inc.

PROJECT NAME Bulkhead Failure Replacement

PROJECT NUMBER EC20-121G

PROJECT LOCATION Corova, Currituck County, North Carolina

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	3.0				0.075	1	SP	24.9			
B-1	11.0				0.075	5	SP-SM	24.4			
B-2	7.0				0.075	7	SP-SM	26.9			
B-2	9.0				0.075	7	SP-SM	28.2			
B-3	9.0	32	17	15	0.075	53	CL	33.4			
B-3	11.0				0.075	7	SP-SM	27.7			

APPENDIX IV

BORING LOGS

RECORD OF SUBSURFACE EXPLORATION

GET Solutions, Inc.
Geotechnical • Environmental • Testing

Virginia Beach
5465 Greenwich Road
Virginia Beach, VA 23642
757-518-1703

Williamsburg
1592-E Penniman Road
Williamsburg, VA 23185
757-564-6452

Elizabeth City
106 Capital Trace Unit E
Elizabeth City, NC 27909
252-335-9765

Jacksonville
415-A Western Blvd
Jacksonville, NC 28546
910-478-9915

BORING ID
B-1

PROJECT NAME: **Bulkhead Failure Replacement**
CLIENT: **Coastal Engineering and Surveying, Inc.**
PROJECT LOCATION: **Corova, Currituck County, North Carolina**
BORING LOCATION: **See Attached Boring Location Plan**
DRILLING METHOD(S): **Rotary wash "mud"**
GROUNDWATER*: INITIAL (ft) ▽: **3** AFTER ____ HOURS (ft) ▼: ____ CAVE-IN (ft) ▽: ____
The initial groundwater readings are not intended to indicate the static groundwater level.

PROJECT NUMBER: **EC20-121G**
SURFACE ELEVATION (MSL) (ft): ____
LOGGED BY: **G. Stalls, PE**
DATE STARTED: **3/6/2020**
DATE COMPLETED: **3/6/2020**
DRILLER: **GET Solutions, Inc.**

Elevation (ft)	Depth (ft)	STRATA DESCRIPTION	Strata Legend	Sample ID	Sample Type	Sample Recovery (in.)	Blow Counts (N-Values)	%<#200
	0	Tan, moist to wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, very loose to loose		1	SS	16	1-2-2-2 (4)	
▽		Gray and Wet from 3 Feet		2	SS	13	2-3-2-3 (5)	1
	5			3	SS	21	2-2-3-2 (5)	
	6.0							
	7.0	Dark Gray, wet, Sandy Lean CLAY (CL), soft		4	SS	24	2-2-5-7 (7)	
	8.0	Dark Gray, wet, Silty fine SAND (SM), loose						
		Dark Gray, wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, medium dense		5	SS	11	7-8-11-14 (19)	
	10			6	SS	12	8-11-15-13 (26)	5
				7	SS	15	9-8-10-10 (18)	
	15							
	19.5			8	SS	14	5-7-9-10 (16)	
	20	Dark Gray, wet, poorly graded fine to coarse SAND (SP), medium dense						
	23.0							
		Dark Gray-Brown, wet, poorly graded fine to medium SAND (SP) with trace Silt and Organics, medium dense		9	SS	13	6-7-6-7 (13)	
	25							
	28.0							
		Gray, wet, poorly graded fine to coarse SAND (SP), mixed with Marine Shell Fragments and trace Mica, dense		10	SS	17	12-15-20-18 (35)	
	30.0							
		Boring terminated at 30 feet below existing grade.						

TEST RESULTS
Plastic Limit X——X Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50 60 70

Sample Type(s):
SS - Split Spoon

Notes:

RECORD OF SUBSURFACE EXPLORATION

GET Solutions, Inc.
Geotechnical • Environmental • Testing

Virginia Beach
5465 Greenwich Road
Virginia Beach, VA 23642
757-518-1703

Williamsburg
1592-E Penniman Road
Williamsburg, VA 23185
757-564-6452

Elizabeth City
106 Capital Trace Unit E
Elizabeth City, NC 27909
252-335-9765

Jacksonville
415-A Western Blvd
Jacksonville, NC 28546
910-478-9915

BORING ID
B-2

PROJECT NAME: **Bulkhead Failure Replacement**
CLIENT: **Coastal Engineering and Surveying, Inc.**
PROJECT LOCATION: **Corova, Currituck County, North Carolina**
BORING LOCATION: **See Attached Boring Location Plan**
DRILLING METHOD(S): **Rotary wash "mud"**
GROUNDWATER*: INITIAL (ft) ▽: **3** AFTER ____ HOURS (ft) ▼: ____ CAVE-IN (ft) ▽: ____
The initial groundwater readings are not intended to indicate the static groundwater level.

PROJECT NUMBER: **EC20-121G**
SURFACE ELEVATION (MSL) (ft): ____
LOGGED BY: **G. Stalls, PE**
DATE STARTED: **3/6/2020**
DATE COMPLETED: **3/6/2020**
DRILLER: **GET Solutions, Inc.**

Elevation (ft)	Depth (ft)	STRATA DESCRIPTION	Strata Legend	Sample ID	Sample Type	Sample Recovery (in.)	Blow Counts (N-Values)	%<#200	TEST RESULTS
	0	Tan, moist to wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, loose		1	SS	20	2-2-4-4 (6)		
▽		Gray and Wet from 3 Feet		2	SS	16	4-3-2-1 (5)		
	5			3	SS	20	2-3-4-4 (7)		
		6.0							
		7.0 Brown, wet, poorly graded fine to medium SAND (SP-SM) with Silt and trace Organics, very loose Organic Content = 0.4%		4	SS	24	2-2-1-1 (3)	7	
		Dark Gray, wet, poorly graded fine SAND (SP-SM) with Silt to Silty fine SAND (SM), very loose to medium dense		5	SS	11	3-6-8-10 (14)	7	
	10	10.0 Dark Gray, wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, medium dense		6	SS	9	3-10-10-13 (20)		
				7	SS	13	10-12-12-12 (24)		
	15								
		19.0		8	SS	12	9-9-11-10 (20)		
	20	Gray, wet, poorly graded fine to coarse SAND (SP) with trace Marine Shell Fragments and Roots, medium dense							
		23.0							
		Dark Gray, wet, poorly graded fine SAND (SP) to poorly graded fine SAND (SP-SM) with Silt, loose to dense		9	SS	12	6-3-3-5 (6)		
	25								
		Gray and trace Mica from 28 Feet		10	SS	17	13-22-28-26 (50)		
	30	30.0 Boring terminated at 30 feet below existing grade.							

TEST RESULTS
Plastic Limit X——X Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50 60 70

Sample Type(s):
SS - Split Spoon

Notes:

RECORD OF SUBSURFACE EXPLORATION

GET Solutions, Inc.
Geotechnical • Environmental • Testing

Virginia Beach
5465 Greenwich Road
Virginia Beach, VA 23642
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Williamsburg
1592-E Penniman Road
Williamsburg, VA 23185
757-564-6452

Elizabeth City
106 Capital Trace Unit E
Elizabeth City, NC 27909
252-335-9765

Jacksonville
415-A Western Blvd
Jacksonville, NC 28546
910-478-9915

BORING ID
B-3

PROJECT NAME: **Bulkhead Failure Replacement**
CLIENT: **Coastal Engineering and Surveying, Inc.**
PROJECT LOCATION: **Corova, Currituck County, North Carolina**
BORING LOCATION: **See Attached Boring Location Plan**
DRILLING METHOD(S): **Rotary wash "mud"**
GROUNDWATER*: INITIAL (ft) ▽: **2.5** AFTER ____ HOURS (ft) ▼: ____ CAVE-IN (ft) ▽: ____
The initial groundwater readings are not intended to indicate the static groundwater level.

PROJECT NUMBER: **EC20-121G**
SURFACE ELEVATION (MSL) (ft): ____
LOGGED BY: **G. Stalls, PE**
DATE STARTED: **3/6/2020**
DATE COMPLETED: **3/6/2020**
DRILLER: **GET Solutions, Inc.**

Elevation (ft)	Depth (ft)	STRATA DESCRIPTION	Strata Legend	Sample ID	Sample Type	Sample Recovery (in.)	Blow Counts (N-Values)	%<#200	TEST RESULTS
	0	Tan, moist to wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, very loose to loose		1	SS	22	2-2-2-3 (4)		
▽		Wet from 2.5 Feet		2	SS	16	3-5-3-3 (8)		
	5	Gray from 5 Feet		3	SS	24	2-3-4-3 (7)		
				4	SS	24	2-2-1-2 (3)		
	8.0	Dark Gray, wet, Sandy Lean CLAY (CL) , very soft		5	SS	22	0-0-0-0 (0)	53	
	10	Dark Gray, wet, poorly graded fine SAND (SP-SM) with Silt to Silty fine SAND (SM), loose		6	SS	13	2-4-5-8 (9)	7	
	13.0	Gray, wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, medium dense		7	SS	14	9-11-12-14 (23)		
	15								
	19.5			8	SS	8	10-9-10-9 (19)		
	20	Gray, wet, poorly graded fine to coarse SAND (SP) with little Marine Shell Fragments, medium dense							
	23.0	Gray, wet, poorly graded fine to medium SAND (SP) to poorly graded fine to medium SAND (SP-SM) with Silt, medium dense		9	SS	12	6-7-7-7 (14)		
	25								
		With trace Mica from 28 Feet		10	SS	15	3-4-7-5 (11)		
	30.0	Boring terminated at 30 feet below existing grade.							

TEST RESULTS
Plastic Limit X——X Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50 60 70

Sample Type(s):
SS - Split Spoon

Notes:

APPENDIX V

GENERALIZED SOIL PROFILES

GET Solutions, Inc.
Geotechnical • Environmental • Testing

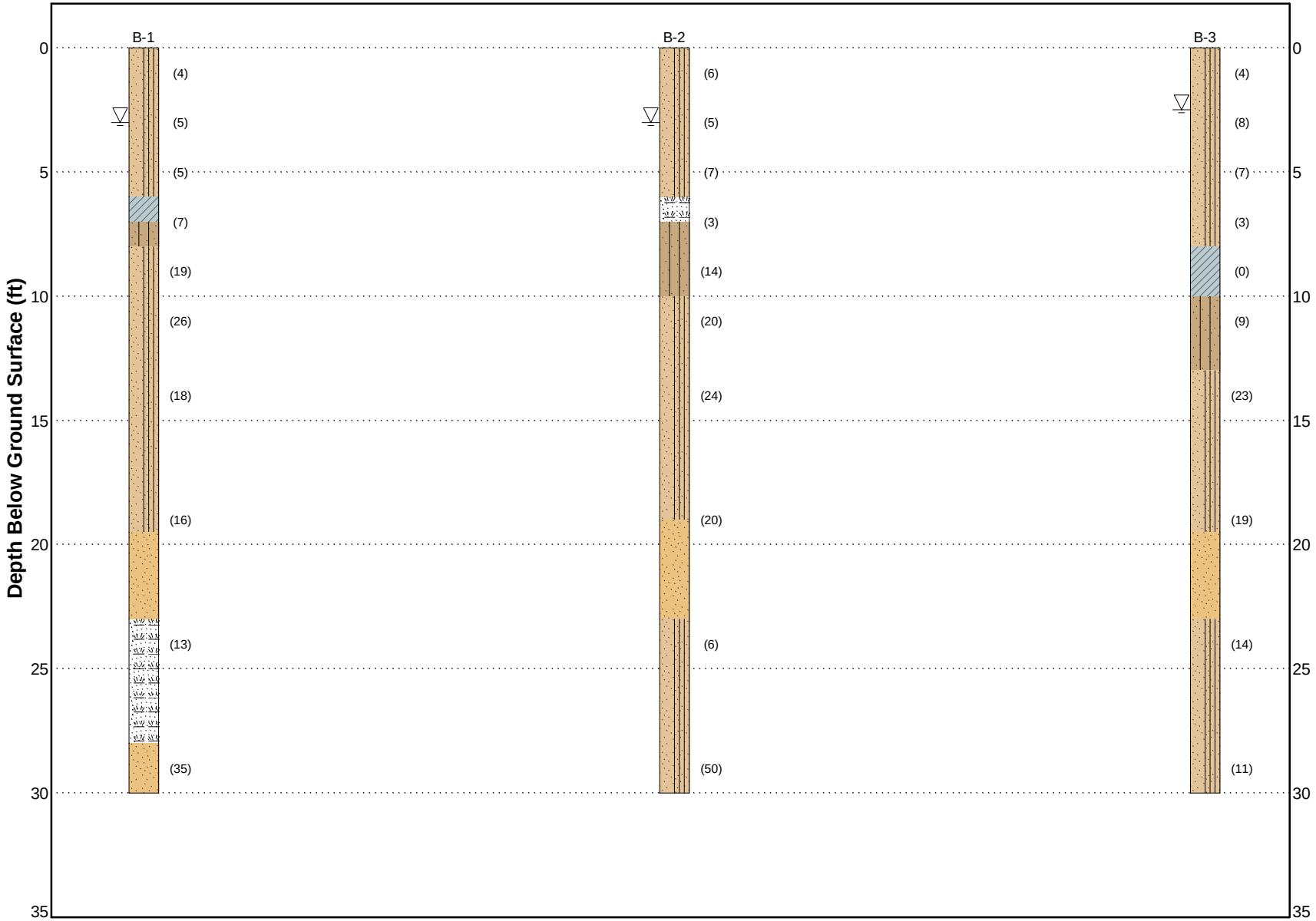
GENERALIZED SOIL PROFILE

PROJECT NAME: **Bulkhead Failure Replacement**

PROJECT NUMBER: **EC20-121G**

PROJECT LOCATION: **Corova, Currituck County, North Carolina**

CLIENT: **Coastal Engineering and Surveying, Inc.**



LEGEND

- USCS Poorly-graded Sand with Silt
- USCS Low Plasticity Clay
- USCS Silty Sand
- USCS Poorly-graded Sand
- Topsoil

(Numerical Value) = Sample N-Value

APPENDIX VI

SEISMIC DESIGN MAPS

Hazards by Location

Search Information

Coordinates: 36.509651, -75.865668

Elevation: 3 ft

Timestamp: 2020-03-24T18:59:28.045Z

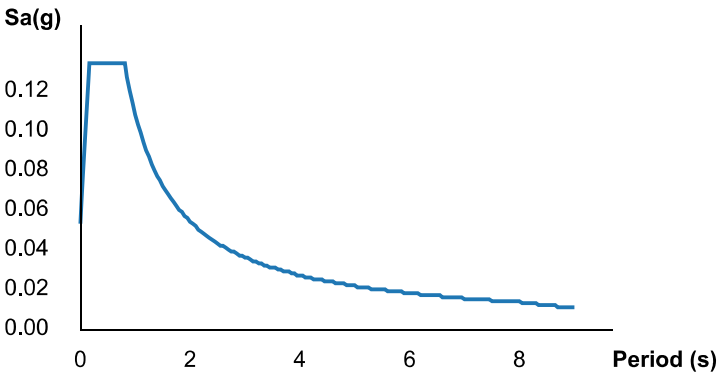
Hazard Type: Seismic

Reference Document: ASCE7-10

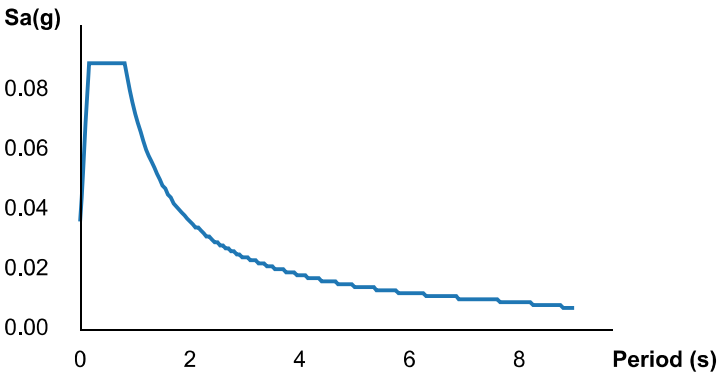
Risk Category: II

Site Class: D

MCER Horizontal Response Spectrum



Design Horizontal Response Spectrum



Basic Parameters

Name	Value	Description
S_S	0.084	MCE_R ground motion (period=0.2s)
S_1	0.045	MCE_R ground motion (period=1.0s)
S_{MS}	0.134	Site-modified spectral acceleration value
S_{M1}	0.108	Site-modified spectral acceleration value
S_{DS}	0.089	Numeric seismic design value at 0.2s SA
S_{D1}	0.072	Numeric seismic design value at 1.0s SA

Additional Information

Name	Value	Description
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2s
F_v	2.4	Site amplification factor at 1.0s
CR_S	0.912	Coefficient of risk (0.2s)

CR_1	0.867	Coefficient of risk (1.0s)
PGA	0.038	MCE_G peak ground acceleration
F_{PGA}	1.6	Site amplification factor at PGA
PGA_M	0.061	Site modified peak ground acceleration
T_L	8	Long-period transition period (s)
SsRT	0.084	Probabilistic risk-targeted ground motion (0.2s)
SsUH	0.092	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
SsD	1.5	Factored deterministic acceleration value (0.2s)
S1RT	0.045	Probabilistic risk-targeted ground motion (1.0s)
S1UH	0.052	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
S1D	0.6	Factored deterministic acceleration value (1.0s)
PGAd	0.5	Factored deterministic acceleration value (PGA)

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Disclaimer

Hazard loads are provided by the U.S. Geological Survey Seismic Design Web Services.