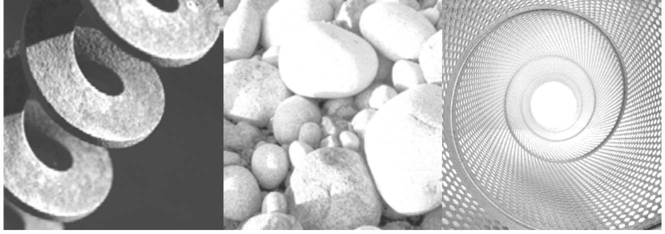
Appendix A. Geotechnical Data Reports for Tidal Basin and West Potomac Park

Geotechnical Data Report - Tidal Basin



GEI Consultants

Consulting
Engineers and
Scientists

Geotechnical Data Report

Rehabilitation of Seawalls and Shoreline – Tidal Basin

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Table of Contents

Figures

Tables

Appendices

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1. Introduction

1.1 Project Description

The Rehabilitation of Seawalls and Shoreline Project (Project) for the National Park Service (NPS) consists of the rehabilitation and reconstruction of seawalls in the West Potomac Park (WPP) and the Tidal Basin to prevent water from the Potomac River and the Tidal Basin from encroaching on the land areas over the seawalls The location of the general project area is shown in Figure 1. This report is focused specifically on the seawalls within the Tidal Basin.

For purposes of this Project, the Tidal Basin seawalls have been divided into two sections, Tidal Basin West and Tidal Basin East as shown in Figure 2. Please note that during the field investigation the Tidal Basin West was being referred to as the North Tidal Basin and therefore any references to the North Tidal Basin or "NTB" are actually for the Tidal Basin West or "TBW". The Tidal Basin West consists of the seawalls that start at the Ohio Drive Bridge and extend approximately 850 feet to the north near the location of the Japanese Pagoda. The Tidal Basin East consists of approximately 1,250 feet of the seawalls starting from the Inlet Bridge to the western edge of the North Plaza in front of the Jefferson Memorial. The WPP seawall, which is not included as part of this study, starts from the northwest side of the Ohio Drive Bridge and runs to the north along the Potomac River for approximately 4,650 feet to the Memorial Bridge.

The purpose of this Geotechnical Data Report (GDR) is to present data collected by GEI Consultants, Inc. (GEI) during a geotechnical exploration program in the Tidal Basin area. The data will be used in the planning and design of components associated with the portions of the Project located in the Tidal Basin East and West. Data obtained from previous geotechnical explorations and laboratory tests performed by others in the vicinity of the Project are also briefly described.

1.2 Report Organization

This GDR includes a brief description of the Project and the procedures and results of a field exploration and geotechnical laboratory testing program.

This report is organized as follows:
Section 1 – Introduction
Section 2 – Historical Information
Section 3 – Subsurface Exploration and Testing
Section 4 – Geotechnical Laboratory Testing
Section 5 – Geologic Conditions
Section 6 – Geotechnical Instrumentation
Section 7 – References

Figures, Tables, and data plots are provided after the text. The data collected and generated during the field exploration and laboratory testing programs are presented in the attached Appendices.

1.3 Geotechnical Exploration Program

GEI was contracted by HDR/M&N JV to perform geotechnical fieldwork and testing. The purpose of this work is to supplement existing geotechnical data and reports provided by the NPS. The scope consisted of drilling soil borings and performing in-situ testing along the alignment of the Tidal Basin walls. A total of four (4) soil borings with rock coring were performed and were utilized for the installation of geotechnical instrumentation. In addition, eleven (11) Cone Penetration Tests (CPTs) and seven (7) Dilatometer Tests (DMTs) were performed.

Geotechnical instrumentation included three (3) Inclinometers (INC) and one (1) multi-point borehole extensometer (MPBX). Each INC contained five (5) multi-level vibrating wire piezometers (VWPZ) attached to the outside of the inclinometer casing.

Geotechnical laboratory testing consisting of classification, strength, and compressibility testing was performed on disturbed and undisturbed samples collected in the borings.

General boring information is provided in Table 1, and the boring logs are provided in Appendix B. Additional details are provided in Section 4.

1.4 Elevation Datum and Coordinate System

Elevations are measured in feet and are referenced to the North American Vertical Datum of 1988 (NAVD88). Boring coordinates are in feet and are referenced to Virginia State Plane Coordinate System, Virginia North Zone defined by the North American Datum of 1983 (NAD83).

1.5 Limitations on Use of this Report

This report has been prepared for the exclusive use of the NPS and its consultants and contractors for the planning, design, and construction of the Project in the Tidal Basin East and West. The data presented in this report are based on subsurface conditions encountered at the time of the subsurface exploration. NPS is not responsible for the interpretation by others of the data contained herein.

The data presented in this report is based solely on the results of the explorations performed for this Project. Observations and data not collected during these exploration programs (i.e., Historical Data) is provided for reference and information only. This report does not reflect any variations which may occur between borings. In the performance of subsurface explorations, specific information is obtained at specific locations at specific times. However, it is well-known that variations in soil and rock conditions exist on most sites between boring locations, and that seasonal and annual fluctuations in groundwater levels will likely occur. The nature and extent of variations may not become evident until the course of construction.

The services described herein have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the area. No warranty, express or implied, is made.

2. Historical Information

2.1 Historical Geotechnical Explorations

Schnabel Engineering Inc. (Schnabel) performed a subsurface investigation near the Jefferson Memorial in 2006. Fill material, soft clay and silt, medium-stiff clay and silt were encountered from the ground surface to the bedrock, in that descending order. The top of bedrock encountered during the geotechnical exploration was approximately between El. -90 ft and El. -104.5 ft. Boring logs prepared by Schnabel in 2006 are presented in Appendix A.

3. Subsurface Exploration and Testing

3.1 General

The geotechnical explorations included soil borings (hollow-stem auger); rock coring; Standard Penetration Tests (SPTs); Dilatometer Tests (DMTs); Cone Penetration Tests (CPTs); installation and monitoring of Vibrating Wire Piezometers (VWPZs), Inclinometers (INC); a multi-point borehole extensometer (MPBX); and the collection of soil samples for geotechnical laboratory testing.

The geotechnical exploration program included performing of eleven (11) CPTs, seven (7) DMTs, four (4) SPT borings, vane shear testing, installation and monitoring of three (3) inclinometers each with five (5) multi-level VWPZs, installation and monitoring of one (1) MPBX, and field and laboratory testing. Test locations for Tidal Basin East and West are shown in Figures 3 and 4. The geotechnical exploration program included laboratory testing on soil from both split spoon samples and tube samples.

3.2 Access, Permits, and Coordination

Borings were performed within the National Park Service property. Permitting and coordination for drilling on the various properties and areas was obtained from the Department of Consumer and Regulatory Affairs (DCRA), the Department of Energy and Environmental (DOEE), and National Park Services (NPS). Copies of the applicable permits were maintained in the field by the drilling subcontractor and the field team during execution of the work. The issued permits are provided in Appendix F. Close-out documentation required by the DOEE was prepared and submitted to close the soil boring permits. This close-out documentation is also included in Appendix F.

The field team located the proposed borings and in-situ test locations in the field using hand-held GPS devices along with visual confirmation of location based on existing site features. The as-drilled locations were resurveyed by GEI using a Global Navigation Satellite System (GNSS) Real Time Kinematic (RTK) rover throughout the project area. Table 1 shows the coordinates of all boring locations.

3.2.1 Utility Clearance

Miss Utility was contacted to clear the boring locations for the presence of possible utilities. No potential conflicts were identified prior to the start of work and no utility lines were encountered during execution of the work.

3.3 Soil Borings

Four (4) SPT soils borings were drilled at select locations along the Tidal Basin East and West walls. Drilling was performed by E2CR, Inc. of Baltimore, Maryland under contract with the HDR/M&N JV. The drilling and field-testing activities were observed by GEI Consultants, Inc. of Washington, DC.

The borings were advanced using truck-mounted, and track-mounted conventional drill rigs. Borings were advanced using 3-¼" minimum ID hollow stem augers (HSA) following the ASTM D6151 procedures until refusal was encountered at the top of bedrock. All borings were extended to the top of bedrock except Boring TBE-B-02 which was terminated at a depth of 55 feet due to the high level of methane gas. HSAs support the sides of the borehole while leaving the center open for sampling and additional drilling. This method is subject to "blow in" or "plugging" of soil at the bottom of the auger flights which can compromise soil sample integrity and the accuracy of the N-value measurements. To prevent this, an auger pilot bit (also referred to as a plug) was attached to the end of the drill rods to fill the void within the HSA and block soil cuttings from plugging the inside of the augers.

Pocket penetrometer and pocket Torvane tests were performed on SPT samples in the field to provide an estimate of undrained strength for fine-grained cohesive soil. Pocket penetrometer and Torvane test results are contained on the boring logs and designated as "$S_{u,pp}$" and "$S_{u,tv}$" and are reported in kips per square foot (ksf).

After the completion of drilling, Inclinometers with five (5) multi-level VWPZs were installed in three borings (TBE-B-01, TBW-B-01, and TBW-B-02). One MPBX was installed in boring TBE-B-02 (BTX) after reaching the final depth.

All soil cuttings brought to the surface by the auger flights and were collected and placed in steel drums for disposal off-site. All borings were tremie-grouted with a bentonite-grout mix upon completion. For the instrumentation holes, grouting encompassed the instruments sealing the hole from the migration of water vertically through the borehole column.

3.3.1 Split Spoon Sampling

Representative soil samples were obtained by means of the split-barrel sampling procedure in accordance with ASTM D1586. A 2-inch outside diameter, split-barrel sampler is driven into the soil a distance of 18 to 24 inches by a 140-pound automatic hammer falling 30 inches. The number of blows required to drive the sampler through the second and third six-inch interval is termed the Standard Penetration Test (SPT) N-value. N-values can be used as a qualitative indication of the in-place relative density of cohesionless soils and the consistency of cohesive soils. This indication is qualitative, since many factors can significantly affect the standard penetration resistance value and prevent a direct correlation among drill crews, drill rigs, drilling procedures and hammer-rod-sampler assemblies.

3.3.2 Tube Sampling

Thin-walled tube samples were obtained using the direct push method. Conventional direct push sampling was performed in general accordance with ASTM D1587 in all borings. In general, two "undisturbed" (Shelby tube) samples were collected from fine-grained (clayey) soil strata in each boring. A summary of the tube sample field data is provided in Table 2.

Tube samples are commonly referred to as "undisturbed samples." However, samples collected using these methods can be subject to some level of disturbance. The field personnel observed the collection of tube samples and handled and transported the tube samples with care during the exploration program. The tubes were stored in a climate-controlled room and were properly oriented while awaiting shipment to the geotechnical laboratory.

Sampling tubes were new, 3-inch-O.D., thin walled, in good condition, and made of stainless steel. Tubes advanced were 30 inches long. The cutting edge of each tube was sharp, free of dents or nicks, and had a slightly smaller I.D. than the I.D. of the rest of the tube.

Samples extruded from the tubes were used for laboratory strength and deformation testing. The locations of the undisturbed samples are denoted by "U-#" on the boring logs.

3.3.3 Rock Coring

Ten (10) feet of rock coring was performed in two (2) of the borings (TBE-B-01 and TBW-B-01). Boring TBE-B-02 (BTX) was drilled for the sole purpose of installing the MPBX. This hole was blind drilled using HSA to the top of bedrock and then five (5) feet of rock coring was performed. Rock coring was performed through the HSA using an NX-sized single core barrel.

3.3.4 Water Supply

When water was needed for drilling fluids, E2CR obtained water from the Tidal Basin for these purposes.

3.3.5 Boring Completion

All boring at the site were grouted upon completion. Borings where instrumentation was installed were fully-grouted into the hole and were finished with flush-mounted well caps. TBE-B-02, the only boring where instrumentation was not installed, was fully backfilled with cement-bentonite grout to the ground surface. The cement-bentonite grout mixture consisted of approximately 40 gallons of potable water, 94 pounds (1 bag) Type I/II Portland Cement, and 50 pounds bentonite powder (Grout-Well DF). Grout was batched in a 55-gallon drum by first mixing the water and bentonite powder using the water pump on the drill rig. The cement was then added slowly while the pump continued to agitate the mixture. Mixing continued until the grout mix achieved the desired consistency. Grout was placed from the bottom up using tremie placement methods. Table 1 provides details on the backfilling methods used at each boring location.

3.4 Soil Classification

Soil samples were logged by a GEI field engineer during the exploration activities. Soil samples obtained from the borings were observed and classified in the field in general accordance with the ASTM Visual-Manual Procedure (ASTM D2488). In addition, information on color, moisture, miscellaneous material, any unusual characteristics or observations, and possible stratum designations were also noted.

Percentages of gravel, sand, and fines are reported using descriptor terms in general accordance with Section 16.1.4 of ASTM D2488. The terminology and the percentage ranges are provided below.

- Trace – Particles present but estimated to be less than or equal to 5%
- Few – Greater than 5% but less than 15%
- Little – Greater than or equal to 15% but less than 30%
- Some – Greater than or equal to 30% but less than 50%
- Mostly – Greater than or equal to 50%

3.5 Borehole Gas Measurement

GEI field personnel recorded gas meter readings to screen for potentially hazardous atmospheric conditions for the field crews, and for potential gassy soil conditions that construction workers could encounter during drilling. The borehole was monitored for hydrogen sulfide (H2S) gas, carbon monoxide (CO), the percentage of available oxygen (O2), VOCs, and potentially combustible gases reported as a percentage of the Lower Explosive Limit (LEL). Gas monitoring was performed during drilling using a multi-gas meter. The LEL sensor was calibrated to methane gas. During the drilling a plastic tube connected to the multi-gas meter was placed just below the top of the casing or HSA and the meter recorded the gas measurements. When the LEL level was higher than the allowable range, drilling was stopped until the gas vented out and LEL level was within the allowable range.

Information on the LEL readings throughout the subsurface exploration is provided in the boring logs as well as a summary of the readings in Figure 7. H_2S, CO, and VOC readings are reported in parts per million (ppm), and O_2 and LEL readings are reported in percent (%). The alarms on the meters were set at current worker levels to assist them in stopping work if there were unsafe gas levels recorded within the breathing zone.

The methane gas venting activities created delays when drilling borings TBE-B-01, TBE-B-02, and TBW-B-02. Boring TBE-B-02 had to be terminated at El. -53 feet due to the high LEL levels that would not dissipate to acceptable levels after venting for seven (7) days. We do note that an action level of less than 10% LEL was initially used. However, due to the ongoing delays with LEL values above this limit, the team decided to increase the action level to 50% which corresponds with 2.5% by volume of methane and is half of the lower end of the explosive range of 5% by volume.

3.6 Water Level

Water levels were measured in the borings during the subsurface explorations. The water level encountered during the drilling is provided in the logs. The water level is being monitored by the installed VWPZs. The VWPZ data is presented in Appendix E and shows the recorded water level collected to date by each of the five (5) VWPZs at each boring location. A summary plot of the water readings versus depth is presented in Figure 8.

It must be noted that fluctuations in the level of the groundwater may occur due to variations in season, rainfall, temperature, tides, and other factors not evident at the time observations were made and reported herein. The monitoring wells will remain operational during the entirety of the project.

3.7 Boring Logs

The boring log is a written record of the observed subsurface conditions, drill rig response, and other observations and measurements made during drilling and sample collection and field testing. A boring log was prepared by the field engineer or geologist during the drilling activities. It includes a description of each sample collected and the soil conditions and soil strata observed at each boring. These boring logs are provided in Appendix B.

The type and depth of soil samples, sampler penetration and recovery, and SPT N-Values are included on the boring logs. Other information generally included on the boring logs include field test results, general remarks about the drilling methods and progress, observed groundwater levels, gas readings, ground surface elevations, coordinates, and drill rig and tooling information.

Soil descriptions shown on the logs are based on the field observations of the soil contained in the sampler and follow the procedure defined in ASTM D2488. There are instances where a sample or core was not recovered, or recovery was poor. When this occurred, a description was typically inferred from the material contained in the sampler (if any), drill action (e.g., ease or difficulty of drilling, rate of advancement, etc.), and the cuttings observed at the ground surface. These descriptions were noted on the logs and should be considered as only general indicators of subsurface conditions at those depths.

Relative density and consistency are reported on the boring logs for coarse- and fine-grained soils, respectively based on the published correlations shown below. These correlations were applied based on the measured N-values (N_{field}) and are noted on the descriptions in the boring logs.

Granular Soils

N-Value (N_{field})	Relative Density
0 to 4	Very Loose
4 to 10	Loose
10 to 30	Medium Dense
30 to 50	Dense
Greater than 50	Very Dense

Cohesive Soils

N-Value (N_{field})	Consistency
0 to 2	Very Soft
2 to 4	Soft
4 to 8	Medium Stiff
8 to 15	Stiff
15 to 30	Very Stiff
Greater than 30	Hard

3.8 In-situ Testing

In-situ testing was performed by In-Situ Testing, LLC and Stable Ground In-situ (SGI) under contract with the E2CR.

Eleven (11) CPTs were performed to identify strata and develop profiles. Dissipation tests were also performed at specific depths within several of the CPTs. Soil behavior type, shear strength parameters, and soil deformation parameters are estimated using the CPTs data.

Seven (7) DMTs were also performed to collect measurement of the Constrained Modulus values of the soil. Seismic DMT were also performed to determine the shear wave velocity and small strain modulus (Gs) of the soils.

All in-situ tests were advanced until refusal of the probe occurred. Refusal was encountered at elevations ranging from El. -60 ft to El -90 ft. Based on nearby borings, this appears to closely match the top of bedrock elevation.

Upon completion of the testing, the rods were pulled out of the ground. In several locations in the Tidal Basin East area we did observe gas venting from the test hole once the friction reducer was removed. This venting was observed as bubbling of the water in the hole. All in-situ test holes were either backfilled with a tremie-placed bentonite-grout mix or with bentonite chips upon completion. Table 1 provides details on the backfilling methods per location.

E2CR performed two vane shear tests in boring TBE-B-01 at depths of 57 ft and 67 ft corresponding with El. -52.1 ft and El. -62.1 ft, respectively. Undrained shear strength was estimated using a vane with 50 mm width and 100 mm long. Three additional vane shear tests were performed in Boring TBE-B-02 (BTX). These tests were performed at depths of 49 ft, 54 ft, and 55.5 ft corresponding with El. -48 ft, El. -53 ft, and El. -54.5 ft, respectively. The upper two tests were performed using the 75 mm wide vane while the lower test was performed using the

50 mm vane. It is noted that the test at 54 feet was terminated without reaching the peak strength of the soil.

Results for the CPTs, DMTs, and vane shear tests are presented in Appendix D.

4. Geotechnical Laboratory Testing

4.1 General

The objective of the geotechnical laboratory testing program was to measure the physical, mechanical, and chemical properties of soil and rock samples obtained during the field explorations. The laboratory testing program included index, strength, and consolidation. The laboratory test results, combined with the field test data collected, help to provide a basis for characterizing the observed subsurface conditions and for developing engineering parameters for use in the design and construction phases of the Project.

Table 1 below provides a summary of the type and number of tests performed.

The laboratory testing report for the samples tested by Soil and Land Use Technology, Inc. (SaLUT), and Baltimore Materials Testing (BMT) are provided in Appendix C. This report provided a brief description of the samples received, the test methods used, and the results of the tests.

Table 1 – Summary of Lab Testing Performed

Description of Test	Test Standard	Number Performed
Moisture Content	ASTM 2216	77
Grain Size – Mechanical Sieve	ASTM D422	18
Grain Size – with Hydrometer	ASTM D422	7
Atterberg Limits	ASTM D4318	22
Specific Gravity	ASTM D854	4
Organic Content	ASTM D2974	10
Direct Shear	ASTM D3080	6
UU Triaxial	ASTM D2850	4
Incremental 1-D Consolidation	ASTM D2435	5
Unconfined Compression on Rock	ASTM D7012	5

4.2 Classification and Index Testing

A brief discussion of the index testing performed is provided below. Index test results are summarized in Table 4 and the data sheets are provided in Appendix C.

4.2.1 Moisture Content

Moisture content was measured in general accordance with ASTM D2216 and was also performed in conjunction with other tests performed on cohesive soils (Atterberg limits, consolidation tests, strength tests) The results are included in Tables 4 and 5.

4.2.2 Unit Weight

Unit weight (i.e. density) testing was performed in general accordance with ASTM D7263 as a part of the consolidation and strength testing. The results of the unit weight testing are provided in Appendix C and are summarized in Tables 4 and 5 and are also included on the strength and deformation test reports.

4.2.3 Specific Gravity

Specific gravity testing was performed in general accordance with ASTM D854. The results are presented in Appendix C and summarized in Table 4.

4.2.4 Atterberg Limit Tests

Atterberg Limit testing was performed in general accordance with ASTM D4318 using the wet preparation procedure on material passing the #40 sieve. Atterberg Limit test results are presented in Appendix C and Atterberg Limit data for the samples are provided in Table 4.

4.2.5 Grain Size Analyses

Grain size analyses were performed in general accordance with ASTM D422 for sieve and hydrometer analysis. Grain size distribution curves are presented in Appendix C and summarized in Table 4. Percentages of major constituents (e.g. gravel, sand, fines) may vary slightly in what is reported in the summary tables versus what is reported on the lab data sheets due to minor variations in the interpretation and interpolation of the data by the multiple software programs used to generate the tables and data sheets.

4.2.6 Organic Content

Organic content testing was performed in general accordance with ASTM D2974. These tests were performed on samples that were visually identified as containing organics in the boring logs. We also tested samples within the depth zone where high LEL levels were measured during drilling. The organic content test results are presented in Table 4 and provided in Appendix C.

4.3 Engineering Property Testing

Testing to measure the engineering properties of soils (compressibility and shear strength) were performed on samples collected in thin-walled tubes (Shelby tubes).

4.3.1 One-Dimensional Consolidation Tests

One-dimensional incremental loading consolidation tests were performed on specimens extracted from the Shelby tubes. The consolidation tests were performed in general accordance with ASTM D2435.

Table 5 summarizes the consolidation test results, and lab data sheets are included in Appendix J.

4.3.2 Soil Strength Tests

Soil strength tests were used to measure the undrained shear strength (S_u) and effective stress strength parameters (c', φ'). Unconsolidated Undrained triaxial compression (UU) tests were performed in general accordance with ASTM D2850 to measure the undrained shear strength of the soils. The triaxial test results are presented in Table 5, and test data are included in Appendix C.

Direct shear (DS) testing was performed in general accordance with ASTM D3080 to measure the shear strength of cohesive soil under consolidated and drained conditions. DS tests were performed on both undisturbed (UD) and remolded samples. The DS results are summarized in Table 5, and test data are included in Appendix C.

4.4 Rock Testing

Unconfined compression tests were performed on intact rock core samples in general accordance with ASTM D7012. The results of these tests are summarized in Table 6, and test data are included in Appendix C.

5. Geologic Conditions

5.1 Regional Geology

The Washington, DC area is located within the Coastal Plain and Piedmont Physiographic Provinces. The boundary between these two provinces, known as the Fall Line, runs southwesterly from the District of Columbia-Montgomery County boundary near Silver Spring across the Potomac River north of Roosevelt Island. Downtown Washington, DC is predominantly located within the Coastal Plain. The Coastal Plain typically contains Pleistocene terrace deposits and recent river alluvium at the lower levels, rising into exposed Cretaceous sediments on higher ground. The Piedmont Province extends from the Hudson River near Nyack, NY to a point just North of Montgomery, Alabama. It is predominantly a rolling upland developed on intensely folded and faulted metamorphic and igneous rocks. Moving southeast from the fall line, the bedrock is overlain by increasing thicknesses of sedimentary deposits, the oldest and lowest dating from the Cretaceous period (Potomac Group Soils), followed by Quaternary deposits and recent alluvium and artificial fill. East of the shoreline is the Atlantic Continental Shelf Province, the submerged continuation of the Coastal Plain, which extends eastward for at least another 75 miles where the sediments reach a maximum thickness of about 40,000 feet. Local relief is on the order of 50 ft, with occasional greater relief near deeply cut stream valleys. Dissection is often greatest near the Fall Line. The metamorphic rocks in the Washington area include the Wissahickon Formation, the Sykesville Formation, and the Laurel Formation. The igneous rocks are more recent intrusions into the older metamorphic rocks.

5.2 Local Geology

The geologic history of the project area is characterized by successive periods of sedimentary deposition and erosion over millions of years. These processes resulted in the current configuration of the bedrock surface and the physical character and configuration of the overlying wedge of overburden soils.

The subsurface materials in this area of Washington, DC typically consist of the following layers in order with depth; recent and older fills, Late-Pleistocene and Holocene Alluvium soils, Late-Pleistocene Terrace deposits, Early-Cretaceous Potomac Group soils, overlying crystalline bedrock. In this specific project area, the majority of the Pleistocene and Cretaceous soils have been eroded away by high velocity flow of the Potomac River. As the river flow decreased over time the area was filled with river alluvial deposits. Documented filling operations were performed as early as the late 1800s and early 1900s to reclaim this area from the river.

5.3 Project Area Geology

5.3.1 Surficial Geology

Based on the available information, the Project area contains artificial fills, alluvial, and terrace soils primarily deposited during the late Pleistocene and Holocene epochs. The fill soils are manmade deposits placed during recent geologic periods.

Underlying the terrace deposits are the Potomac Group soils, which constitutes the base of the Coastal Plain in the mid-Atlantic region and extends from southern Virginia to northern New Jersey. The Potomac soils are completely eroded away and replaced with alluvial soils below East Potomac Park Island. The Potomac Group soils are Cretaceous in age (circa 66-145 million years ago), indicating a significant geologic unconformity (time gap) between the Potomac Group soils and the geologic units above it.

The Potomac Group soils are divided into several informal local members, or soil groups, based on a combination of gross lithologic and textural characteristics, clay mineralogy, sedimentary structures, and stratigraphic position. The soils in the upper Potomac Group consists primarily of silt and clay layers with minor sand layers, and the underlying soils in the lower Potomac Group consist primarily of silty/clayey sands, with minor silt and clay layers.

5.3.2 Bedrock Geology

The underlying bedrock is part of the Mid-Atlantic Piedmont province, which occupies the area between the Blue Ridge Mountains and the Atlantic Coastal Plain. The bedrock in the area formed about 450 to 550 million years ago in a volcanic arc associated with the Taconic subduction zone. The oldest bedrock was probably deposited in or near a submarine trench before being metamorphosed, folded, and intruded by several phases of plutonic rocks.

The bedrock in the Project area is generally early Paleozoic crystalline schist and gneiss bedrock of the Chopawamsic Formation. The top of bedrock encountered during the geotechnical exploration was encountered between Elevations (El.) -60 ft and El. -90 ft.

5.4 Local Soils

General descriptions of the main soil strata in the project area are provided below, based on the available geotechnical data, the surficial geology maps, and the observations from the completed explorations. From the top down (i.e. youngest to oldest deposits) the major soil strata are:

- Fill
- Alluvial Deposits
- Decomposed Rock
- Bedrock

Subsurface profiles have been prepared for the Tidal Basin East and West walls and are presented in Figures 5 and 6, respectively.

5.4.1 Fill

In recent history, many areas around the site have been filled or re-graded to increase the amount of available land for development. Fill was placed using hydraulic placement and mechanical dumping over the past 120 plus years. Older Fill materials are assumed to have been generated from dredging of the river alluvial materials. Given this, the contact between man placed Fill and the underlying alluvium can be difficult to identify.

The Fill materials were identified to consist of clay and silt with varying amounts of sand and gravel, and sand with varying amounts of silt, clay and gravel.

5.4.2 Alluvium

Quaternary-age Alluvium was deposited within the current Potomac River valley and its tributaries incised into the pre-existing Coastal Plain sediments. The Alluvium generally consists of interbedded deposits of clay, silt, sand, and gravel with varying amounts of organic materials, including peat and wood fragments. The Alluvium was deposited by rivers and tributary streams within channels, bars, flood plains, terraces, estuaries, and alluvial fans. It is generally characterized by cross-bedding, rapid pinching and thickening of beds, and lateral and vertical particle-sized grading.

Fine-grained soils are deposited during low energy river flows while coarse-grained soils are deposited during high velocity river flow events. Seasonal and storm-based river flows will result in interbedded layering of these coarse and fine soils.

The results of the field investigation in the Tidal Basin indicate that the Alluvial soils can be subdivided into three layers, the upper loose sandy soils, the middle very soft fine-grained soils, and the lower stiffer fine-grained soils.

5.4.3 Decomposed Rock

The decomposed rock layer was identified based on high SPT N-values, high tip resistance in the CPTs, and refusal of the DMTs. The decomposed rock was found in most of the borings between the alluvial soils and the competent bedrock. In some locations, the CPTs were able to advance several feet but indicated very high tip resistance and eventually reached refusal either in this layer or on the top of bedrock. The DMTs appeared to refuse at the top of this layer. The soils within this layer were identified as a mix of fine- and coarse-grained soils with varying amounts of decomposed gravel rock fragments.

5.4.4 Bedrock

The bedrock was encountered between El. -60 ft and El. -95 ft with the shallowest location being on the northern end of the Tidal Basin West near the Japanese Pagoda. The bedrock was identified as a coarse-grained metamorphic Schist. The percentage recovered in the rock coring was found to range from 80% to 100%. The Rock Quality Designation (RQD) is a measure to indicate the quality of the rock based on a summation of the solid intact cores recovered that are greater than 4 inches in length. The RQD values measured were found to range between 25% and 100%.

6. Geotechnical Instrumentation

Inclinometers (INC), vibrating-wire piezometers (VWPZ), and a multiple position borehole extensometer (MPBX) were installed in boreholes to measure lateral and vertical soil deformations and groundwater levels. Table 3 provides a summary of the installation information and the groundwater levels for the VWPZ. Appendix E contains installation logs and the data collected from these instruments to date.

INCs and five (5) multi-level VWPZs were installed and fully-grouted in borings TBE-B-01, TBW-B-01, and TBW-B-02 with approximate tip elevations of El. -105 ft, El. -92.5 ft, and El. -91 ft, respectively. A five anchor MPBX was installed in Boring TBE-B-02 (BTX) with an approximate tip elevation of El. -94 feet. The location of the extensometer was changed after having a high methane gas level in its original planned location of TBE-B-02.

6.1 Inclinometer and Vibrating Wire Piezometers

Borings TBW-B-01, TBW-B-02, and TBE-B-01 were finished off by installing five (5) vibrating wire piezometers (VWPZ) co-located with an inclinometer (INC) that were all fully-grouted. The VWPZs were factory calibrated and checked in the field prior to installation in general accordance with the manufacturer's instructions before they were installed.

6.1.1 VWPZ Calibration and Initial Zero Reading

Each VWPZ was provided with an individual calibration report from the manufacturer. Field calibrations were therefore not performed. A device-specific linear gage factor (G) (psi/digit) and a thermal factor (K) (psi/°C) was provided with the manufacturer's calibration.

An initial zero reading was established for each device prior to installation. This was achieved by saturating the filter stone to remove air bubbles from the sensing chamber. The device was submerged in a bucket of water until the temperature of the device stabilized with the surrounding water temperature. The instrument was plugged into the readout device and was lifted just above the surface of the water after the temperature had stabilized. A set of readings were taken at this position and the average was considered the initial zero reading. This reading was represented as a digit (R_0) and its corresponding temperature (T_0).

The initial zero reading was used as a baseline value to compare with the pressure reported by the instrument while submerged.

6.1.2 VWPZ and INC Installation

The INC casing was placed on the ground and the VWPZs were fastened to the casing at the appropriate locations. A service loop was added to the cable near the sensor location to provide slack and reduce stress on the cable connection to the VWPZ. The casing and the attached instruments were then assembled while being lowered into the borehole to the specified depth with the grooves on the inclinometer casing pointed perpendicular to the water. The VWPZs were read and checked prior to grouting. Once checked, the borehole was tremie grouted with cement-bentonite grout.

6.1.3 VWPZ Data Collection

Data from the VWPZ was collected in the field using a data logger (Worldsensing LS-G6-VW). The VWPZ data was recorded once per hour. Data collected from the data logger was sent to a central gateway using RF radios where it is packaged and sent using a cellular modem to the monitoring server.

6.1.4 VWPZ Data Reporting

Similar to the initial zero reading, each data point collected from a VWPZ was represented by a digit (R_1) and a temperature (T_1). The water pressure was calculated by multiplying the difference between the measurement and the Initial Zero Reading by its calibrated gage factor (G) and thermal factor (K) and summing the two results.

The water level was computed by first translating the calculated pressure into a height of water above the VWPZ. This was done by dividing the calculated pressure (force/area) by the unit weight of water (force/volume). The resulting distance was then added to the known elevation of the VWPZ to calculate the corresponding water level.

Plots of the VWPZ data to date are included in Appendix E. A summary of the current water pressures versus elevation for each borehole is presented in Figure 8.

6.1.5 INC Initial Baseline Reading

Each INC was read two times using a Digitlt AT Inclinometer system (DGSI) a minimum of one week after grouting. Readings were taken where the A0 was set as the grooves closest to perpendicular with the water. The probe was lowered to the bottom elevation in the A0 direction then 2-foot intervals were recorded using the cable gate as reference, after completing a reading in the A0 direction, the readings were repeated in the A180 direction. The sum of the two readings were checked to ensure repeatability. The average of these two readings is used as the baseline reading in which subsequent readings are compared.

6.1.6 INC Data Collection

Data from the INC was collected in the field using a Digitilt AT (DGSI) in the same method as in the baseline once every two weeks. The data collected from INC was sent to the monitoring server for data reduction.

6.1.7 INC Data Reporting

Each data point collected at two-foot intervals is reported in inches. The displacement was calculated by multiplying the difference between the measurement and the Initial Reading added by the displacement from an initial bottom reading which is assumed to be fixed. Plots of the INC data to date are included in Appendix E.

6.2 Multiple Position Borehole Extensometer

A multiple position borehole extensometer (MPBX) consisting of five rebar anchors and stainless-steel extension rods encased in protective PVC sleeves were installed and fully-grouted in the boring at separate elevations. After fully grouting the anchors, the transducer head was installed and baselined. MPBX transducers were factory calibrated and checked in the field prior to installation in general accordance with the manufacturer’s instructions before they were installed onto the extension rods.

6.2.1 MPBX Calibration and Initial Zero Reading

Each MPBX transducer was provided with an individual calibration report from the manufacturer. Field calibrations were therefore not performed. A device-specific linear gage factor (G) (in/digit) was provided with the manufacturer’s calibration.

The MPBX transducers were threaded onto the extension rods, then the transducer head was bolted onto the tube mount. Each transducer was locked off at an approximate half stroke range to allow for 2 inches of settlement and 2 inches of heave.

An initial zero reading was established for each transducer as an average of initial readings taken after the transducers were locked in place. This reading was represented as a digit (R_0).

6.2.2 MPBX Installation

The MPBX stainless steel rods, and protective PVC sleeves were laid out on the ground. The rods and PVC were connected to reflect the appropriate elevations of El. -19 ft, El. -39 ft, El. -59 ft, El. -79 ft, and El. -99 ft. The rods were attached with internal threads while the PVC was attached with PVC couplers with telescoping members. The rebar anchors were attached to the bottom end of the rods and the top end of the rods were attached to the tube mount using sacrificial rod extensions and compression fittings. A rope loop was added to the tube mount to suspend the MPBX at the correct depth in the road box to accommodate the transducer head. The MPBX anchors and the attached rods were then lowered into the borehole to the specified depth and the borehole was tremie grouted with cement-bentonite grout.

6.2.3 MPBX Data Collection

Data from the MPBX was collected in the field using a data logger (Worldsensing LS-G6-VW). The MPBX data was recorded once per hour. Data collected from the data logger was sent to a central gateway using RF radios where it packaged and sent using a cellular modem to the monitoring server.

6.2.4 MPBX Data Reporting

Similar to the initial zero reading, each data point collected from a VWPZ was represented by a digit (R_1). The displacement of the transducer head is calculated by assuming the bottom anchor in rock is fixed. This is calculated by multiplying the difference between the measurement and the initial zero reading by its calibrated gage factor (G) and summing the two results.

The displacement of the remaining anchors is computed by first calculating the displacement of the anchor relative to the transducer head and adding that to the displacement of the ground surface. Plots of the MPBX data to date are included in Appendix E.

6.2.5 MPBX Data Limitations

Anchor 1 set at 20 feet was not able to be read due to damage to the anchor during installation. Therefore, data for Anchor 1 is omitted from the data presented. The transducer for Anchor 5 set at 100 feet was found to have fully compressed on September 28, 2022, and was subsequently reset on November 9, 2022. From the time Anchor 5 was fully compressed until it was reset, ground surface displacement was calculated assuming the Anchor 4 set at depth of 80 feet was fixed.

In addition, the transducer for Anchor 2 set at a depth of 80 feet was also fully compressed on October 20, 2022, and was reset on November 9, 2022. As a result, no readings were collected during this time.

6.3 Surface Protection

All instrumentation were installed in borings that were finished with a flush-mount cover consisting of a 12"-diameter roadbox set in an approximately 6-inch-thick concrete collar flush with the existing ground surface.

7. References

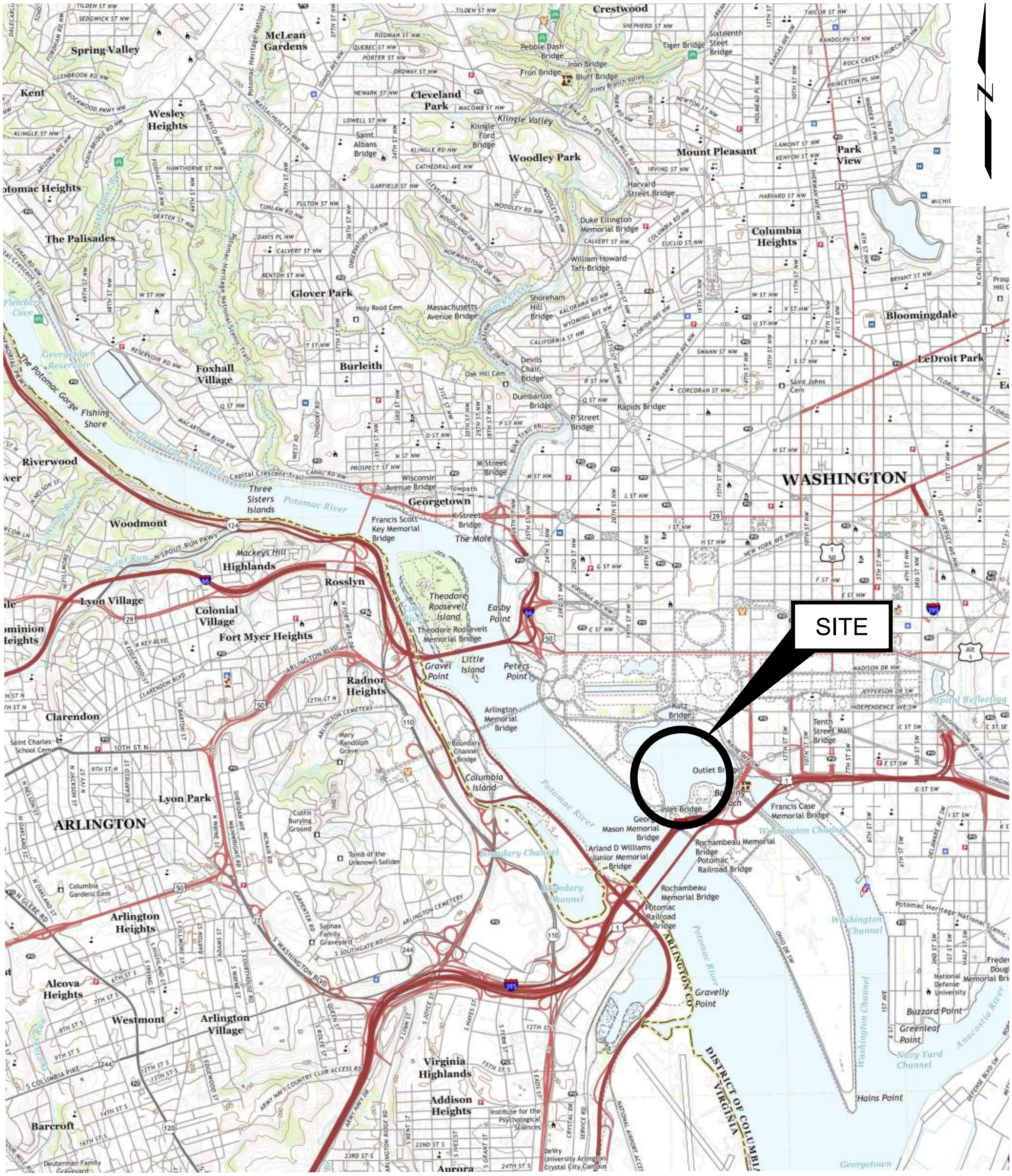
ASTM International (Most recent edition)

- D422*, Standard Test Method for Particle-Size Analysis of Soils.*
- D854, *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer.*
- D1586, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.*
- D1587, *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*.
- D2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.*
- D2435, *Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading*
- D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*
- D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*
- D2974, *Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils*
- ASTM D2850, *Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils*
- D3080/D3080M-11*, Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.*
- D4318, *Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*
- D7012, *Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures*
- D6151, *Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling.*

Casagrande, A., "The Determination of the Pre-Consolidation Load and Its Practical Significance," *Proceedings of the 1st International Conference on Soil Mechanics*, Harvard, Vol. 3, 1936.

Gomez, Jesus E., et. al., "A Unique Solution to Mitigate Movement at the Jefferson Memorial Seawall," *Deep Foundations Institute*, 2011.

FIGURES



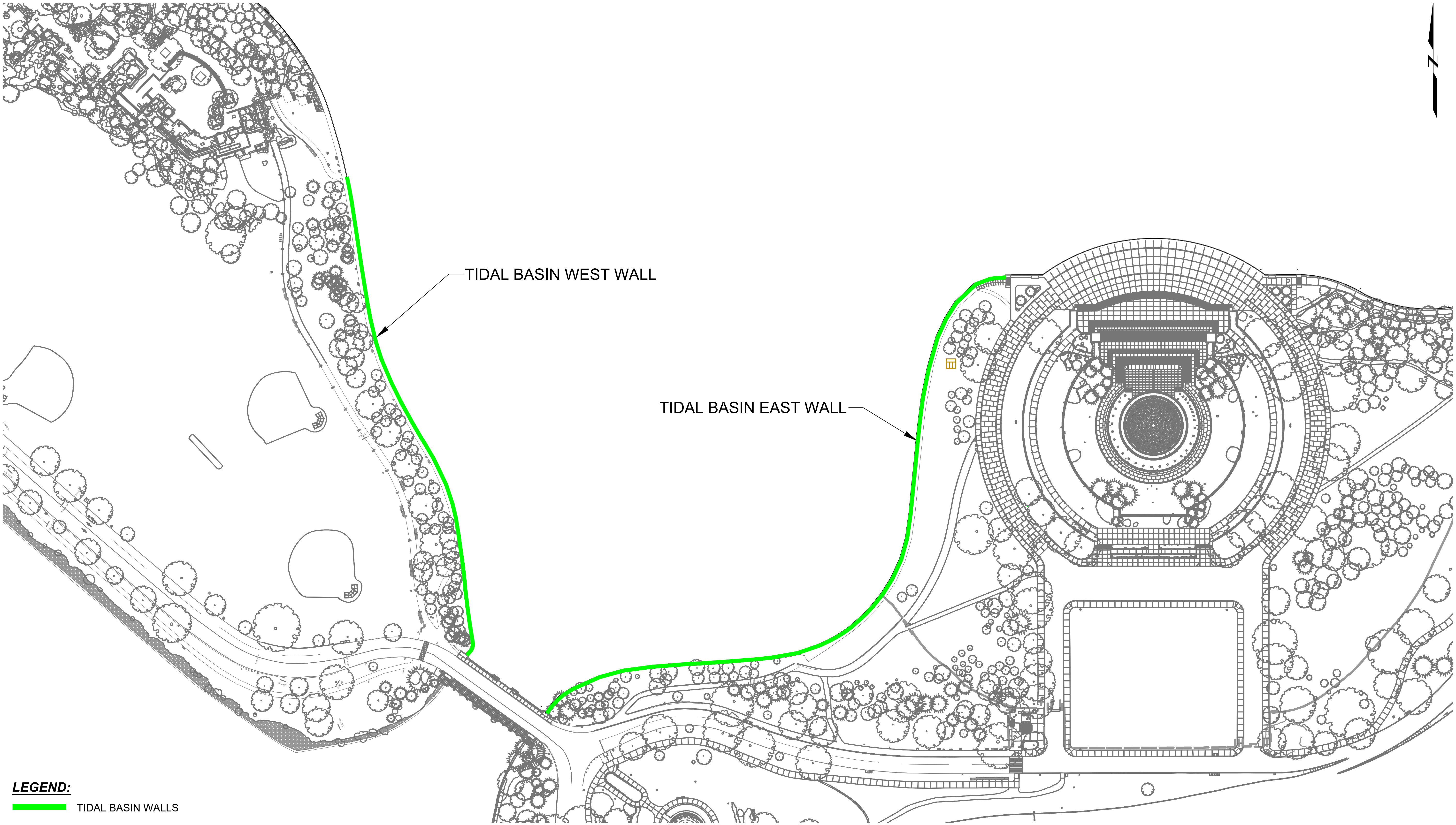
0 2000' 4000' 8000'

SCALE: 1" = 4000'

SOURCE:

1. MAP TAKEN FROM USGS.GOV, NOVEMBER 2022.

National Parks Service National Capital Seawalls Washington, DC	GEI Consultants	SITE VICINITY MAP
HDR/M&N Denver, CO	Project 2201647	January 2023 Fig. 1



LEGEND:

TIDAL BASIN WALLS

NOTES:

1. ACTUAL WALL LIMITS ARE APPROXIMATE.

SOURCE:

1. PLAN BASED ON GEOTECHNICAL BORING PLAN DRAWINGS DOWNLOADED FROM THE HDR PROJECTWISE SITE ON NOVEMBER, 11, 2022.

0 150' 300'

SCALE: 1" = 150'

National Parks Service
National Capital Seawalls
Washington, DC

HDR/M&N
Denver, CO

GEI Consultants

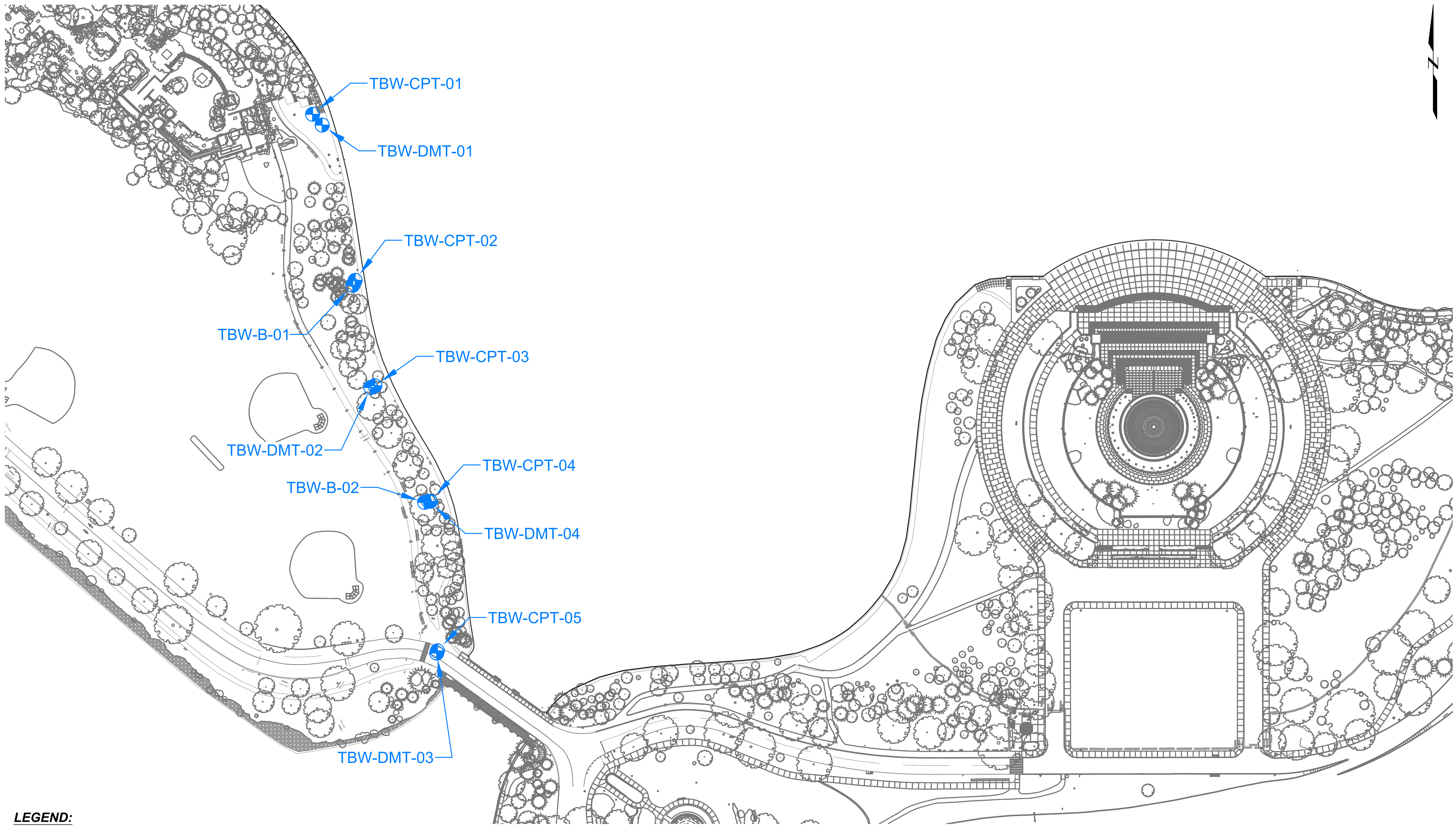
Project 2201647

WALL LOCATION MAP

January 2023

Fig. 2

MORTON, TIMOTHY \\geiconsultants.com\Data\Data_Storage\Working\NATIONAL PARK SERVICE\2201647 National Capital Area Seawall\00_CAD\Figures\Figs 2-4_Seawall + Boring Location Plans.dwg - 1/5/2023



LEGEND:

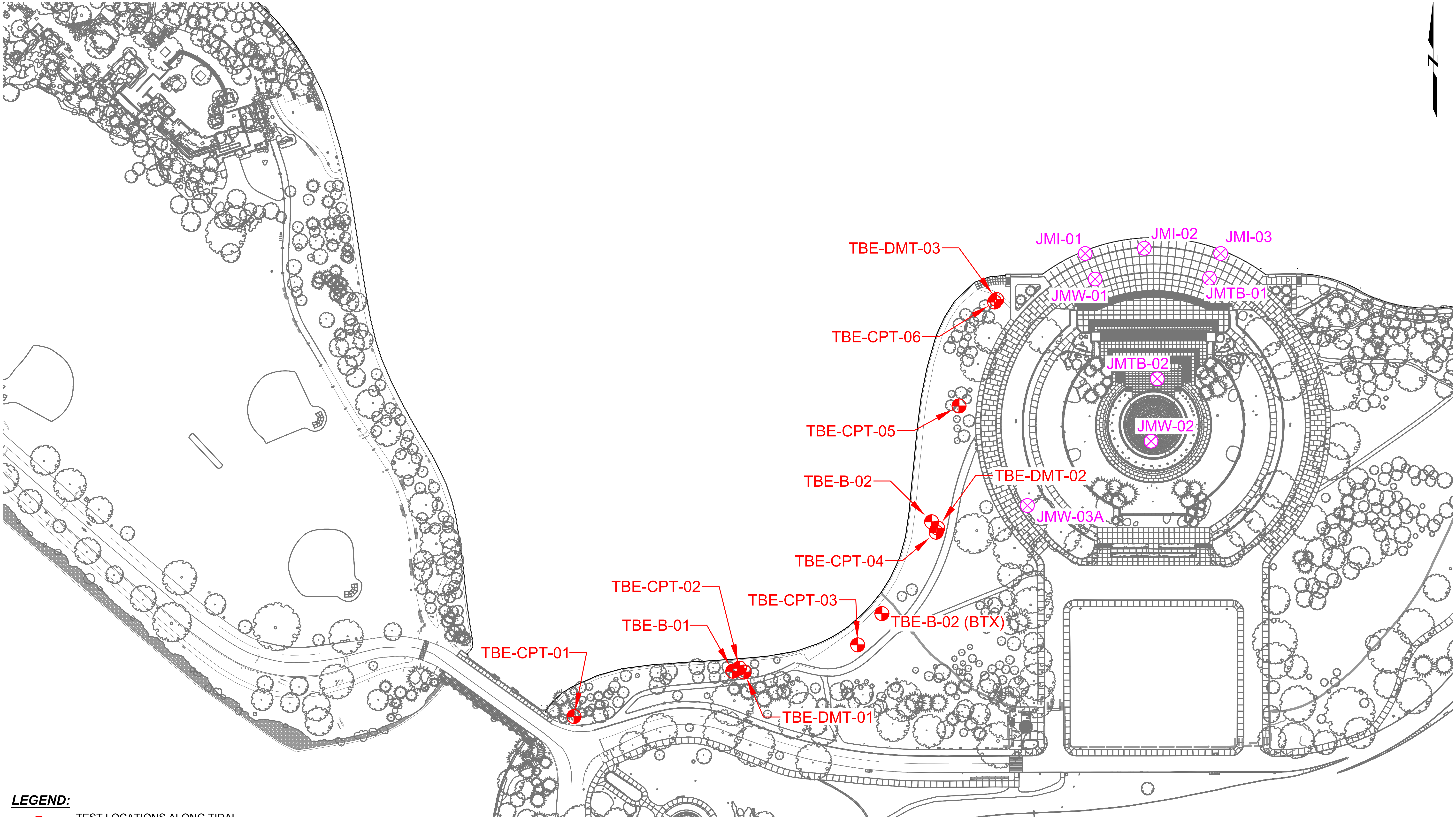
TEST LOCATIONS ALONG TIDAL BASIN WEST WALL

SOURCE:

1. PLAN BASED ON GEOTECHNICAL BORING PLAN DRAWINGS DOWNLOADED FROM THE HDR PROJECTWISE SITE ON NOVEMBER, 11, 2022.

National Parks Service National Capital Seawalls Washington, DC	GEI Consultants	TIDAL BASIN WEST TEST LOCATION PLAN
HDR/M&N Denver, CO	Project 2201647	January 2023 Fig. 3

MORTON, TIMOTHY \\geiconsultants.com\Data\Data_Storage\Working\NATIONAL PARK SERVICE\2201647 National Capital Area Seawall\00_CAD\Figures\Figs 2-4_Seawall + Boring Location Plans.dwg - 1/5/2023



LEGEND:

TEST LOCATIONS ALONG TIDAL BASIN EAST WALL

HISTORICAL BORING LOCATIONS

SOURCE:

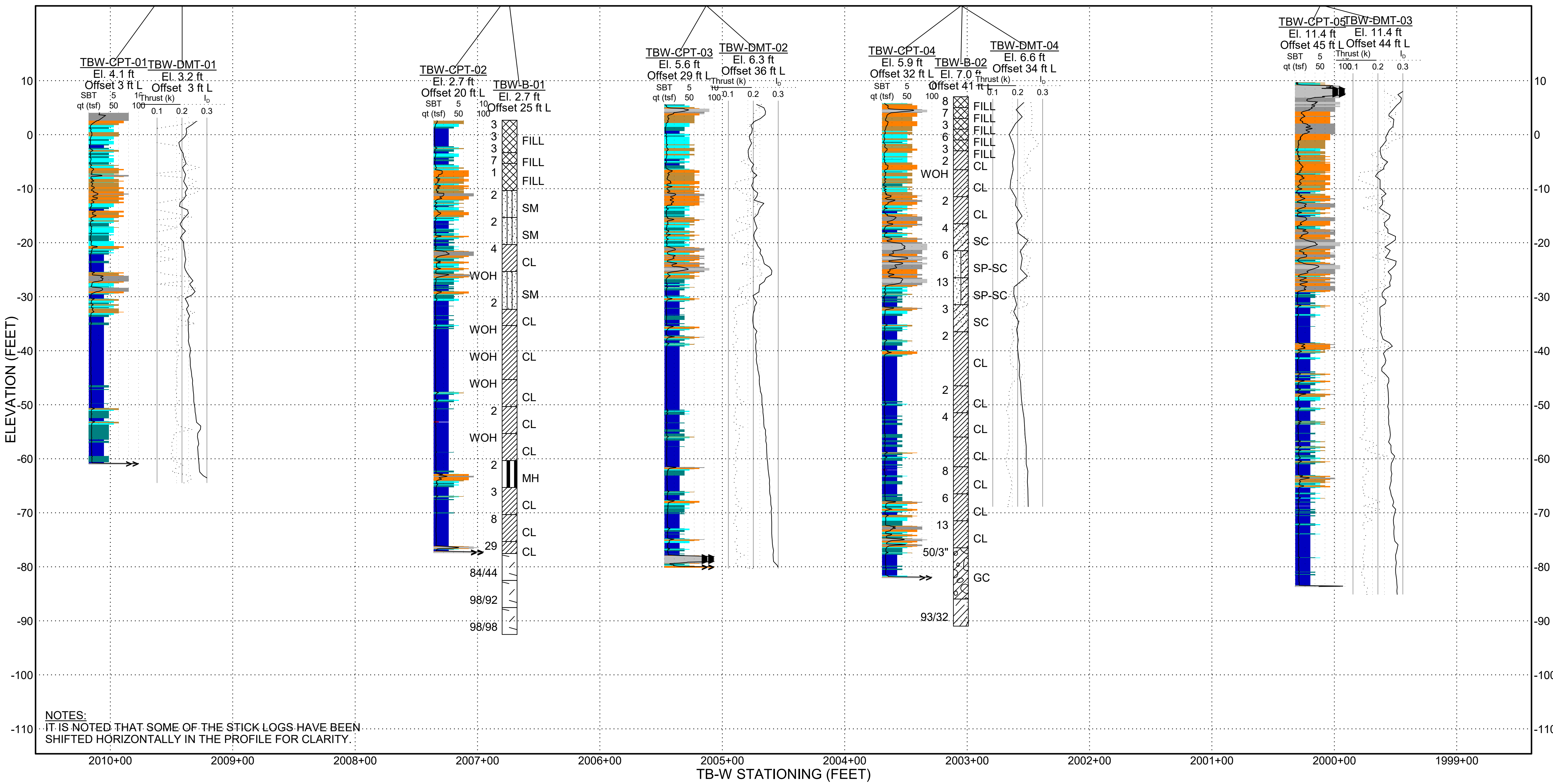
1. PLAN BASED ON GEOTECHNICAL BORING PLAN DRAWINGS DOWNLOADED FROM THE HDR PROJECTWISE SITE ON NOVEMBER, 11, 2022.

0 150' 300'

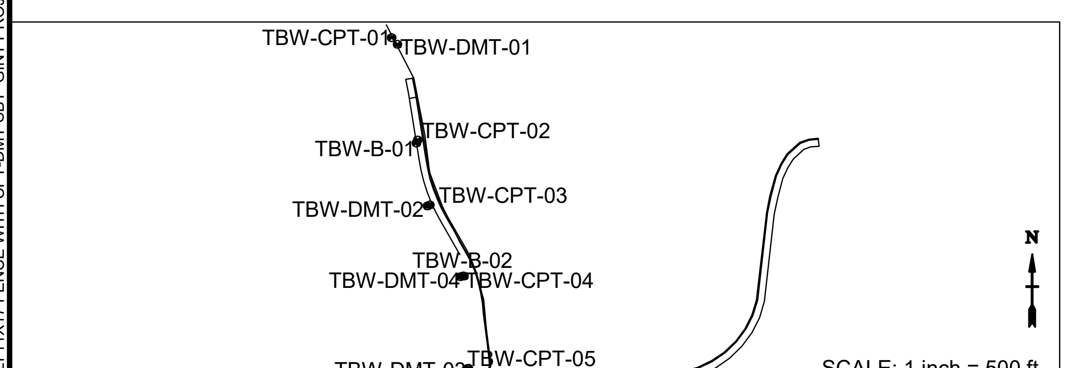
SCALE: 1" = 150'

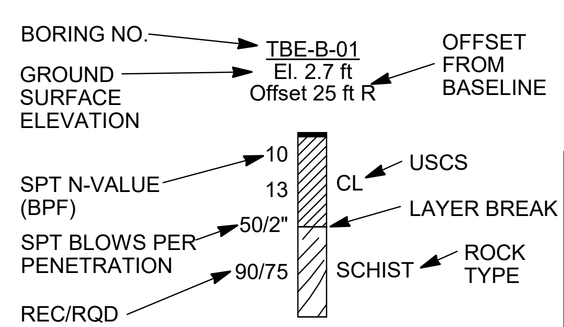
National Parks Service National Capital Seawalls Washington, DC	GEI Consultants	TIDAL BASIN EAST TEST LOCATION PLAN
HDR/M&N Denver, CO	Project 2201647	January 2023 Fig. 4

MORTON, TIMOTHY \\geiconsultants.com\Data\Data_Storage\Working\NATIONAL PARK SERVICE\2201647 National Capital Area Seawall\00_CAD\Figures\Figs 2-4_Seawall + Boring Location Plans.dwg - 1/5/2023



NOTES:
IT IS NOTED THAT SOME OF THE STICK LOGS HAVE BEEN SHIFTED HORIZONTALLY IN THE PROFILE FOR CLARITY.





DRAWING IS SHOWN WITH A 4.5x VERTICAL EXAGERATION

0 18 37
APPROXIMATE VERTICAL SCALE: 1 inch = 18 ft

0 81 163
APPROXIMATE HORIZONTAL SCALE: 1 inch = 81 ft

NATIONAL PARK SERVICE
NATIONAL CAPITAL SEAWALLS

HDR/M&N
DENVER, CO

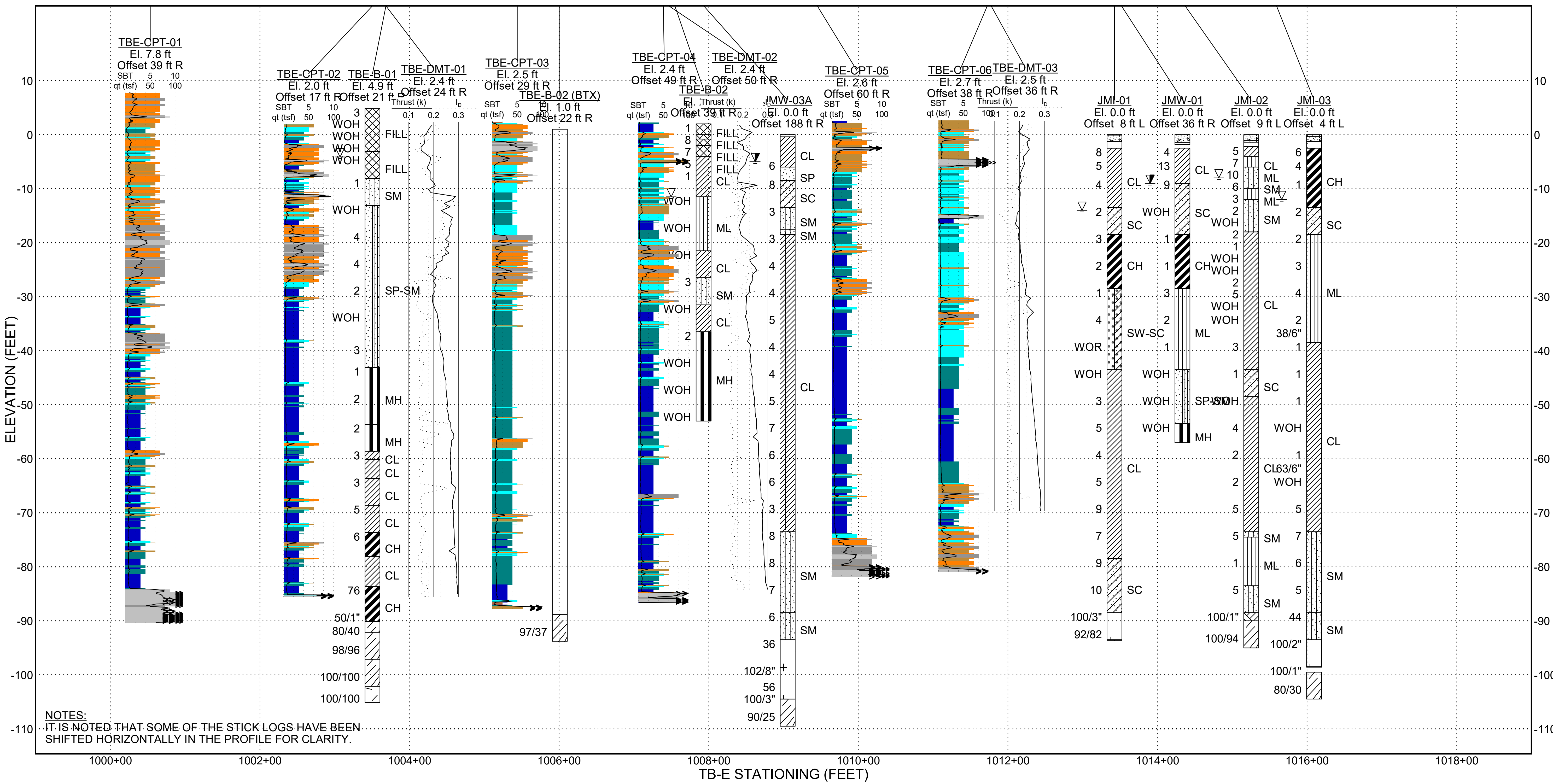
GEI Consultants

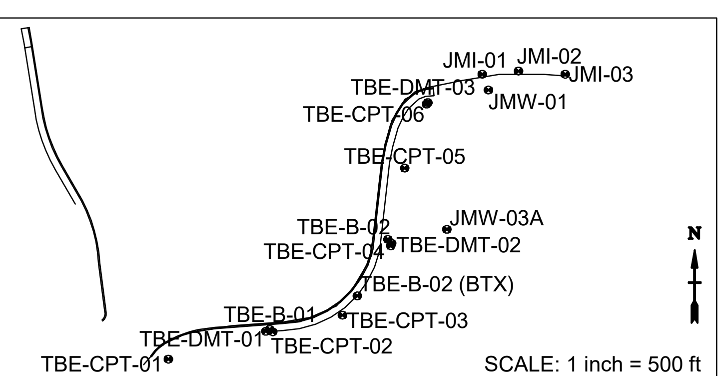
TIDAL BASIN WEST CROSS-SECTION

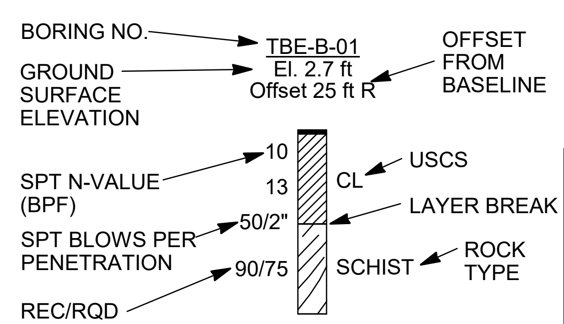
Project: 2201647 | January 2023 | Fig. 5

Proj. No.-2201647 PDL 11/09/2022

GEI 11X17 FENCE WITH CPT-DMT SBT GINT PROJECT SAC1V-ELOGGING: GINT PROJECT 11/9/22







DRAWING IS SHOWN WITH A 7x VERTICAL EXAGERATION

APPROXIMATE VERTICAL SCALE: 1 inch = 18 ft (0, 18, 37)

APPROXIMATE HORIZONTAL SCALE: 1 inch = 133 ft (0, 133, 267)

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Project: 2201647

TIDAL BASIN EAST CROSS-SECTION

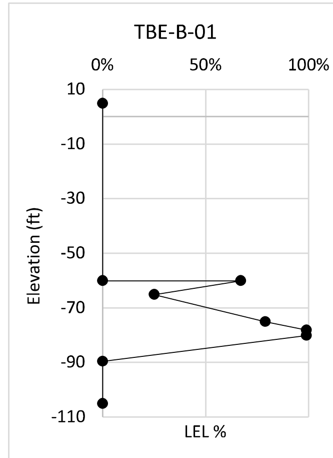
January 2023

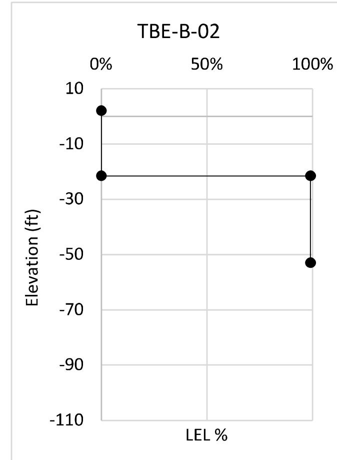
Fig. 6

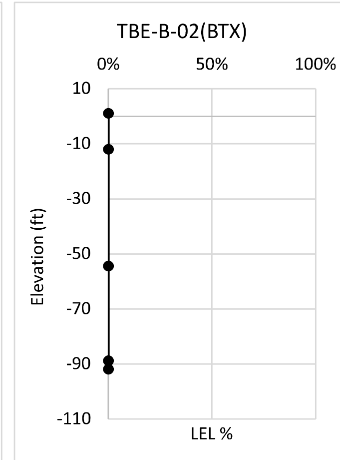
Proj. No.-2201647 PDL 11/09/2022

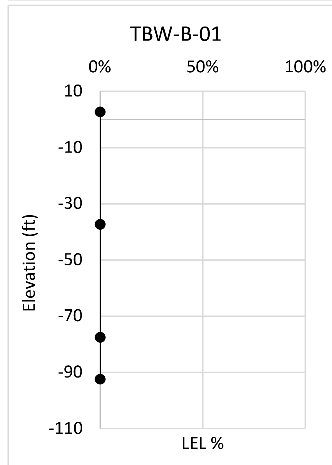
NPS - National Park Service
Project #: 2201647

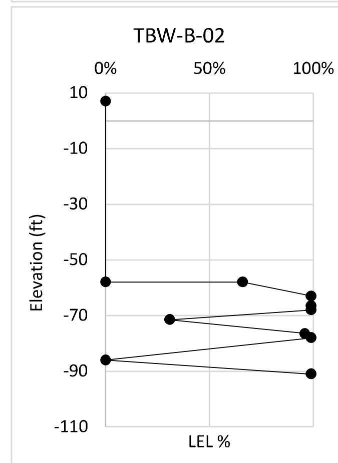
Boring ID	Recorded Date	Depth (ft)	Elevation (ft)	Measured LEL	Note
TBE-B-01	7/11/2022	0.0	4.9	0%	
	7/13/2022	65.0	-60.1	0%	
	7/13/2022	65.0	-60.1	67%	
	7/21/2022	70.0	-65.1	25%	
	7/22/2022	80.0	-75.1	79%	
	7/25/2022	83.0	-78.1	99%	
	7/25/2022	85.0	-80.1	99%	
	7/25/2022	94.5	-89.6	0%	**Bedrock**
	7/26/2022	110.0	-105.1	0%	
TBE-B-02	7/13/2022	0.0	2.0	0%	
	7/13/2022	23.5	-21.5	0%	
	7/13/2022	23.5	-21.5	99%	
	7/13 thru 7/19	55.0	-53.0	99%	**Abandon**
TBE-B-02(BTX)	8/24/2022	0	1	0%	
	8/24/2022	13	-12	0%	
	8/25/2022	55.5	-54.5	0%	
	8/29/2022	89.83	-88.83	0%	**Bedrock**
	8/31/2022	93	-92	0%	
TBW-B-01	8/17/2022	0.0	2.7	0%	
	8/17/2022	40.0	-37.3	0%	
	8/18/2022	80.2	-77.5	0%	**Bedrock**
	8/19/2022	95.2	-92.5	0%	
TBW-B-02	7/22/2022	0.0	7.0	0%	
	7/22/2022	65.0	-58.0	0%	
	7/22/2022	65.0	-58.0	66%	
	7/27/2022	70.0	-63.0	99%	
	8/1/2022	73.5	-66.5	99%	
	8/1/2022	75.0	-68.0	99%	
	8/1/2022	78.5	-71.5	31%	
	8/1/2022	83.5	-76.5	96%	
	8/2/2022	85.0	-78.0	99%	
	8/2/2022	93.0	-86.0	0%	**Bedrock**
	8/3/2022	98.0	-91.0	99%	











Notes:
Drilling was stopped when LEL levels exceeded action levels until values reduced to safe levels.

NATIONAL PARK SERVICE
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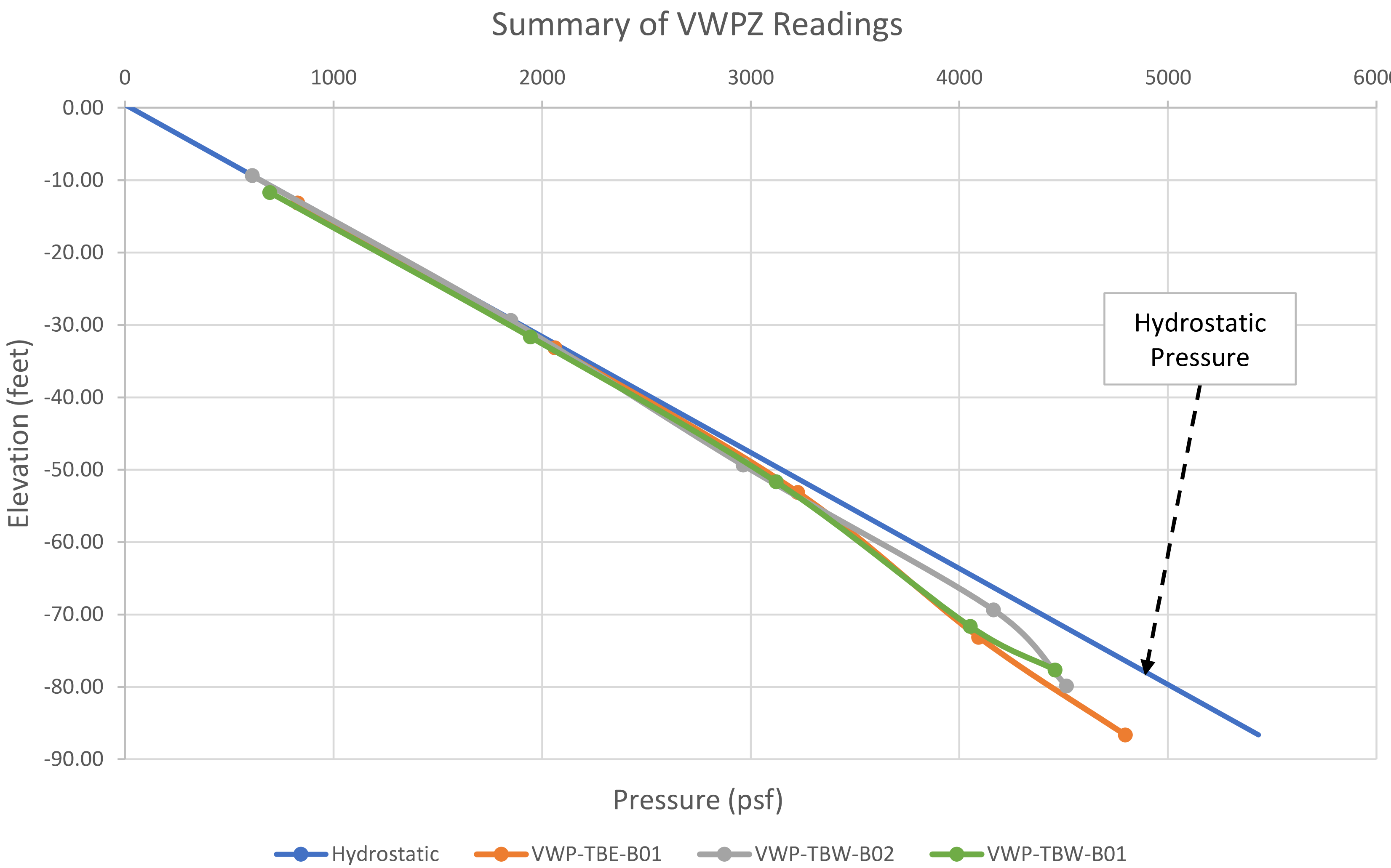
PROJECT: 2201647

SUMMARY OF LEL READINGS

January 2023 Figure 7



NATIONAL PARK SERVICE NATIONAL CAPITAL SEAWALLS	GEI Consultants	SUMMARY OF VWPZ READINGS
HDR/M&N DENVER, CO	PROJECT: 2201647	January 2023 Figure 8

TABLES

Table 1. BORING SUMMARY

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Test No.	Date Completed	Drilling Method	Max Depth (feet)	Ground Surface Elevation (feet, NAVD88)	Northing (feet, NAD83)	Easting (feet, NAD83)	Latitiude (deg, NAD83)	Longitude (deg, NAD83)	Station (feet)	Offset Distance and Direction (ft, L/R)	Instrumentation	Other Tests	Notes
TBE-B-01	7/26/2022	HSA/NX	110.0	4.88	441986.92	1301253.04	38.880288	-77.038923	1003+22.21	19.17, R	INC w/ 5 VWPZ	Vane Shear	Tremie placed bentonite grout
TBE-B-02	7/19/2022	HSA	55.0	2.00	442227.28	1301572.91	38.880949	-77.037800	1007+24.49	38.19, R	--	--	Tremie placed bentonite grout
TBE-B-02 (BTX)	8/31/2022	HSA/NX	94.8	1.00	442079.53	1301492.82	38.880543	-77.038081	1005+69.19	36.40, R	MPBX	Vane Shear	Tremie placed bentonite grout
TBE-CPT-01	6/15/2022	CPT	98.2	7.81	441913.96	1300997.58	38.880088	-77.039820	1000+28.58	40.99, R	--	Dissipation	Bentonite chips
TBE-CPT-02	6/16/2022	CPT	87.5	1.97	441991.83	1301263.63	38.880302	-77.038886	1003+33.16	15.13, R	--	--	Bentonite chips
TBE-CPT-03	6/20/2022	CPT	90.2	2.48	442029.16	1301453.86	38.880405	-77.038218	1005+14.30	32.79, R	--	--	Bentonite chips
TBE-CPT-04	6/24/2022	CPT	89.0	2.35	442210.47	1301580.27	38.880903	-77.037774	1007+08.88	47.86, R	--	Dissipation	Bentonite chips
TBE-CPT-05	6/29/2022	CPT	84.4	2.56	442413.73	1301616.98	38.881461	-77.037645	1009+15.43	62.12, R	--	--	Tremie placed bentonite grout
TBE-CPT-06	6/30/2022	CPT	83.6	2.73	442581.15	1301674.22	38.881921	-77.037445	1011+49.32	40.92, R	--	--	Bentonite chips
TBE-DMT-01	6/17/2022	DMT	87.9	2.35	441985.54	1301270.96	38.880285	-77.038860	1003+39.96	21.99, R	--	--	Bentonite chips
TBE-DMT-02	6/2/2022	DMT	86.6	2.44	442217.15	1301582.67	38.880921	-77.037766	1007+15.80	49.28, R	--	--	Tremie placed bentonite grout
TBE-DMT-03	6/30/2022	DMT	72.2	2.53	442585.01	1301677.63	38.881931	-77.037433	1011+64.04	37.52, R	--	Seismic	Bentonite chips
TBW-B-01	8/23/2022	HSA/NX	95.2	2.67	442611.54	1300639.59	38.882003	-77.041079	2006+71.79	22.80, L	INC w/ 5 VWPZ	--	Tremie placed bentonite grout
TBW-B-02	8/3/2022	HSA/NX	98.0	7.02	442261.94	1300755.19	38.881043	-77.040672	2002+67.94	43.06, L	INC w/ 5 VWPZ	--	Tremie placed bentonite grout
TBW-CPT-01	7/1/2022	CPT	65.1	4.14	442887.01	1300574.83	38.882759	-77.041307	2009+24.25	28.02, L	--	--	Bentonite chips
TBW-CPT-02	7/7/2022	CPT	80.1	2.66	442619.43	1300643.28	38.882024	-77.041066	2006+43.90	15.38, L	--	Dissipation	Bentonite chips
TBW-CPT-03	7/11/2022	CPT	85.7	5.63	442449.67	1300675.01	38.881558	-77.040954	2004+76.50	27.57, L	--	--	Bentonite chips
TBW-CPT-04	7/11/2022	CPT	87.9	5.89	442263.54	1300764.49	38.881047	-77.040640	2002+66.52	33.73, L	--	--	Bentonite chips
TBW-CPT-05	7/1/2022	CPT	95.0	11.38	442022.48	1300775.80	38.880385	-77.040600	2000+06.72	55.18, L	--	--	Bentonite chips and aquaphalt patch
TBW-DMT-01	7/5/2022	DMT	67.6	3.15	442869.60	1300590.14	38.882711	-77.041253	2009+03.21	18.44, L	--	Seismic	Bentonite chips
TBW-DMT-02	7/13/2022	DMT	86.6	6.29	442446.90	1300668.51	38.881551	-77.040977	2004+76.51	34.63, L	--	--	Bentonite chips
TBW-DMT-03	6/28/2022	DMT	96.5	11.35	442019.08	1300774.84	38.880376	-77.040603	2000+10.98	56.55, L	--	--	Bentonite chips and aquaphalt patch
TBW-DMT-04	7/13/2022	DMT	75.5	6.63	442263.54	1300761.77	38.881047	-77.040649	2002+66.42	33.46, L	--	Seismic	Bentonite chips

General Notes:

TBE - Tidal Basin East
TBW - Tidal Basin West
HSA - Hollow Stem Auger
NX - Rock Coring
CPT - Cone Penetration Test
DMT - Dilatometer Test
NAD83 - North American Datum of 1983
NAVD88 - North American Vertical Datum of 1988
INC - Inclinometer
MPBX - Multi-Position Borehole Extensometer
VWPZ - Vibrating Wire Piezometer

Table 2. TUBE SAMPLE FILED DATA

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Test No.	Sample No.	Depth to Top of Sample (feet)	Penetration (inch)	Recovery (inch)
TBE-B-01	U-01	65.0	24	24
	U-02	75.0	24	0
	U-03	83.0	24	19
TBW-B-01	U-01	35.0	24	24
	U-02	55.0	24	24
TBW-B-02	U-01	43.0	24	0
	U-02	48.0	24	22
	U-03	63.0	24	24

General Notes:
TBE - Tidal Basin East
TBW - Tidal Basin West

Table 3. VWPZ INSTALLATION AND GROUNDWATER LEVELS

Geotechnical Data Report
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Boring No.	Instrument ID	Instrument Type	Sensing Elevation (feet)	Minimum GW El. (feet)	Maximum GW El. (feet)	Average GW El. (feet)	Average GW Head (ft)	Average GW Pressure (psf)
VWP-TBE-B01	VWP-TBE-B01-A	VWPZ	-13.1	-0.3	2.2	0.9	14.0	874
	VWP-TBE-B01-B	VWPZ	-33.1	-0.3	1.1	0.5	33.6	2097
	VWP-TBE-B01-C	VWPZ	-53.1	-2.3	-0.7	-1.8	51.4	3205
	VWP-TBE-B01-D	VWPZ	-73.1	-3.1	-2.4	-2.7	70.4	4394
	VWP-TBE-B01-E	VWPZ	-86.6	-7.5	-6.2	-6.9	79.7	4975
VWP-TBW-B01	VWP-TBW-B01-A	VWPZ	-7.6	-0.9	1.8	0.5	8.1	503
	VWP-TBW-B01-B	VWPZ	-27.6	-0.2	0.5	0.1	27.7	1726
	VWP-TBW-B01-C	VWPZ	-47.6	-1.6	-0.7	-1.2	46.3	2891
	VWP-TBW-B01-D	VWPZ	-67.6	-7.5	-6.9	-7.3	60.3	3763
	VWP-TBW-B01-E	VWPZ	-73.6	-9.8	-9.2	-9.5	64.1	3998
VWP-TBW-B02	VWP-TBW-B02-A	VWPZ	-9.5	-1.0	0.6	-0.2	9.3	580
	VWP-TBW-B02-B	VWPZ	-36.5	-0.7	0.6	-0.2	36.3	2266
	VWP-TBW-B02-C	VWPZ	-56.5	-3.5	-0.9	-1.4	55.1	3438
	VWP-TBW-B02-D	VWPZ	-76.5	-6.8	-6.3	-6.6	70.0	4365
	VWP-TBW-B02-E	VWPZ	-87.0	-6.4	-5.1	-5.8	81.2	5068

General Notes:

TBE - Tidal Basin East
TBW - Tidal Basin West
GW - Groundwater
VWPZ - Vibrating Wire Piezometer

Table 4. INDEX TEST RESULTS

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Boring No.	Ground Surface Elevation (feet)	Sample No.	Sample Depth Range (feet)	Average Sample Depth (feet)	Average Sample Elevation (feet)	SPT N-Value (bpf)	Water Content (%)	Atterberg Limits			Grain Size Analysis				USCS Classifi-cation	AASHTO	Organic Content (%)	Specific Gavity	Dry Density (pcf)	Moist Density (pcf)	Initial Void Ratio	Other Tests Performed		
								Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Gravel	% Sand	% Fines: % Silt	% Fines: % Clay								Consolidation	Direct Shear	UU Triaxial
TBE-B-01	4.88	S-01	0 - 2	1	3.88	3	24.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-02	2 - 4	3	1.88	0	30.6	34	20	14	0.0	29.9	33.8	36.3	CL	A-6	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-03	4 - 6	5	-0.12	0	28.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-04	6 - 8	7	-2.12	0	44.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-05	8 - 10	9	-4.12	0	37.0	40	22	18	0.0	31.8	68.2		CL	A-6	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-06	13 - 15	14	-9.12	1	40.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-07	18 - 20	19	-14.12	0	24.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-08	23 - 25	24	-19.12	4	24.4	NP	NP	NP	0.2	82.5	17.2		SM	A-2-4	--	2.65	--	--	--	--	--	--
TBE-B-01	4.88	S-09	28 - 30	29	-24.12	4	26.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-10	33 - 35	34	-29.12	2	46.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-11	38 - 40	39	-34.12	0	64.5	68	35	33	0.0	20.0	80.0		MH	A-7-5	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-12	44 - 46	45	-40.12	3	55.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-13	48 - 50	49	-44.12	1	54.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-14	53 - 55	54	-49.12	2	57.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-15	58.5 - 60	59.25	-54.37	2	59.1	71	35	36	0.8	9.1	90.1		MH	A-7-5	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-16	63.5 - 65	64.25	-59.37	3	56.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-17	68.5 - 70	69.25	-64.37	3	65.7	--	--	--	--	--	--	--	--	--	6.13	--	--	--	--	--	--	--
TBE-B-01	4.88	U-01	65 67	66	-61.12	Push	61.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	U-01	65 67	66	-61.12	Push	57.7	--	--	--	--	--	--	--	--	--	--	--	65.1	102.7	1.51	--	--	X
TBE-B-01	4.88	U-01	65 67	66	-61.12	Push	58.9	--	--	--	--	--	--	--	--	--	--	--	63.1	100.3	1.55	--	X	--
TBE-B-01	4.88	U-01	65 67	66	-61.12	Push	71.8	44	26	18	0.0	35.4	38.2	26.4	CL	A-7-6	--	2.62	56.8	97.6	1.9	X	--	--
TBE-B-01	4.88	S-18A	73.5 - 75	74.25	-69.37	5	28.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-18B	73.5 - 75	74.25	-69.37	5	49.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	S-19	78.5 - 80	79.25	-74.37	6	50.7	54	28	26	0.0	7.8	92.2		CH	A-7-6	6.35	--	--	--	--	--	--	--
TBE-B-01	4.88	U-03	83 85	84	-79.12	Push	45.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-01	4.88	U-03	83 85	84	-79.12	Push	46.7	--	--	--	--	--	--	--	--	--	--	--	70.4	103.3	1.42	--	--	X
TBE-B-01	4.88	U-03	83 85	84	-79.12	Push	54.7	56	31	25	0.0	35.4	38.2	26.4	MH	A-7-5	--	--	65.3	101.1	1.53	X	--	--

Table 4. INDEX TEST RESULTS

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Boring No.	Ground Surface Elevation (feet)	Sample No.	Sample Depth Range (feet)	Average Sample Depth (feet)	Average Sample Elevation (feet)	SPT N-Value (bpf)	Water Content (%)	Atterberg Limits			Grain Size Analysis				USCS Classifi-cation	AASHTO	Organic Content (%)	Specific Gavity	Dry Density (pcf)	Moist Density (pcf)	Initial Void Ratio	Other Tests Performed		
								Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Gravel	% Sand	% Fines									Consolidation	Direct Shear	UU Triaxial
													% Silt	% Clay										
TBE-B-01	4.88	S-20	88.5 - 90	89.25	-84.37	76	54.0	56	28	28	0.0	23.9	76.1		CH	A-7-6	--	--	--	--	--	--	--	--
TBE-B-02	2	S-01	0 - 2	1	1	1	27.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-02	2 - 2.8	2.4	-0.4	8	16.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-02A	2.8 - 4	3.4	-1.4	8	24.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-03	4 - 6	5	-3	7	23.3	28	22	6	0.0	47.8	52.2		CL-ML	A-4	--	--	--	--	--	--	--	--
TBE-B-02	2	S-04	6 - 8	7	-5	5	34.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-05	8 - 10	9	-7	1	27.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-06	13.5 - 15	14.25	-12.25	0	32.1	30	22	8	0.4	39.4	60.2		CL	A-4	--	--	--	--	--	--	--	--
TBE-B-02	2	S-07	18.5 - 20	19.25	-17.25	0	46.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-08	23.5 - 25	24.25	-22.25	0	41.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-09	28.5 - 30	29.25	-27.25	3	33.1	--	--	--	0.0	66.6	33.4		--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-10	33.5 - 35	34.25	-32.25	0	50.1	39	30	9	0.0	37.2	62.8		ML	A-4	--	--	--	--	--	--	--	--
TBE-B-02	2	S-11	38.5 - 40	39.25	-37.25	2	42.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-12	43.5 - 45	44.25	-42.25	0	58.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-13	48.5 - 50	49.25	-47.25	0	63.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBE-B-02	2	S-14	53.5 - 55	54.25	-52.25	0	69.6	61	34	27	0.0	7.4	92.6		MH	A-7-5	7.61	--	--	--	--	--	--	--
TBW-B-01	2.67	S-02	2 - 4	3	-0.33	3	32.9	--	--	--	--	--	--	--	--	--	11.9	--	--	--	--	--	--	--
TBW-B-01	2.67	S-04	6 - 8	7	-4.33	7	28.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-05	8 - 10	9	-6.33	1	30.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-06	13 - 15	14	-11.33	2	39.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-07	18 - 20	19	-16.33	2	48.0	--	--	--	0.8	22.2	77.0		--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-8B	23 - 25	24	-21.33	4	54.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-09	28 - 30	29	-26.33	0	43.6	35	31	4	0.0	53.4	46.6		SM	A-4	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-10	33 - 35	34	-31.33	2	56.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	U-01	35 37	36	-33.33	Push	42.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	U-01	35 37	36	-33.33	Push	43.0	--	--	--	--	--	--	--	--	--	--	--	76	108.7	1.13	--	--	X
TBW-B-01	2.67	U-01	35 37	36	-33.33	Push	44.0	--	--	--	--	--	--	--	--	--	--	--	66.6	95.9	1.38	--	X	--

Table 4. INDEX TEST RESULTS

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Washington, DC

Boring No.	Ground Surface Elevation (feet)	Sample No.	Sample Depth Range (feet)	Average Sample Depth (feet)	Average Sample Elevation (feet)	SPT N-Value (bpf)	Water Content (%)	Atterberg Limits			Grain Size Analysis				USCS Classifi-cation	AASHTO	Organic Content (%)	Specific Gavity	Dry Density (pcf)	Moist Density (pcf)	Initial Void Ratio	Other Tests Performed		
								Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Gravel	% Sand	% Fines: % Silt	% Fines: % Clay								Consolidation	Direct Shear	UU Triaxial
TBW-B-01	2.67	U-01	35 37	36	-33.33	Push	38.0	35	22	13	0.0	51.6	25.0	23.4	SC	A-6	--	2.6	80.9	111.6	1.01	X	--	--
TBW-B-01	2.67	S-11	38 - 40	39	-36.33	0	44.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-12	43 - 45	44	-41.33	0	63.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-13	48 - 50	49	-46.33	0	57.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-14	53 - 55	54	-51.33	2	56.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-15A	58 - 60	59	-56.33	0	65.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-16	63 - 65	64	-61.33	2	73.5	80	39	41	0.0	5.5	34.3	60.2	MH	A-7-5	5.86	--	--	--	--	--	--	--
TBW-B-01	2.67	S-17	68 - 70	69	-66.33	3	66.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-01	2.67	S-18	73 - 75	74	-71.33	8	67.2	--	--	--	--	--	--	--	--	--	5.71	--	--	--	--	--	--	--
TBW-B-01	2.67	S-19	78 - 80	79	-76.33	29	25.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-01	0 - 2	1	6.02	8	15.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-02	2 - 4	3	4.02	7	13.0	40	24	16	0.0	21.1	78.9		CL	A-6	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-03	4 - 6	5	2.02	3	17.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-04	6 - 8	7	0.02	6	14.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-05	8 - 10	9	-1.98	3	19.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-06	10 - 12	11	-3.98	2	42.5	39	23	16	0.2	36.5	31.4	31.8	CL	A-6		--	--	--	--	--	--	--
TBW-B-02	7.02	S-07	13.5 - 15	14.25	-7.23	0	29.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-08	18.5 - 20	19.25	-12.23	2	29.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-09	23.5 - 25	24.25	-17.23	4	32.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-10	28.5 - 30	29.25	-22.23	6	22.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-11	33.5 - 35	34.25	-27.23	13	24.9	--	--	--	0.2	68.2	31.7	--	--	--	2.38	--	--	--	--	--	--	--
TBW-B-02	7.02	S-12	38.5 - 40	39.25	-32.23	3	31.6	37	26	11	0.6	60.9	38.5	--	SM	A-6	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-13	43.5 - 45	44.25	-37.23	2	36.5	41	24	17	1.2	60.0	38.9	--	SC	A-7-6	--	--	--	--	--	--	--	--
TBW-B-02	7.02	U-02	48 - 50	49	-41.98	Push	50.4	--	--	--	--	--	--	--	--	--	--	--	68	102.3	1.28	--	X	--
TBW-B-02	7.02	U-02	48 - 50	49	-41.98	Push	79.5	45	26	19	0.7	38.6	38.1	22.6	CL	A-7-6	--	2.61	52.8	94.8	2.08	X	--	--
TBW-B-02	7.02	S-14	53.5 - 55	54.25	-47.23	2	51.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-15	58.5 - 60	59.25	-52.23	4	47.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 4. INDEX TEST RESULTS

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Boring No.	Ground Surface Elevation (feet)	Sample No.	Sample Depth Range (feet)	Average Sample Depth (feet)	Average Sample Elevation (feet)	SPT N-Value (bpf)	Water Content (%)	Atterberg Limits			Grain Size Analysis				USCS Classifi-cation	AASHTO	Organic Content (%)	Specific Gavity	Dry Density (pcf)	Moist Density (pcf)	Initial Void Ratio	Other Tests Performed		
								Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Gravel	% Sand	% Fines									Consolidation	Direct Shear	UU Triaxial
													% Silt	% Clay										
TBW-B-02	7.02	U-3	63 - 65	64	-56.98	Push	53.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	U-3	63 - 65	64	-56.98	Push	40.0	56	31	25	0.0	7.6	48.4	44.0	--	--	5.04	--	74.7	104.6	1.21	X	--	--
TBW-B-02	7.02	U-3	63 - 65	64	-56.98	Push	55.8	--	--	--	--	--	--	--	--	--	--	--	65.4	101.9	1.58	--	--	X
TBW-B-02	7.02	S-16	68.5 - 70	69.25	-62.23	8	58.2	--	--	--	--	--	--	--	--	--	6.96	--	--	--	--	--	--	--
TBW-B-02	7.02	S-17	73.5 - 75	74.25	-67.23	6	42.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TBW-B-02	7.02	S-18	78.5 - 80	79.25	-72.23	13	43.0	--	--	--	--	--	--	--	--	--	4.53	--	--	--	--	--	--	--
TBW-B-02	7.02	S-19	83.5 - 85	84.25	-77.23	50/3"	60.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

General Notes:

TBE - Tidal Basin East
TBW - Tidal Basin West
bpf - blows per foot
pcf - pounds per cubic foot

Table 5. ENGINEERING TEST RESULTS

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

					CONSOLIDATION										UU TRIAXIAL						DIRECT SHEAR							
Boring ID	Sample Number	Top of Sample (Depth, feet)	Bottom of Sample (Depth, feet)	Lab USCS	Sample Preparation	Initial Dry Density (pcf)	Initial Moisture Content (%)	Initial Moist Density (pcf)	Initial Saturation (%)	Initial Void Ratio	Final Void Ratio	Compression Index, C_c	Recompression Index, C_r	Overconsolidation Ratio, OCR	Sample Preparation	Average Dry Density (pcf)	Average Moisture Content (%)	Average Moist Density (pcf)	Average Void Ratio	Undrained Shear Strength, S_u (psf)	Sample Preparation	Average Dry Density (pcf)	Average Moisture Content (%)	Average Moist Density (pcf)	Average Void Ratio	Cohesion, c' (psf)	Internal Friction Angle, Φ' (deg)	Internal Friction Angle, Φ' (deg) with c=0 psf
TBE-B-01	U-01	65	67	CL	UD	56.8	71.8	97.6	100.1	1.88	1.15	0.43	0.06	1.0	UD	65.1	57.7	102.7	1.51	90	UD	63.1	58.9	100.2	1.59	620	27.9	32.8
																					RM	NA	NA	NA	NA	118	35.5	36.3
TBE-B-01	U-03	83	85	CL	UD	65.3	54.7	101.0	94.6	1.53	0.92	0.48	0.09	1.0	UD	70.4	46.7	103.3	1.36	166	--	--	--	--	--	--	--	--
TBW-B-01	U-01	35	37	SC	UD	80.9	37.9	111.6	97.9	1.01	0.71	0.28	0.02	1.6	UD	76.0	42.9	108.5	1.14	478	UD	66.6	44.0	95.9	1.44	552	33.8	37.6
																					RM	NA	NA	NA	NA	292	38.7	40.5
TBW-B-02	U-02	48	50	CL	UD	52.8	79.5	94.8	99.6	2.08	1.28	0.6	0.14	1.0	--	--	--	--	--	--	UD	68.0	50.4	102.2	1.40	502	33.1	36.7
																					RM	NA	NA	NA	NA	541	35.6	39.2
TBW-B-02	U-03	63	65	CL	UD	74.7	40.0	104.6	87.3	1.21	0.95	0.55	0.05	1.2	UD	65.4	55.8	101.9	1.53	756	--	--	--	--	--	--	--	--

Abbreviations:

TBE - Tidal Basin East
TBW - Tidal Basin West
UD = Undisturbed
RM = Remolded
NA = Not Applicable
UU = Unconsolidated Undrained

Table 6. ROCK TEST RESULTS

Geotechnical Data Report
Rehabilitation of Seawalls and Shoreline
NPS National Mall and Memorial Parks
Washington, DC

Boring ID	Sample Number	Top of Sample (Depth, feet)	Bottom of Sample (Depth, feet)	Moist Density (pcf)	Unconfined Compressive Strength, q_u (psi)	Failure Type
TBE-B-01	C-01	95	95.4	171.5	6,998	Vertical and Diagonal
TBE-B-01	C-04	107	107.3	164.8	9,925	Vertical and Diagonal
TBE-B-01 (BTX)	C-01	94	94.4	170.6	6,294	Vertical and Diagonal
TBW-B-01	C-02	85.2	85.6	169.3	7,938	Vertical and Diagonal
TBW-B-02	C-01	94	94.4	163.8	5,719	Vertical and Diagonal

General Notes:
TBE - Tidal Basin East
TBW - Tidal Basin West

Geotechnical Data Report - West Potomac Park

GEOTECHNICAL DATA REPORT

NAMA 318722 – West Potomac Park Seawall
Washington, DC

Schnabel Reference #: 22410101.000
December 19, 2022

December 19, 2022

Mr. Kent Brogger, PE
HDR / Moffatt-Nichol Joint Venture
1670 Broadway, Suite 3400
Denver, CO 80202

Subject: **Project NAMA 318722, Geotechnical Data Report, West Potomac Park Seawall, Washington, DC (Schnabel Reference 22410101.000)**

Dear Mr. Brogger:

SCHNABEL ENGINEERING DC, INC. is pleased to submit our geotechnical data report for this project. This study was performed in accordance with our proposal dated December 17, 2021 and incorporated into HDR Task Order/Agreement No: 001/10001000731212, dated April 21, 2022 and fully executed on May 19, 2022. The task order was issued under the Master Federal Subconsultant Agreement, Agreement No. 1000100071112, dated and fully executed on May 9, 2022.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING DC, INC.

Joan Bentel, PE
Senior Associate

Bill Khouri, PE
Principal

JB:BK:

GEOTECHNICAL DATA REPORT
NAMA 318722 - WEST POTOMAC PARK SEAWALL
WASHINGTON, DC

TABLE OF CONTENTS

1.0 SCOPE OF SERVICES

Our proposal dated December 17, 2021, incorporated into the HDR Task Order/Agreement No.: 001/1000100073121 defines the scope of services for this project. The scope of services includes the following:

- Develop approximate boring and sound location plan.
- Preparation of a subsurface exploration work plan.
- Full-time boring inspection by a junior engineer from our office during drilling activities at West Potomac Park.
- Preparation of a geotechnical data report, to include:
    - Estimated subsurface conditions and groundwater levels within the area explored based on data collected in the subsurface exploration.
    - Estimated subsurface profiles and groundwater levels within the area explored based on data collected in the subsurface exploration. Two subsurface profiles have been created.
    - Boring logs with soil description, classification, and depth of fill, groundwater observations, and any other observations made during the exploration, including the ground surface elevations at boring locations.
    - Laboratory testing results.
    - In-situ field testing results.

2.0 DESCRIPTION OF SITE AND PROPOSED CONSTRUCTION

2.1 Site Description

The subject site run along the Potomac river and is bounded by Arlington Memorial Bridge to the north, Ohio Drive SW to the east, the Ohio Drive SW Inlet Bridge to the south and the Potomac River to the west. A Site Vicinity Map is included as Figure 1. The West Potomac Park wall extends from the Arlington Memorial Bridge to the Ohio Drive SW Inlet Bridge and the wall length is 4,671 ft.

Portions of the existing West Potomac Park (WPP) seawall and adjacent shoreline have eroded over time due to age, highwater and poor drainage. The WPP seawall will be repaired and designed to consider climate resiliency and to preserve the West Potomac Park landscape. The repair is also planned to decrease the National Park Service (NPS) maintenance duties (such as debris clean-up caused by high tides).

We obtained the site information from information shared by HDR/Moffatt-Nichol Joint Venture and through our site visits.

2.2 Proposed Construction

We understand that the repair will consist of constructing a new wall with raised grades and that deep foundations will be needed to support the new seawall.

3.0 SUBSURFACE EXPLORATION PROGRAM

A subsurface exploration and field-testing program were performed to identify the subsurface stratigraphy underlying the site and to evaluate the geotechnical properties of the materials encountered. This program included test borings and in-situ testing (i.e., cone penetration testing and dilatometer testing). Exploration methods used are discussed below. The appendices to this report contain the results of our exploration.

3.1 Subsurface Exploration and Field Testing

3.1.1 Test Borings

E2CR drilled thirteen (13) test borings under our observation between June 15, 2022 and August 10, 2022. The Standard Penetration Test (SPT) was performed at selected depths in the borings. Appendix A includes specific observations, remarks, and logs for the borings, classification criteria, drilling methods, and sampling protocols. Figures 2A and 2B, included at the end of this report, indicates the approximate test boring locations. We will retain soil and rock samples up to 45 days beyond the issuance of this report, unless you request other disposition.

It should be noted that originally sixteen (16) standard penetration test (SPT) borings were planned (WPP-B-05, WPP-B-09 and WPP-B-13); however, three of the locations were converted to cone penetration test (CPT) probes (WPP-CPT-04, WPP-CPT-05 and WPP-CPT-06).

In addition to the SPTs performed in the test borings, in-situ testing was performed to further establish the geotechnical properties of the materials encountered at the site. Cone penetration and dilatometer testing was performed.

3.1.2 In Situ Testing

3.1.2.1 Cone Penetration Testing

In-Situ Soil Testing, LC performed cone penetration testing (CPT) at six locations on the site (designated as WPP-CPT-01, WPP- CPT-02, WPP-CPT-03, WPP-CPT-04, WPP-CPT-05, and WPP-CPT-06). The CPTs were performed to depths of 45.7 ft to 85.5 ft. Details of the CPTs and test results are included in Appendix B.

3.1.2.2 Dilatometer Testing

In-Situ Soil Testing, LC performed flat-blade dilatometer testing (DMT) at three locations on the site (designated as WPP-DMT-01, WPP-DMT-02, and WPP-DMT-03). The DMTs were performed to depths of 48.5 ft to 72.5 ft. Details of the DMTs and test results are included in Appendix B.

3.1.3 Instrumentation

Four inclinometers were installed at borings WPP-B-01, WPP-B-06, WPP-B-11, and WPP-B-16 to depths ranging between 55.4 ft and 108.5 ft, or between EL -49.9 (ft) and EL -102.1 (ft). Two vibrating wire piezometers were installed at borings WPP-B-03 and WPP-B-14 to depths ranging between 20 ft and 30 ft, or between EL -15.9 (ft) and EL -25.1 (ft).

GEI Consultants, Inc. is providing all monitoring and reporting services for the installed instrumentation.

3.1.4 Coordinates

GEI Consultants, Inc. surveyed the as-drilled boring and in-situ testing locations.
Elevations are measured in feet and are referenced to the North American Vertical Datum of 1988 (NAVD88). Boring coordinates are in feet and are referenced to the Virginia State Plane Coordinate System, Virginia North Zone defined by the North American Datum of 1983 (NAD83). Please note that the as-drilled coordinates and elevation for WPP-CPT-03 were not surveyed and the staked coordinates and an approximate elevation are included herein. Elevations and coordinates are shown in the tables below:

Table 3.1: As-Drilled Coordinates and Elevations for SPT Borings

Boring ID	Vertical Datum	Ground Surface Elevation (feet)	Northing (feet)	Easting (feet)	Horizontal Datum	Latitude (deg)	Longitude (deg)
WPP-B-01	NAVD88	5.48	444864.70	1297430.70	NAD 83	38.888185	-77.052356
WPP-B-02	NAVD88	5.45	444561.33	1297675.19	NAD 83	38.887352	-77.051497
WPP-B-03	NAVD88	4.11	444348.27	1297876.85	NAD 83	38.886768	-77.050788
WPP-B-04	NAVD88	2.3	444139.07	1298060.73	NAD 83	38.886193	-77.050141
WPP-B-06	NAVD88	3.06	443685.90	1298538.03	NAD 83	38.884950	-77.048464
WPP-B-07	NAVD88	4.36	443428.83	1298815.80	NAD 83	38.884244	-77.047487
WPP-B-08	NAVD88	4.56	443184.01	1299062.23	NAD 83	38.883573	-77.046621
WPP-B-10	NAVD88	4.19	442831.12	1299427.86	NAD 83	38.882604	-77.045336
WPP-B-11	NAVD88	4.97	442638.18	1299636.36	NAD 83	38.882075	-77.044603
WPP-B-12	NAVD88	5.08	442456.11	1299851.26	NAD 83	38.881575	-77.043848
WPP-B-14	NAVD88	4.86	442021.38	1300354.33	NAD 83	38.880382	-77.042080
WPP-B-15	NAVD88	6.41	441915.65	1300545.67	NAD 83	38.880092	-77.041408
WPP-B-16	NAVD88	5.15	441939.69	1300724.42	NAD 83	38.880158	-77.040780

Table 3.2: As-Drilled Coordinates and Elevations for In-Situ Testing

Test ID	Vertical Datum	Ground Surface Elevation (feet)	Northing (feet)	Easting (feet)	Horizontal Datum	Latitude (deg)	Longitude (deg)
WPP-CPT-01	NAVD88	5.75	444868.02	1297436.45	NAD 83	38.888194	-77.052336
WPP-CPT-02	NAVD88	5.6	443189.64	1299077.68	NAD 83	38.883588	-77.046567
WPP-CPT-03	NAVD88	5[(a)]	441937.42[(b)]	1300728.74[(b)]	NAD83	38.88016[(b)]	-77.04077[(b)]
WPP-CPT-04	NAVD88	4.72	443903.08	1298330.19	NAD 83	38.885546	-77.049194
WPP-CPT-05	NAVD88	4.37	443003.78	1299253.62	NAD 83	38.883078	-77.045949
WPP-CPT-06	NAVD88	5.85	442271.04	1300076.25	NAD 83	38.881067	-77.043058
WPP-DMT-01	NAVD88	5.66	444565.57	1297674.12	NAD 83	38.887364	-77.051500
WPP-DMT-02	NAVD88	4.3	443424.31	1298816.49	NAD 83	38.884232	-77.047485
WPP-DMT-03	NAVD88	5.17	442630.45	1299645.94	NAD 83	38.882053	-77.044570

(a) Ground surface elevation assumed to be similar to surveyed WPP-B-16 location, WPP-CPT-03 and WPP-B-16 were located within close proximity to one another.

(b) Latitude and longitude of as-staked location included since as-drilled coordinates were not provided for CPT-03.

3.2 Previous Explorations by Others

AECOM previously performed a subsurface exploration for the nearby Potomac River Tunnel between 2014 and 2022. Appendix D contains logs for seventeen (17) borings from that exploration. These data were developed by others and we were not present during collection of this information. We have reviewed the data for reasonableness, but we assume no responsibility for the completeness and accuracy of this information.

4.0 LABORATORY TESTING PROGRAM

SaLUT laboratory performed tests on selected samples obtained during the subsurface exploration. The testing aided in the classification of materials encountered in the subsurface exploration and provided data for use in the development of preliminary geotechnical parameters. Moisture contents and index test results are shown on the boring logs in Appendix A. The remainder of the test results is included in Appendix C.

4.1 Soils Testing

4.1.1 Index Testing

Natural moisture content, Atterberg limits, and gradation tests on 68 jar samples and 8 tube samples were performed representing Stratum A1, A2, B1, and B2, to provide soil classifications and parameters for use with published correlations with soil properties. The results are presented in the Summary of Laboratory Tests in Appendix C and are summarized (for each stratum) in Section 7.0.

4.1.2 Strength and Consolidation Testing

Two (2) unconsolidated-undrained (UU) triaxial shear tests and four (4) direct shear tests were performed on tube samples of soils representing Stratum B2. One direct shear test was performed on a tube sample representing Stratum B1. These tests were performed to evaluate the shear strength of these materials. Additionally, seven (7) one-dimensional consolidation tests were performed on tube samples of soils representing Stratum B2 to evaluate the compressibility characteristics of these soils. The test results are presented in Appendix C and summarized in Section 7.0.

4.1.3 Organic Content Testing

Organic content testing was performed on seven (7) jar samples and nine (9) tube samples of Stratum B2, and one tube sample of Stratum B1. The organic content values ranged between 3.56 percent and 9.69 percent. The test results are included in Appendix C and summarized in Section 7.0.

4.1.4 Corrosivity Testing

Corrosion potential testing was performed on eight composite (blended) soil samples, two samples from Stratum A1/A2, two samples of Stratum B1, and four samples of Stratum B2 collected during our on-site investigation. These samples were tested for resistivity, redox potential, sulfides, pH, sulfate content, and chloride content. These results are provided in Appendix C and summarized in Section 7.0.

4.2 Rock Testing

Unconfined compressive strength testing (without moduli curves; ASTM D7012 – Method C) was conducted on rock core samples obtained from three of the boring locations (WPP-B-01, WPP-B-06, and WPP-B-16). Results are included in Appendix C and summarized in Section 7.0.

4.3 Previous Testing by Others

Summary tables of laboratory testing performed by others for the Potomac River Tunnel project (AECOM) are included in Appendix E. Please note that detailed lab results can be found in the Potomac River Tunnel contract documents. These data were developed by others and we were not present during the performance of these tests. We have reviewed these data for general reasonableness, but we assume no responsibility for the completeness and accuracy of this information.

5.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Regional Geology

The site is located within the Atlantic Coastal Plain physiographic province and the Piedmont Plateau physiographic province. The boundary between the two provinces is known as the Fall Line. The Coastal Plain consists of a heterogeneous wedge of unconsolidated sedimentary deposits overlying steeply dipping bedrock. The sedimentary deposits thicken southeastward to about 1,500 ft at the Atlantic Ocean. The upper Coastal Plain sediments consist primarily of Pleistocene age terrace deposits typically composed of interbedded sands, gravels, silts, and clays. The terrace deposits are underlain by fluvial marine sedimentary deposits of the Cretaceous age.

The sedimentary deposits overlay Piedmont residual soils that are predominantly fine sandy silts and silty fine sands with traces of mica that have developed in-place from the weathering of the underlying bedrock. The weathering creates a zone of decomposed or "disintegrated" rock that can possess rock-like qualities that can extend to a significant depth. The bedrock below the sedimentary deposits and residual soils consists of crystalline rock (igneous and/or metamorphic rock) of Proterozoic and Paleozoic ages.

5.2 Site Geology

During our exploration, we encountered the following stratigraphy:

- Stratum A1: Existing Fill and Probable Fill (Fine-Grained)
- Stratum A2: Existing Fill and Probable Fill (Coarse-Grained)
- Stratum B1: Recent Alluvial Deposits (Coarse-Grained)
- Stratum B2: Recent Alluvial Deposits (Fine-Grained)
- Stratum C: Residual Soils
- Stratum D: Disintegrated Rock
- Stratum E: Bedrock

Significant filling of this area took place early in the 20th century during reclamation of the West Potomac Park. The existing fill and probable fill soils are believed to be a result of previous grading and dredging reclamation activities. The recent alluvial deposits encountered at the site and are believed to have been deposited from the adjacent Potomac River and the Tiber Creek tributary. If any terrace deposits were present at the site historically, they were extensively eroded and replaced with recent alluvial deposits.

5.3 Generalized Subsurface Stratigraphy

We characterized the following generalized subsurface stratigraphy based on our recent subsurface exploration included in Appendix A. The stratum designations do not imply continuity of materials encountered elsewhere on site but reflect the general description and characteristics of the subsurface materials at the boring locations.

Ground Cover: (Topsoil)
At most of the borings between about 2 to 10 inches of topsoil was encountered. At borings WPP-B-08 and WPP-B-10, 24 inches to 30 inches of topsoil was encountered. These depths may vary at other locations at the site.

Stratum A1: Fill and Probable Fill (Coarse-Grained)
Below the ground cover and interlayered with Stratum A2, the borings encountered coarse-grained fill and probable fill soils to maximum depth of 15.0 ft. The fill and probable fill material generally consisting of well graded sand, silty sand, clayey sand, well graded gravel with sand, poorly graded sand with gravel, and poorly graded sand with silt, containing various amounts of gravel, roots, asphalt, brick, rock fragments, pieces of plastic, slag, organics, clay pockets, silt pockets, quartz fragments, glass, and mica. Based on the SPTs, this stratum exhibits generally variable density and consistency. SPT N-values within the coarse-grained fill layer ranged between 1 blow per foot (bpf) and 35 bpf. The average SPT N-value for this material was 4 bpf to 5 bpf indicating that the soil is generally very loose to loose.

Stratum A2: Fill and Probable Fill (Fine-Grained)
Below the ground cover and interlayered with Stratum A1, the borings encountered fine-grained fill and probable fill soils to maximum depth of 23.5 ft. The fill and probable fill material generally consisting of sandy lean clay, lean clay with sand, elastic silt, lean clay, sandy elastic silt, sandy lean clay with gravel, sandy silt, and fat clay with sand, containing various amounts of gravel, shells, roots, wood fragments, wood pieces, asphalt, concrete, brick, rock fragments, pieces of foam, organics, ceramic pieces, sand pockets, glass, and mica. Based on the SPTs, this stratum exhibits generally variable density and consistency. SPT N-values within the fine-grained fill layer ranged between WOH over one foot and 50 blows over 3 inches. The average SPT N-value for this material was 4 bpf to 5 bpf indicating that the soil is medium stiff.

Stratum B1: Recent Alluvial Deposits (Coarse-Grained)
Below Stratum A1 and A2 and interlayered with the fine-grained deposits of Stratum B2, most of the borings encountered coarse-grained alluvial deposits extending up to 83.5 ft below existing grades. These alluvial deposits generally consist of gray, dark brown, brownish gray, reddish brown, olive, dark gray, light brown, dark olive and brown clayey SAND (SC), silty SAND, silty, clayey SAND (SC-SM), well-graded SAND with silt (SW-SM), poorly-graded SAND with clay (SP-SC), poorly-graded SAND with silt (SP-SM), and poorly-graded SAND (SP), containing varying amounts of mica, organics, roots, gravel, wood fragments, shells, clay seams, lean clay pockets, sandy lean clay pockets, silt pockets, and quartz fragments. Based on the SPTs, this stratum is generally very loose to medium dense (SPT values varied from WOH over one foot and 14 bpf). The average SPT N-value for this stratum was 4 bpf to 5 bpf indicating that the stratum is generally very loose.

Stratum B2: Recent Alluvial Deposits (Fine-Grained)
Below Stratum A1 and A2 and interlayered with the coarse-grained deposits of Stratum B1, the borings encountered fine-grained alluvial deposits extending up to 93.5 ft below existing grades. These fine-grained deposits generally consist of dark gray, dark brown, gray, brown, dark olive, olive, tan, light gray, and reddish brown LEAN CLAY(CL), sandy ELASTIC SILT (MH), ELASTIC SILT with sand (MH), sandy LEAN CLAY (CL), LEAN CLAY with sand (CL), FAT CLAY (CH), ELASTIC SILT (MH), sandy SILT (ML), FAT CLAY with sand (CH), and SILT (ML), containing varying amounts of mica, gravel, sand seams, organics, clayey sand seams and pockets, sand lenses, shell fragments, cemented sands, quartz fragments, and wood fragments. Based on the SPTs, this stratum exhibits generally very soft to very hard consistency (SPT values varied from WOH over one foot and 50 blows over 2 inches). The average SPT N-value for this stratum was

4 bpf to 5 bpf indicating that the stratum is generally soft to medium stiff. Pocket penetrometer values ranged between 0 tons per square foot (tsf) and greater than 1.25 tsf, with an average pocket penetrometer value of 0.4 tsf.

Stratum C: Residual Soils
Below Stratum B2 in boring WPP-B-02, a 4 ft thick residual soil layer was encountered at a depth of 43.5 ft below surface grades. The residual soil layer consists of gray silty SAND (SM), containing traces amounts of mica. Based on the SPT performed in this stratum, the stratum exhibits generally medium dense (an SPT value of 28 bpf was obtained).

Stratum D: Disintegrated Rock
Residual disintegrated rock was encountered below Stratum B1, B2, and C and extended to depths ranging between 47.4 ft to 103.0 ft below the ground surface in most of the borings, except boring WPP-B-14. The Stratum D material consisted of dark gray, light gray, bluish gray, and gray DISINTEGRATED ROCK sampled as poorly-graded gravel with silt and gravel, silty sand, poorly-graded gravel with sand and clay, clayey gravel, silty sand with gravel, poorly-graded gravel with clay, poorly-graded gravel with sand, gravelly sand with clay, and lean clay containing varying amounts of rock fragments, quartz fragments, and mica. Based on the SPTs performed, this stratum is generally very dense (SPT values varied between 50 blows per 5.5 inches and 50 blows over 0 inches).

Stratum E: Bedrock
Below the disintegrated rock of Stratum D, bedrock (Stratum E) was encountered at all boring locations. Rock coring extended to depths of 57.4 ft and 113 ft below existing exterior grades. The bedrock classifies as gray, dark gray, light gray, and bluish gray SCHIST with varying amounts of mica. The rock was weak to medium strong, slightly to highly weathered, and slightly to intensely fractured. The Rock Core Recovery (REC) of the cores varied between 55 and 100 percent and the Rock Quality Designation (RQD) ranged between 0 percent and 95 percent.

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. Disintegrated rock is defined as residual material with SPT N values between 60 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of 1 inch or less. We encountered disintegrated rock at depths between 47.3 ft and 93.5 ft below existing grades, or between about EL -41.8 (ft) and EL -88.4 (ft).

We observed refusal on rock at depths between 47.4 ft and 103.0 ft below existing grades, or between about EL -41.9 (ft) and EL -97.9 (ft).

The above stratification is shown in detail on the boring logs in Appendix A. Numbers after the description of the soil strata in the above tabulation indicate the minimum and maximum penetration resistances, or N values, recorded in each stratum. The sampling procedures used to determine N values are also presented in Appendix A.

The soil group symbols, indicated on the boring logs and in the generalized subsoil stratum descriptions above, represent the Unified Soil Classification System (USCS) group symbols and are based on visual observation of the specimens recovered, per ASTM D-2488. The criteria for visual identification of soil specimens are presented in Appendix A. It should be noted that there may be differences between visual classifications and laboratory classifications based on ASTM D-2487.

5.3.1 Soil Stratigraphy Identified in Previous Exploration by Others

The seventeen (17) borings conducted for the nearby Potomac River Tunnel project indicate similar subsurface stratigraphy. Existing fill material extended between depths of 4 ft and 23 ft, or between about EL +8.6 (ft) and EL -17.9 (ft) and was underlain by soft and loose alluvial deposits to depths of 52 ft to 92 ft below surface grades, or between about EL -37.4 (ft) and EL -83.3 (ft). Residual material was encountered below the alluvial deposits at most of the locations. The depth the residual material extended to/top of rock was between 51 ft and 95 ft, or between about EL -32 (ft) and EL -85.8 (ft).

5.3.2 Methane

During drilling activities, Schnabel utilized RAE Systems MultiRae Pumped Portable Multi-Gas Monitors (10.6eV) to monitor combustible gas due to the presence of methane at the subject site. The lower explosive limit percent (%LEL) was recorded every 5 ft during advancement and removal of the drilling augers at the Standard Penetration Test (SPT) borings. Please note that Schnabel was not originally recording the %LEL at the start of the project; however, once we were notified that methane had been encountered on the Tidal Basin side, we arranged for the delivery and use of the MultiRae gas monitors.

During drilling if a %LEL of greater than 50 percent was recorded drilling was stopped to allow the methane to vent off. Once the %LEL was below the 50 percent threshold drilling was allowed to proceed. Please note that gas detectors display a gas's presence as a percentage of its LEL. An atmosphere free of methane would show 0% LEL on the gas detector, but an atmosphere containing 5% methane would display 100% LEL.

Venting off methane to below the 50%LEL threshold took between about an hour to 5 hours per elevated reading. At four of the locations when a reading of 99%LEL was detected mid-day and/or towards the end of day, boreholes were left to gas off overnight.

A summary of the %LEL readings at each borehole location is provided in the table below.

Table 3: %LEL Readings During Drilling Activities

Boring No.	Depth Where 99%LEL Reading or Greater Registered (ft)	Approximate Elevation Where 99% LEL Reading or Greater Registered (ft)	Notes
WPP-B-01	N/A(1)	N/A(1)	%LEL not measured in this borehole.
WPP-B-02	43.5	EL -38	10 to 33% LEL at 38.5 ft- 40 ft.
WPP-B-03	N/A(1)	N/A(1)	%LEL not measured in this borehole.
WPP-B-04	N/A(1)	N/A(1)	%LEL not measured in this borehole.
WPP-B-06	--(2)	--(2)	
WPP-B-07	55	EL -50.6	
WPP-B-08	60 - 76.5	EL -55.4 - EL -71.9	Bubbling noted at 57 ft.
WPP-B-10	66.5 - 75.5	EL -62.3 - EL-71.3	26%LEL at 50 ft; 43%LEL at 59 ft
WPP-B-11	58.5 - 78.5	EL -53.5 - EL -73.6	
WPP-B-12	--(2)	--(2)	20-33%LEL at depth of 58.5 ft.
WPP-B-14	52	EL -47.1 - EL -73.6	
WPP-B-15	68.5	EL -62.1	Methane re-registered at 70 ft when pulling augers.
WPP-B-16	N/A(1)	N/A(1)	%LEL not measured in this borehole.

(1) %LEL not measured in boreholes WPP-B-01, WPP-B-03, WPP-B-04 and WPP-B-16. MultiRae readers were mobilized to the site once Schnabel was made aware of methane being encountered on the Tidal Basin side.
(2) No %LEL readings of 99% or greater were recorded.

When methane was detected, our field personnel visually observed bubbling of water within the augers and, in some instances, projection of water and grout through the drill rods/augers. Additionally, hissing and bubbling were also noted by our field personnel when methane was detected.

5.4 Groundwater

Groundwater was encountered during drilling at depths between 5 ft and 12 ft below existing grades, or between about EL +0.2 (ft) and EL -10 (ft). The deeper encountered water level is believed to be due to a restrictive (fine-grained) layer in the upper portion of the fill material (Stratum A1). Discarding that measurement from the data, the encountered groundwater depth ranged between 5 ft and 10 ft below grade, or between about EL +0.2 (ft) and EL -4.5 (ft). Upon completion of the drilling, prior to pulling augers, groundwater was recorded at three of the borings between depths of 2 ft and 10 ft below existing grades, or between about EL +4.4 (ft) and EL -2.5 (ft). Groundwater readings were not taken upon completion at the remainder of the borings. All boreholes were grouted upon completion, except where instrumentation was installed.

The CPT and dilatometer soundings encountered groundwater at depths ranging between 0.6 ft and 5.9 ft below surface grades, or between about EL +5 (ft) and EL +0 (ft).

The vibrating wire piezometer data should be utilized to assess the groundwater level at the site, accounting for low tide and high tide. In general, we anticipate that the groundwater level will be close in elevation to the adjacent Potomac River (anticipated to be at about EL +0 (ft)) with variations of +/- 5 ft. The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. Fluctuation of the hydrostatic water table can depend on variations in tidal action, precipitation, surface runoff, pumping, evaporation, leaking utilities, the nearby Potomac River and other similar factors.

6.0 IN-SITU FIELD TESTING

6.1 Cone Penetrometer Testing

6.1.1 Brief Description of the Cone Penetrometer Test

The cone penetrometer consists of a 44-mm diameter cone and a 44-mm diameter friction sleeve that sits directly above the cone. The penetrometer contains strain gages to record the force on the cone and the friction sleeve. The penetrometer is attached to the end of a string of drill rods and is hydraulically advanced at a rate of 2 cm/sec. The force on the cone (tip resistance) and on the friction sleeve (friction resistance) is recorded approximately every 3 cm of penetration, providing a continuous record of tip resistance and friction resistance.

Piezocones are penetrometers fitted with pore pressure transducers to record the pore water pressure within the soil as the cone is advanced.

In-Situ Soil Testing, LC performed cone penetration testing (CPT) at six locations on the site (designated as WPP-CPT-01, WPP- CPT-02, WPP-CPT-03, WPP-CPT-04, WPP-CPT-05, and WPP-CPT-06). The CPTs were performed to depths of 45.7 ft to 85.5 ft. Details of the CPTs and test results are included in Appendix B.

6.1.2 Brief Description of the Flat-blade Dilatometer Test

The flat-blade dilatometer is a 95-mm wide, 15-mm thick blade with a wedge-shaped bottom edge. In the center of one face of the blade there is a 60-mm diameter diaphragm. The dilatometer is attached to the end of a string of drill rods and is hydraulically advanced into the soil. At selected locations, the advancement is stopped and the dilatometer test is performed. The dilatometer test involves pneumatically pushing the circular diaphragm into the soil a distance of 1.1 mm. The pressure required to move the diaphragm is recorded at the beginning of movement (A reading), at the full extension of the diaphragm (B reading), and when the diaphragm returns to its initial position (C reading). After completion of the test, the blade is advanced to the next depth and the test repeated.

In-Situ Soil Testing, LC performed flat-blade dilatometer testing (DMT) at three locations on the site (designated as WPP-DMT-01, WPP-DMT-02, and WPP-DMT-03). The DMTs were performed to depths of 48.5 ft to 72.5 ft. Details of the DMTs and test results are included in Appendix B.

7.0 LABORATORY TESTING RESULTS

7.1 Index Testing

Natural moisture content, Atterberg limits, and gradation tests on 68 jar samples and 8 tube samples were performed representing Stratum A1, A2, B1, and B2. The results are presented in the Summary of Laboratory Tests in Appendix C and the following summarizes the results of the laboratory testing for each of the strata encountered in the borings:

Stratum A1/A2: Fill and Probable Fill

Twenty-one (21) jar samples of Stratum A1 and Stratum A2 material were tested for moisture content. The laboratory testing measured the following properties:

Moisture Content:	8.5% to 40.1%

Stratum B1: Recent Alluvial Deposits (Coarse-Grained)

Twenty-three (23) jar samples and one tube sample of Stratum B1 material were tested. The material classified as silty, clayey SAND (SC-SM), well-graded SAND with silt (SW-SM), silty SAND (SM), and poorly graded SAND with silt (SP-SM). Seven jar samples and the tube sample from this stratum were tested for index properties and sixteen (16) samples were tested for moisture content only. The laboratory testing measured the following properties:

Moisture Content:	15.2% to 58.4%
Liquid Limit:	Non-plastic to 28
Plasticity Index:	Non-plastic to 4
% Passing No. 200 Sieve:	10% to 42%

Stratum B2: Recent Alluvial Deposits (Fine-Grained)

Twenty-four (24) jar samples and seven (7) tube samples of Stratum B2 material were tested. The material classified as LEAN CLAY (CL), ELASTIC SILT with sand (MH), ELASTIC SILT (MH), sandy LEAN CLAY (CL), LEAN CLAY with sand (CL), FAT CLAY (CH), sandy SILT (ML), and FAT CLAY with sand (CH). Seventeen (17) jar samples and the seven (7) tube samples from this stratum were tested for index properties and twelve (12) samples were tested for moisture content only. The laboratory testing measured the following properties:

Moisture Content:	30.3% to 79.3%
Liquid Limit:	41 to 96
Plasticity Index:	14 to 52
% Passing No. 200 Sieve:	58% to 99%

7.2 Strength and Consolidation Testing

Two (2) unconsolidated-undrained (UU) triaxial shear tests and four (4) direct shear tests were performed on tube samples of soils representing Stratum B2. One direct shear test was performed on a tube sample representing Stratum B1. These tests were performed to evaluate the shear strength of these materials. Additionally, seven (7) one-dimensional consolidation tests were performed on tube samples of soils representing Stratum B2 to evaluate the compressibility characteristics of these soils. The test results are presented in Appendix C and summarized below:

Table 7.1: Unconsolidated-Undrained (UU) Triaxial Shear Tests – Stratum B2

Boring ID No.	Depth (ft)	Test Elevation (ft)
WPP-B-06	16.5 - 18.5	EL -14.4
WPP-B-14	60.0 - 62.0	EL -56.1

Table 7.2: Direct Shear Testing Results

Boring ID No.	Stratum	Depth (ft)	Test Elevation (ft)
WPP-B-03	B2	16.5 - 18.5	EL -13.4
WPP-B-06	B1	36.5 - 38.5	EL -34.4
WPP-B-08	B2	43.0 - 45.0	EL -39.4
WPP-B-10	B2	63.0 - 65.0	EL -59.8
WPP-B-12	B2	51.0 - 53.0	EL -46.9

Table 7.3: Consolidation Testing Results for Stratum B2

Boring ID No.	Depth (ft)	Test Elevation (ft)	Initial Void Ratio
WPP-B-03	16.5 - 18.5	EL -13.4	1.19
WPP-B-06	46.5 - 48.5	EL -44.4	1.49
WPP-B-08	43.0 - 45.0	EL -39.4	1.44
WPP-B-10	63.0 - 65.0	EL -59.8	1.62
WPP-B-12	51.0 - 53.0	EL -46.9	1.59
WPP-B-14	70.0 - 72.0	EL -67.1	1.47
WPP-B-16	35.0 - 37.0	EL -30.8	1.58

7.3 Organic Content Testing

Organic content testing was performed on seven (7) jar samples and nine (9) tube samples of Stratum B2, and one tube sample of Stratum B1. The organic content values ranged between 3.56 percent and 9.69 percent. The test results are included in Appendix C and summarized in the table below:

Table 7.4: Organic Content Testing Results

Boring ID No.	Stratum	Depth (ft)	Test Elevation (ft)	As Received Moisture Content (%)	Organic Content (%)
WPP-B-01	B2	43.5 - 44.2	-38.4	56.8	8.2
WPP-B-03	B2	16.5 - 18.5	-13.4	48.3	5.9
WPP-B-03	B2	48.5 - 50.0	-45.2	78.8	9.4
WPP-B-06	B2	16.8 - 18.5	-14.4	45.8	4.9
WPP-B-06	B1	36.5 - 38.5	-34.4	25.6	3.6
WPP-B-06	B2	46.5 - 48.5	-43.4	47.5	5.8
WPP-B-06	B2	60.0 - 61.5	-57.7	70.8	9.7
WPP-B-08	B2	43.0 - 45.0	-39.4	42.3	4.8
WPP-B-10	B2	45.0 - 46.0	-41.3	45.7	5.8
WPP-B-10[(a)]	B2	63.0 - 65.0	-59.8	63.8	6.7
WPP-B-11	B2	48.5 - 50.0	-44.3	47.8	8.7
WPP-B-12	B2	51.0 - 53.0	-46.9	40.5	4.1
.WPP-B-14	B2	60.0 - 62.0	-56.1	53.1	3.9
WPP-B-14 [(a)]	B2	70.0 - 72.0	-66.1	49.7	3.6
WPP-B-15	B2	68.5 - 70.0	-62.9	48.6	6.3
WPP-B-16	B2	35.0 - 37.0	-30.8	55.4	4.7
WPP-B-16	B2	63.5 - 65.0	-59.1	51.3	6.8

[(a)] Note: The organic content of these samples was unintentionally tested twice, during different assignments from the main laboratory (SaLUT) to one of their subcontracted laboratories. The additional testing values are included in the Laboratory Assignment No. 2 organic content test results in Appendix C.

7.4 Corrosivity Testing

Corrosion potential testing was performed on eight composite (blended) soil samples, two samples from Stratum A1/A2, two samples of Stratum B1, and four samples of Stratum B2 collected during our on-site investigation. These samples were tested for resistivity, redox potential, sulfides, pH, sulfate content, and chloride content. These results are provided in Appendix C. The table below summarizes these results:

Table 7.5: Summary of Corrosivity Test Results

Boring ID No.	Stratum	USCS	Sample Depth (ft)	In Situ Resistivity (ohm-cm)	Redox Potential (mV)	Sulfides (mg/kg)	pH	Chloride Content (mg/kg)	Sulfate Content (mg/kg)
WPP-B-04	A1/A2		13.5 - 17.5	2600	619	6.2	6.2	81	520
WPP-B-04	B2	ML	25.0 - 31.5	4700	625	8.7	5.8	36	190
WPP-B-04	B2	MH	45.0 - 51.5	3060	611	11	5.9	46	800
WPP-B-15	A1		5.0 - 9.0	1980	580	23	5.5	75	320
WPP-B-15	B1	SP-SM / SC	18.5 - 25.0	2640	629	18	5.3	79	230
WPP-B-15	B1	SM	38.5 - 45.0	3010	592	< 5.5	5.5	28	240
WPP-B-15	B2	CL	58.5 - 65.0	10100	526	< 6.1	5.8	30	190
WPP-B-15	B2	CL	73.5 - 80.0	4510	483	7.8	7.2	68	330

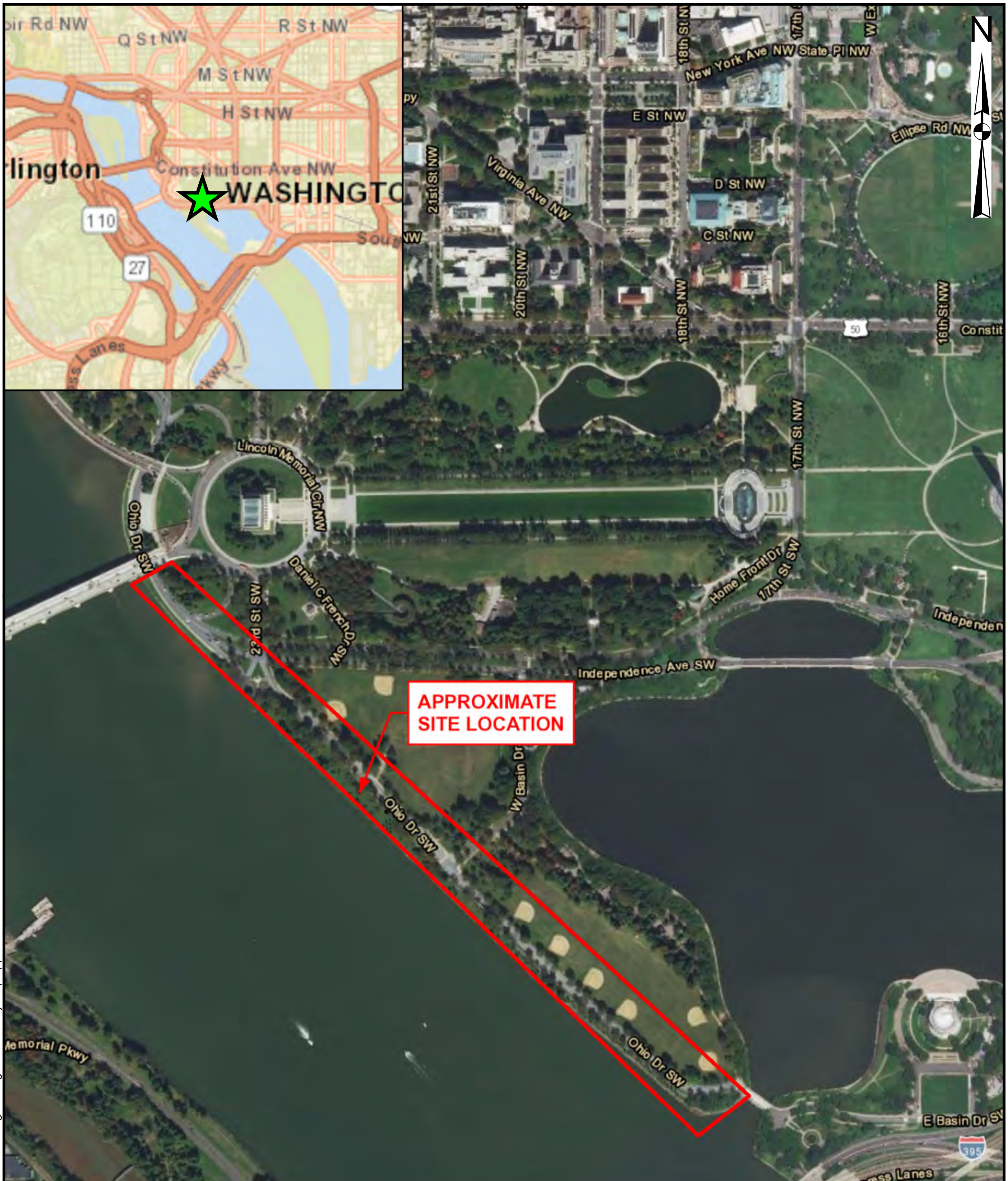
7.5 Unconfined Compressive Strength of Rock

We performed unconfined compressive strength (UCS) tests and bulk density measurements on three rock core specimens. Table 7.6 summarizes the results of UCS tests on rock cores.

Table 7.6: Unconfined Compressive Strength of Rock Cores

Boring ID No.	Rock Type	Approximate Depth (ft)	Approximate Elevation (ft)	Unconfined Compressive Strength (psi)
WPP-B-01	Schist	48.3 - 48.7	-43.0	9,185
WPP-B-06	Schist	72.5 - 72.9	-69.6	11,607
WPP-B-16	Schist	109.7 - 110.1	-96.7	6.814

FIGURES



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Projection: WGS 1984 Web Mercator Auxiliary Sphere

NOT TO SCALE

Schnabel ENGINEERING

NAMA 318722 - WEST PARK POTOMAC SEAWALL
OHIO STREET SW
WASHINGTON, DC
PROJECT NO. 22410101.000

SITE VICINITY MAP

FIGURE 1

10/26/2022 This Map was Created In Schnabel Engineerings Site Vicinity Map Application

arcgis

LEGEND

● WPP-B-01 — APPROXIMATE BORING OR IN-SITU SOUNDING LOCATION

SPT Boring Coordinates and Elevations

Boring ID	Ground Surface Elevation (feet)	Latitude (deg)	Longitude (deg)
WPP-B-01	5.48	38.888185	-77.052356
WPP-B-02	5.45	38.887352	-77.051497
WPP-B-03	4.11	38.886768	-77.050788
WPP-B-04	2.3	38.886193	-77.050141
WPP-B-06	3.06	38.88495	-77.048464
WPP-B-07	4.36	38.884244	-77.047487
WPP-B-08	4.56	38.883573	-77.046621
WPP-B-10	4.19	38.882604	-77.045336
WPP-B-11	4.97	38.882075	-77.044603
WPP-B-12	5.08	38.881575	-77.043848
WPP-B-14	4.86	38.880382	-77.04208
WPP-B-15	6.41	38.880092	-77.041408
WPP-B-16	5.15	38.880158	-77.04078

In-Situ Sounding Coordinates and Elevations

Test ID	Ground Surface Elevation (feet)	Latitude (deg)	Longitude (deg)
WPP-CPT-01	5.75	38.888194	-77.052336
WPP-CPT-02	5.6	38.883588	-77.046567
WPP-CPT-03*	5	38.88016	-77.04077
WPP-CPT-04	4.72	38.885546	-77.049194
WPP-CPT-05	4.37	38.883078	-77.045949
WPP-CPT-06	5.85	38.881067	-77.043058
WPP-DMT-01	5.66	38.887364	-77.0515
WPP-DMT-02	4.3	38.884232	-77.047485
WPP-DMT-03	5.17	38.882053	-77.04457

*As-staked coordinates provided, elevation estimated from nearby SPT boring WPP-B-16.

BASE PLAN OBTAINED FROM GOOGLE EARTH.

Schnabel ENGINEERING	NAMA 318722 - WEST PARK POTOMAC SEAWALL OHIO STREET SW WASHINGTON, DC	APPROXIMATE BORING AND IN-SITU SOUNDING LOCATION PLAN	DRAWN BY: J. BENTEL	APPROXIMATE SCALE: AS SHOWN
		PROJECT NO. 22410101.000 FIGURE 2A	REVIEWED BY: B. KHOURI	DATE: NOVEMBER 2022

LEGEND

WPP-B-01 — APPROXIMATE BORING OR IN-SITU SOUNDING LOCATION

SPT Boring Coordinates and Elevations

Boring ID	Ground Surface Elevation (feet)	Latitude (deg)	Longitude (deg)
WPP-B-01	5.48	38.888185	-77.052356
WPP-B-02	5.45	38.887352	-77.051497
WPP-B-03	4.11	38.886768	-77.050788
WPP-B-04	2.3	38.886193	-77.050141
WPP-B-06	3.06	38.88495	-77.048464
WPP-B-07	4.36	38.884244	-77.047487
WPP-B-08	4.56	38.883573	-77.046621
WPP-B-10	4.19	38.882604	-77.045336
WPP-B-11	4.97	38.882075	-77.044603
WPP-B-12	5.08	38.881575	-77.043848
WPP-B-14	4.86	38.880382	-77.04208
WPP-B-15	6.41	38.880092	-77.041408
WPP-B-16	5.15	38.880158	-77.04078

In-Situ Sounding Coordinates and Elevations

Test ID	Ground Surface Elevation (feet)	Latitude (deg)	Longitude (deg)
WPP-CPT-01	5.75	38.888194	-77.052336
WPP-CPT-02	5.6	38.883588	-77.046567
WPP-CPT-03*	5	38.88016	-77.04077
WPP-CPT-04	4.72	38.885546	-77.049194
WPP-CPT-05	4.37	38.883078	-77.045949
WPP-CPT-06	5.85	38.881067	-77.043058
WPP-DMT-01	5.66	38.887364	-77.0515
WPP-DMT-02	4.3	38.884232	-77.047485
WPP-DMT-03	5.17	38.882053	-77.04457

*As-staked coordinates provided, elevation estimated from nearby SPT boring WPP-B-16.

BASE PLAN OBTAINED FROM GOOGLE EARTH.

Schnabel ENGINEERING	NAMA 318722 - WEST PARK POTOMAC SEAWALL OHIO STREET SW WASHINGTON, DC	APPROXIMATE BORING AND IN-SITU SOUNDING LOCATION PLAN	DRAWN BY: J. BENTEL	APPROXIMATE SCALE: AS SHOWN
		PROJECT NO. 22410101.000 FIGURE 2B	REVIEWED BY: B. KHOURI	DATE: NOVEMBER 2022