FROEHLING & ROBERTSON, INC.

Report of Geotechnical Study

31st Street S. Parking Lot
Arlington, Virginia, 22202
F&R Project No. 72Y0060

Prepared For:

Facilities Design and Construction
Arlington Department of Environmental Services
1400 N Uhle St. Suite 403
Arlington, VA 22201

Prepared By:
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April 23, 2020

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April 23, 2020

John Mir
Project Manager
Facilities Design & Construction
Arlington County Department of Environmental Services
1400 N Uhle St. Suite 403
Arlington, VA 22201

Subject: **Report of Subsurface Exploration and Geotechnical Evaluation**
31st Street S. Parking Lot
Arlington, Virginia
F&R Project No. 72Y0060

Dear Mr. Mir:

The purpose of this study is to present the results of the subsurface exploration program and geotechnical engineering evaluation undertaken by Froehling & Robertson, Inc. (F&R) in connection with the 31st Street Parking Lot project at Arlington, Virginia. Our services were performed in general accordance with F&R Proposal No. 2072-00037 dated February 20, 2020, as authorized by your office. The attached report presents our understanding of the project, reviews our exploration procedures, describes existing site and general subsurface conditions, and presents our geotechnical evaluations.

We have enjoyed working with you on this project, and we are prepared to assist you with the recommended quality assurance monitoring and testing services during construction. Please contact us if you have any questions regarding this report or if we may be of further service.

Sincerely,
FROEHLING & ROBERTSON, INC.

Will Kelsey
Apr 24 2020 8:09 AM

Will Kelsey, E.I.T.
Staff Geotechnical Engineer

COMMONWEALTH OF VIRGINIA
VENISRI NAGULAPATI
No. 41997
PROFESSIONAL ENGINEER

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Venisri Nagulapati, P.E.
Director of Monitoring Services

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EXECUTIVE SUMMARY

This Executive Summary is provided as a brief overview of our geotechnical engineering evaluation for the project and is not intended to replace more detailed information contained elsewhere in this report. As an overview, this summary inherently omits details that could be very important to the proper application of the provided geotechnical design recommendations. This report should be read in its entirety prior to implementation into design and construction.

- The proposed construction will consist of a permeable paver SWM facility to be located within the existing parking lot along South 31st Street between South Fern Street and South Eads Street (Drawing No. 1, Appendix I). A subsurface exploration consisting of eight (8) test borings drilled to depths ranging from 6.0 to 10.0 feet each was conducted on site to evaluate the subsurface characteristics of the soils.
- Soil test borings conducted on site indicate a soil stratigraphy consisting of fill and possible fill materials underlain by coastal plain deposit soils. Approximately 2 inches of surficial soil were encountered within borings B-1 through B-5.
- Infiltration is not feasible at locations B-2 through B-8 at the planned invert elevation due to the presence of fill soils. Infiltration is not suitable within boring B-3 due to the presence of clay. If infiltration is desirable within borings B-2 and B-4 through B-8, the invert elevation may be lowered to the elevations where coastal deposit soils were encountered as shown in the boring logs.
- The Virginia Department of Environmental Quality requires field infiltration testing to establish actual infiltration rates. Field infiltration testing was not included within our scope of work. USDA textural classifications were performed on the soils at the invert depth of the proposed permeable paver facility. Table 3.10 of the *Virginia Stormwater Management Handbook* (1999) shows soil classifying as Sandy Loam has an anticipated minimum infiltration rate 1.02 inches/hour. If infiltration is desirable, field infiltration testing should be conducted to confirm these infiltration rates.
- On-site soils consisting of SILTY SAND (SM), or POORLY-GRADED SAND (SP) may be suitable for use as controlled fill pending further testing. Based on our testing, on-site soils consisting of CLAYEY SAND (SC) are not suitable for use as controlled fill due to having a liquid limit greater than 40 and plasticity index greater than 15. Standard Proctor testing of a representative sample of proposed control fill material should be performed prior to placement of the material.
- Subsurface water was encountered at depths ranging from 4.8 to 9.7 feet 24 hours after completion of drilling, at completion of drilling, and during drilling for borings B-4, B-5, and B-7. Generally, seasonal and yearly fluctuations of the water table should be expected with variations in precipitation, surface runoff, evaporation, and other similar factors.

1.0 PURPOSE & SCOPE OF SERVICES

Froehling & Robertson conducted a geotechnical study to explore the subsurface conditions on site for the proposed permeable paver SWM facility to be located within the existing parking lot along South 31st Street between South Fern Street and South Eads Street and to develop geotechnical engineering evaluation of the subsurface conditions encountered and construction recommendations that can be used during the design and construction of the proposed permeable paver SWM facility.

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

- Review of readily available geologic information for the project site;
- Completion of an on-site field exploration consisting of eight soil test borings drilled to depths ranging from 6 to 10 feet;
- Preparation of typed Boring Logs;
- Performing geotechnical laboratory testing on representative soil samples;
- Performing a geotechnical engineering evaluation of the subsurface conditions with regard to their suitability for the proposed construction;
- Preparation of this geotechnical report by professional engineers.

Our scope of services did not include plan review, environmental screening or testing, evaluation of wetland or environmental aspects of the project site, infiltration testing, health and safety considerations for non-F&R personnel, and landscape repair.

2.0 PROJECT INFORMATION

2.1 Proposed Construction

The proposed construction will consist of a permeable paver storm water management facility located within the parking lot along 31st Street South between South Fern Street and South Eads Street in Arlington Virginia. The project site is located northeast of the intersection of 31st Street South and Fern Street South in Arlington, Virginia, as shown on the Site Location Plan (Drawing No. 1, Appendix I). Information regarding the proposed construction was obtained from phone conversations and email correspondence with the Arlington Department of Environmental Services as well as the request for proposals titled *Project WPB5 – Geotechnical Analysis and Design Services 31st Street South – Parking Lot Improvements*, the plans titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Ferns Street and S. Eads Street* dated February 14, 2020 and prepared by the Arlington Department of Environmental Services, and the plans titled *SWM Drainage Area Map – Existing, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street*, prepared by the Arlington Department of Environmental Services and dated February 7, 2020. We understand that the parking lot will be replaced with a plastic grid or concrete permeable pavement system. The

parking lot will be expanded to include the unimproved area to the west of the existing parking lot. The parking lot will be divided into two halves. The western half of the permeable pavement will overlie a below grade stormwater detention facility consisting of 9.5 inches of angular base stone. The eastern half of the permeable pavement will not have below grade stormwater detention storage. We understand that the invert depth for the proposed SWM facility is approximately 1.5 feet beneath existing grades and infiltration is not planned. The recommendations contained herein address only these permeable paver facility.

The proposed permeable paver facility will be located within the existing parking lot between South Fern Street and South Eads Street. A green chain link fence surrounds the area. The site slopes downward from the north towards lower elevations in the southeast, from EL 59 feet to EL 49 feet.

3.0 EXPLORATION PROCEDURES

3.1 Subsurface Exploration

3.1.1 Soil Test Borings

The subsurface exploration program (consisting of eight test borings designated B-1 through B-8) was performed on April 2, 2020 at the locations shown on the attached Boring Location Plan (Drawing No. 2, Appendix I). F&R personnel marked the boring locations in the field utilizing a hand held GPS unit. Ground surface elevations were interpolated to the nearest tenth of a foot from the topographic information shown on the plan titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street,* prepared by Arlington County Department of Environmental Services and dated February 14, 2020. In consideration of the methods used in their determination, the boring locations shown on the attached Boring Location Plan, as well as the elevations shown on the attached boring logs, should be considered approximate.

The test borings were performed in accordance with generally accepted drilling practice using an ATV mounted CME-55 rotary drill rig. Hollow-stem augers were advanced to pre-selected depths, the center plug was removed, and representative soil samples were recovered with a standard split-spoon sampler (1 3/8 in. ID, 2 in. OD) in general accordance with ASTM D 1586, the Standard Penetration Test. The split-spoon sampler was driven into the soil by freely dropping a weight of 140 pounds from a height of 30 inches.

The number of blows required to drive the split-spoon sampler three or four consecutive 6-inch increments is recorded, and the blows of the second and third increments are summed to obtain the Standard Penetration Resistance (N-value). The N-value provides a general indication of in-situ soil conditions and has been correlated with certain engineering properties of soils.

An automatic hammer was used to perform the Standard Penetration Test (SPT) test borings for this project. Research has shown that the Standard Penetration Resistance (N-value) determined by an

automatic hammer is different than the N-value determined by the safety hammer method. Most correlations that are published in the technical literature are based on the N-value determined by the safety hammer method. This is commonly termed N_{60} as the rope and cathead with a safety hammer delivers about 60 percent of the theoretical energy delivered by a 140-pound hammer falling 30 inches. Several researchers have proposed correction factors for the use of hammers other than the safety hammer to correct the values to be equivalent to the safety hammer SPT N_{60}-values. The correction is made using the following equation:

$$N_{60} = N_{field} \times C_E$$

where N_{field} is the value recorded in the field and CE is the drill rod energy ratio for the hammer utilized in the field. A correction factor (CE) of 1.45 was utilized to convert N_{field} values to N_{60} values for analysis in this exploration. This correction factor is based on specific energy measurements obtained utilizing the specific automatic hammer assembly used in this exploration. The N-values reported on the Boring Logs and Subsurface Profiles included in this report are the actual, uncorrected, field derived values (N_{field}).

Subsurface water level readings were taken in each of the borings during drilling and immediately upon completion of the drilling process. 24-hour subsurface water level readings were taken in all of the borings. The borings were then backfilled utilizing soil cuttings from the bore hole.

3.2 Laboratory Testing

Representative portions of the split-spoon soil samples and bulk sample obtained throughout the exploration program were placed in glass jars and plastic bags, respectively, and transported to our laboratory. The samples were transported to our laboratory for further visual evaluation and selected laboratory testing. In the laboratory, the soil samples were evaluated by a member of our professional staff in general accordance with techniques outlined in the visual-manual identification procedure (ASTM D 2488) and the Unified Soil Classification System (ASTM D 2487). The soil descriptions and classifications discussed in this report and shown on the attached boring logs are based on visual observation and should be considered approximate. Copies of the boring logs are provided and classification procedures are further explained in the attached Appendix II.

Laboratory tests were performed on selected split spoon samples in general accordance with applicable American Society for Testing and Materials (ASTM) methods. The tests performed were Water Content (ASTM D 2216), Atterberg Limits (ASTM D 4318), and Mechanical Sieve Analysis with Hydrometer (ASTM D 6913).

Soil samples recovered on this project will be stored at F&R's office for a period of sixty days. After sixty days, the samples will be discarded unless prior notification is provided to us in writing.

4.0 REGIONAL GEOLOGY & SUBSURFACE CONDITIONS

4.1 Regional Geology

Available geologic references (Geologic Map of the Washington West 30' x 60' Quadrangle, Maryland, Virginia, and Washington D.C.) indicate that the site is underlain by soil of the Coastal Plain as shown on the attached site Geology Map, Drawing No. 3. The site is underlain by the Potomac Formation. Soil in this area typically consists of montmorillonite-illite clay and clayey sand, yellowish brown sandy silt and clay.

The on-site soils, as mapped by the USDA Web Soil Survey, are *Urban Land - Sassafras Complex, Urban Land – Udorthents Complex and Sassafras-Urban Land Complex*. Urban land soils have been disturbed from their natural state. These soils are characterized by medium run off class and depths to subsurface water of more than 80 to inches.

4.2 Subsurface Conditions

4.2.1 General

The subsurface conditions discussed in the following paragraphs and those shown on the attached boring logs represent an estimate of the subsurface conditions based on interpretation of the boring data using normally accepted geotechnical engineering judgments. The transitions between different soil strata are usually less distinct than those shown on the boring logs. Although individual soil test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. Data from the specific soil test borings are shown on the attached boring logs in Appendix II.

Below the existing ground surface, the borings generally encountered a subsurface profile of surficial soils, possible fill and fill overlying alluvial and coastal deposits. Test boring data was used to develop generalized profiles for the site. These profiles can be found in Appendix I, Drawing Nos. 4.1 through 4.2 of this report.

4.2.2 Surficial Soil

Surficial soil of 2 inches was encountered within borings B-1 through B-5. Surficial soil is typically a dark colored soil material containing roots, fibrous matter, and/or other organic components, and is generally unsuitable for engineering purposes. F&R has not performed any laboratory testing to determine the organic content or other horticultural properties of the observed surficial soil material; therefore, the term surficial soil is not intended to indicate suitability for landscaping and/or other purposes.

The surficial soil depths provided in this report are based on driller observations and should be considered approximate. We note that the transition from surficial soil to underlying materials may be gradual, and therefore, the observation and measurement of surficial soil depths are subjective. Actual surficial soil depths should be expected to vary.

4.2.3 Fill and Possible Materials

Fill and possible materials were encountered within test borings B-2 through B-8 underlying the surficial soils extending to depths ranging from 2.0 to 8.0 feet. Fill and possible fill materials encountered in this exploration consisted of LEAN CLAY (CL) with various amounts of sand and gravel, POORLY-GRADED GRAVEL WITH SAND (GP), CLAYEY SAND (SC) with various amounts of gravel, and SILTY SAND (SM). Standard Penetration Test (SPT) N-values ranging from 2 to 57 blows per foot (bpf) indicating a very loose to very dense state for granular soils and a firm to very stiff consistency for cohesive soils.

4.2.4 Coastal Deposits

The Coastal Plain is formed by alluvial deposition of soil and sedimentation. Coastal deposits were encountered within all of the test borings beneath the surficial soil and fill materials to the termination depths of the borings ranging from 6 to 10 feet below ground surface. Coastal Deposits encountered in this exploration consisted of SANDY LEAN CLAY (CL), CLAYEY SAND (SC), SILTY SAND (SM), and POORLY-GRADED SAND (SP). SPT N-values ranging from 7 to 18 bpf were recorded for the soils in this stratum indicating a very stiff consistency for the cohesive soils and a loose to medium dense state for the granular soils. An average SPT N-value of 13 bpf was recorded for the soils in this stratum.

4.3 Subsurface Water

Subsurface water was encountered at depths ranging from 4.8 to 9.7 feet 24 hours after completion of drilling, at completion of drilling, and during drilling for borings B-4, B-5, and B-7. Generally, seasonal and yearly fluctuations of the water table should be expected with variations in precipitation, surface runoff, evaporation, and other similar factors.

In accordance with Virginia Department of Environmental Quality (VDEQ) requirements, the Seasonal High Water Table (SHWT) may be determined by direct observation of the subsurface water level between the months of November through May.

4.3 Laboratory Test Results

The results of the geotechnical laboratory tests are summarized in Table 2 below and are presented in Appendix III of this report.

Table 2. Soil Classification Test Summary

Boring No.	Sample Depth (ft)	Water Content (%)	% Retained on No. 4 Sieve	% Finer than No. 200 Sieve	Atterberg Limits			% Silt[1]	% Clay[1]	USCS Classification	USDA Textural Classification[1]
					L.L.	P.L.	P.I.				
B-2	2.0 – 4.0	12.9	78.9	21.1	54	26	28	5.7	15.4	SC	Sandy Loam
B-5	2.0 – 4.0	17.1	78.0	22.0	50	28	22	5.9	16.1	SC	Sandy Loam

1. % Silt and % Clay determined in accordance with ASTM D 6913 Mechanical Sieve Analysis with Hydrometer

5.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

5.1 General

The following evaluations and recommendations are based on our observations at the site, interpretation of the field and laboratory data obtained during the exploration at the site, and our experience with similar subsurface conditions and projects. Soil samples collected from the site have been utilized to evaluate the subsurface conditions as they relate to the proposed construction. Subsurface conditions in unexplored locations may vary from those encountered. If the locations of the proposed permeable paver facility are moved, we request that we be advised so that we may re-evaluate our recommendations.

5.2 Permeable Paver Facility

A permeable paver facility is planned to be constructed within the site. The invert elevations are described in Section 2.1, Proposed Construction.

Fill soils were encountered at the invert elevations at all locations at the site, with the exception of boring location B-1. The Virginia Department of Environmental Quality (VDEQ) does not permit infiltration practices above fill soils. For this reason, the soils encountered within all the borings with the exception of B-1 are not suitable for infiltration at the planned invert elevation. If infiltration is desirable, the invert elevation may be lowered to the elevations where residual soils were encountered as shown in the boring logs. Coastal deposit soil was encountered at depths ranging from 2 feet to 8 feet beneath the ground surface within borings B-2 through B-8. In addition, infiltration would not be suitable within the coastal deposit soil encountered at boring B-3 due to the presence of clay.

In accordance with the Virginia Stormwater Management Handbook, 3.10, soil textures with infiltration rates less than 0.52 inches per hour or greater than 8.27 inches per hour are not suitable for infiltration practices. The Virginia Department of Environmental Quality requires field infiltration

testing to establish actual infiltration rates. Field infiltration testing was not included within our scope of work. USDA textural classifications were performed on the soils underlying the permeable paver facility at boring locations B-1 and B-5 at 2 feet beneath existing grades. These textural classifications correspond to SANDY LOAM. Table 3.10 of the *Virginia Stormwater Management Handbook* (1999) shows soil classifying as Sandy Loam has an anticipated minimum infiltration rate 1.02 inches/hour. If infiltration is desirable, field infiltration testing should be conducted to confirm these infiltration rates. As noted above, infiltration is not suitable at boring locations B-2 through B-8 at the planned invert elevation due to the presence of fill soils. In addition, infiltration would not be suitable within the coastal deposit soil encountered at boring B-3 due to the presence of clay.

There should be a minimum separation of 2.0 feet between the groundwater table or the Seasonal High Water Table (SHWT) and the bottom of the infiltration facility. In accordance with VDEQ requirements, the Seasonal High Water Table (SHWT) may be determined by direct observation of the subsurface water level between the months of November through May. Subsurface water was encountered within borings B-4, B-5, and B-7 at depths ranging from 4.7 and 9.7 feet below ground surface. Therefore, the SHWT is located at least 2 feet below the invert elevation of the permeable paver facility at all boring locations.

Existing fill and possible fill materials were encountered within proposed permeable pavement areas in test borings B-2 through B-8 to approximate depths ranging from 2.0 to 8.0 feet below existing site grades. Any undercutting and/or in-place stabilization required shall be evaluated by the geotechnical engineer of record at the time of construction.

6.0 GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

6.1 Site Preparation

Before proceeding with construction, any surficial soils, and other deleterious non-soil materials should be stripped or removed from the proposed construction area. During the clearing and stripping operations, positive surface drainage should be maintained to prevent the accumulation of water.

After stripping, areas intended to support permeable paver facility should be carefully evaluated by a geotechnical engineer. At that time, the engineer shall require proofrolling of the subgrade with a 20- to 30-ton loaded truck or other pneumatic-tired vehicle of similar size and weight. Proofrolling should be performed during a time of good weather and not while the site is wet, frozen, or severely desiccated. The purpose of the proofrolling is to locate soft, weak, or excessively wet soils present at the time of construction.

Any unsuitable materials observed during the evaluation and proofrolling operations should be undercut and replaced with compacted fill and/or stabilized in-place.

The proofrolling process provides a good opportunity to identify areas of poorer support materials intermediate of the boring locations, if present. If encountered, low-consistency materials may require undercutting and/or in-place stabilization. The possible need for, and extent of, undercutting and/or in-place stabilization required can best be determined by the geotechnical engineer at the time of construction. Once the site has been properly prepared, at-grade construction may proceed. It should be noted that compaction of weak soils may remove the infiltration function of the subgrade.

To the maximum extent possible, heavy equipment traffic within the footprint of the permeable pavement system should be avoided to avoid compaction of the permeable pavement subgrade. The specifications outlined in Virginia Department of Environmental Quality Stormwater Design Specification No. 7 *Permeable Pavement* and the specifications provided by the permeable pavement system manufacturer should be followed.

6.2 Structural Fill Placement and Compaction

All fill utilized in the construction of the new permeable paver facility should be controlled fill, if necessary. It should be noted that compaction of permeable pavement subgrade soils will severely reduce the infiltration function and this reduction should be considered during design. Compaction of the base stone and/or interlocking pavers is typically required for stability and should follow manufacturer recommendations. It is our expectation that the materials excavated on site will be used as controlled fill. The final grading was not available at the time of writing this report.

Based on the boring data, controlled fill may be constructed using the non-organic on-site soils and/or an off-site borrow source having a classification of GW, GP, SW, SP as defined by the Unified Soil Classification System. Fill materials should have a maximum liquid limit of 40 and plasticity index less than 15. Other materials may be suitable for use as controlled structural fill material and should be individually evaluated by the geotechnical engineer. Controlled fill should be free of boulders, organic matter, debris, or other deleterious materials and should have a maximum particle size no greater than 3 inches. In addition, we recommend a minimum standard Proctor (ASTM D 698) maximum dry density of approximately 100 pounds per cubic feet for fill materials.

After acceptance of the soil subgrade, fill materials should be placed in horizontal lifts with a maximum height of 8 inches loose measure. New fill should be adequately keyed into stripped and scarified subgrade soils and should, where applicable, be benched into the existing slopes. During fill operations, positive surface drainage should be maintained to prevent the accumulation of water. We recommend that structural fill be compacted to at least 95 percent of the standard

Proctor maximum dry density. In confined areas such as utility trenches, portable compaction equipment and thin lifts of 3 to 4 inches may be required to achieve specified degrees of compaction.

In general, we recommend that the moisture content of fill soils be maintained within three percentage points of the optimum moisture content as determined from the standard Proctor density test. Excessively wet or excessively dry soils should not be used as fill material without proper drying or wetting. We recommend that the contractor have equipment on site during earthwork for both drying and wetting of fill soils. Each lift of fill should be tested in order to confirm that the recommended degree of compaction is attained.

Each lift of fill should be tested in order to confirm that the recommended degree of compaction is attained. Field density tests to verify fill compaction should be performed for every 2,500 square feet (approximately 50 feet square) of fill area, with a minimum of two tests per lift. In confined areas, a greater frequency may be required.

6.3 Subsurface Water Conditions

Subsurface water for the purposes of this report is defined as water encountered below the existing ground surface. As previously noted, the subsurface water was encountered within borings B-4, B-5, and B-7 at depths ranging from 4.7 to 9.7 feet during drilling, at completion of drilling, and 24 hours after completion of drilling. Subsurface water is not expected to be encountered during construction. However, the contractor should be prepared to dewater storm water runoff during construction. Perched water may be encountered during installation of the permeable paver facility and should be allowed to drain. Fluctuations in subsurface water levels and soil moisture can be anticipated with changes in precipitation, runoff, and season.

7.0 CONTINUATION OF SERVICES

We recommend that we be given the opportunity to review the grading plan and project specifications when construction documents approach completion. This review evaluates whether the recommendations and comments provided herein have been understood and properly implemented. We also recommend that Froehling & Robertson, Inc. be retained for professional and construction materials testing services during construction of the project. Our continued involvement on the project helps provide continuity for proper implementation of the recommendations discussed herein.

The Geotechnical Engineer of Record should be retained to monitor and test earthwork activities and subgrade preparations for permeable paver facility. It should be noted that the actual soil conditions at the various subgrade and invert depths will vary across this site and thus the presence of the Geotechnical Engineer and/or his representative during construction will serve to validate the

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

- Review of project plans and construction specifications to verify that the recommendations presented in this report have been properly interpreted and implemented;
- Observe and perform testing during construction to evaluate the installation characteristics of the subgrade soils and to ensure they are consistent with those anticipated in this report;
- Observe subgrade preparation including any proofrolling operations, undercutting of soft/loose unsuitable soils, installation of drainage materials, geotextiles and fill placement;

8.0 LIMITATIONS

This report has been prepared for the exclusive use of the Arlington Department of Environmental Services or their agent, for specific application to the construction of the proposed permeable pavement system located at the 31st Street S Parking Lot site in Arlington, Virginia, in accordance with generally accepted soil engineering practices. No other warranty, express or implied, is made. Our evaluations and recommendations are based on design information furnished to us; the data obtained from the previously described subsurface exploration program, and generally accepted geotechnical engineering practice. The evaluations and recommendations do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to re-evaluate our recommendations based upon on-site observations of the conditions.

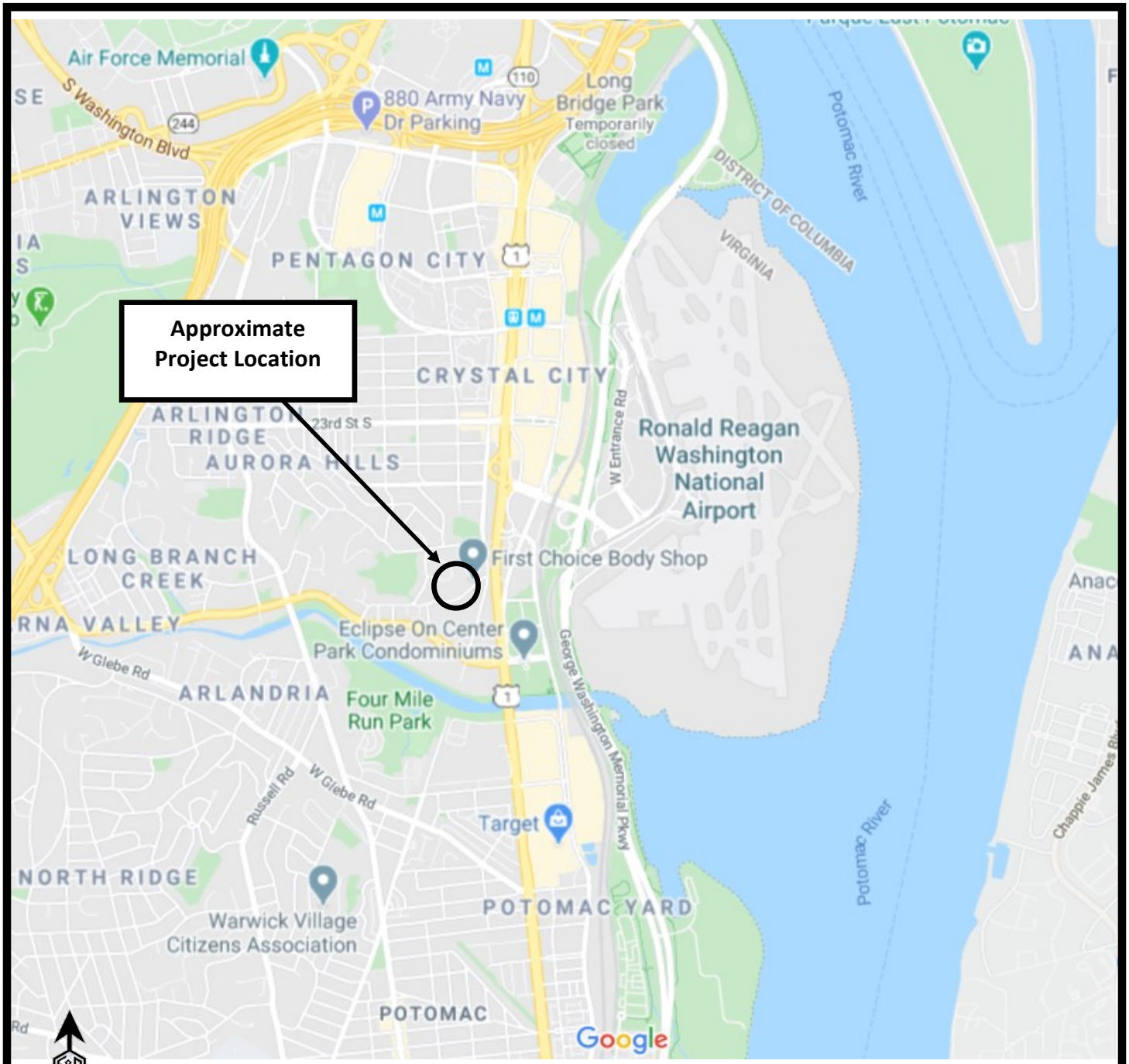
There are important limitations to this and all geotechnical studies. Some of these limitations are discussed in the information prepared by GBA, which is included in Appendix IV. We ask that you please review this GBA information.

Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should evaluate earthwork and pavement construction to verify that the conditions anticipated in design actually exist. Otherwise, we assume no responsibility for construction compliance with the design concepts, specifications, or recommendations.

In the event that changes are made in the design or location of the proposed structures, the recommendations presented in the report shall not be considered valid unless the changes are

reviewed by our firm and conclusions of this report modified and/or verified in writing. If this report is copied or transmitted to a third party, it must be copied or transmitted in its entirety, including text, attachments, and enclosures. Interpretations based on only a part of this report may not be valid.

APPENDIX I



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DATE: April 2020

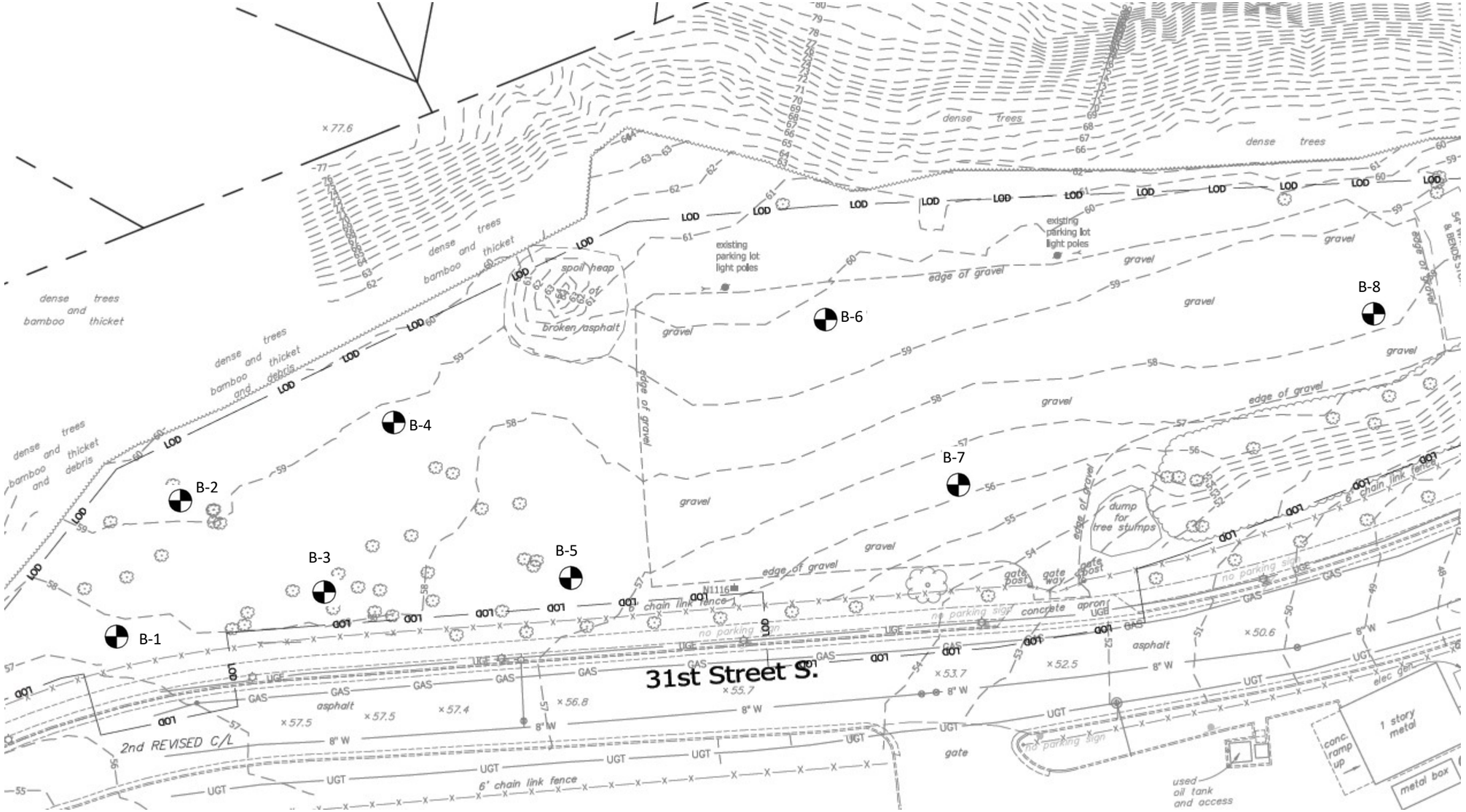
SOURCE: Google Maps

DRAWN: WBK

F&R # 72Y0060

Site Location Map
31st Street Parking Lot
Arlington, Virginia
Arlington Department of Environmental Services

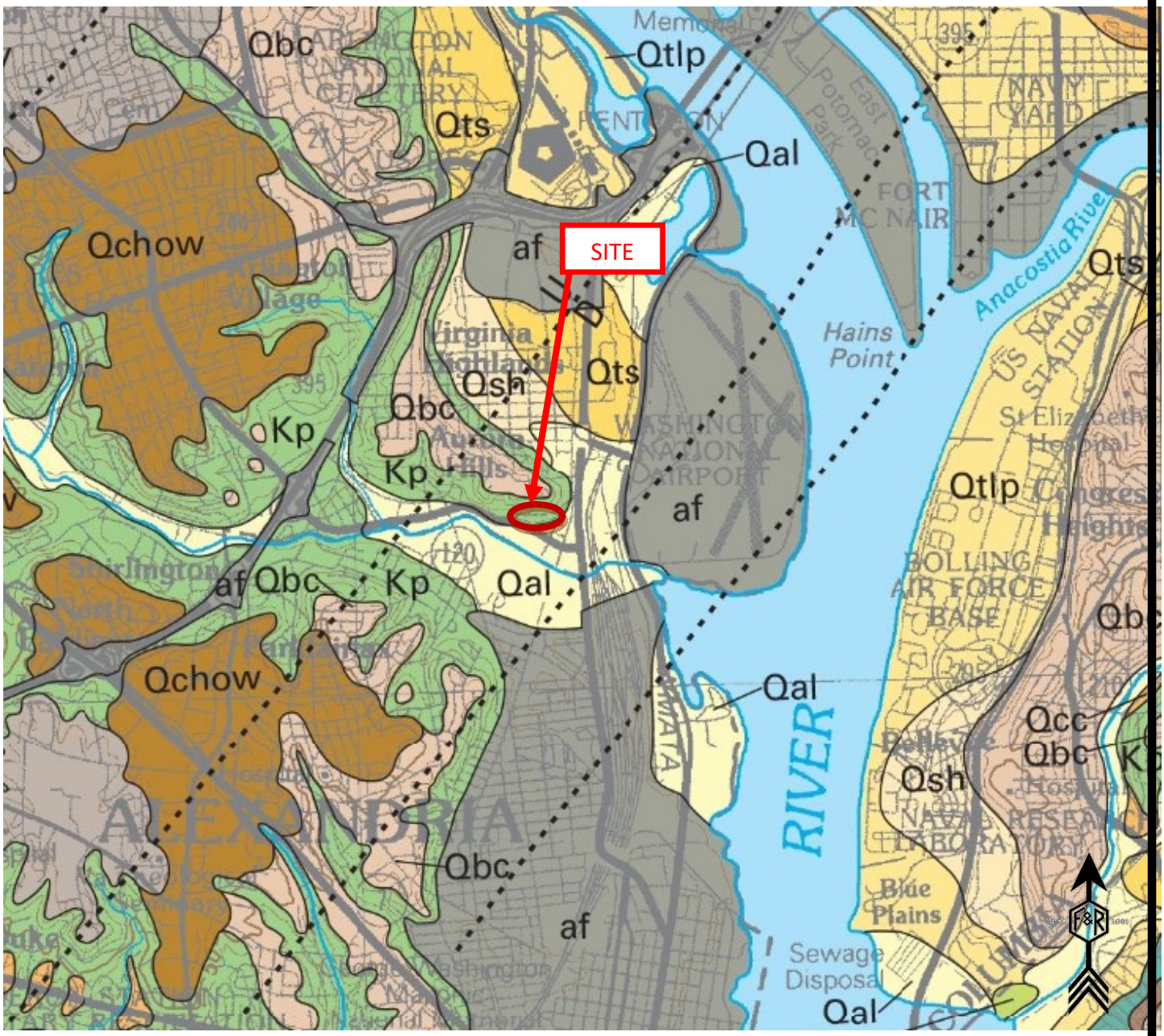
Drawing No.
1



Legend:

- Approximate Boring Location

FROEHLING & ROBERTSON, INC. *Engineering Stability Since 1881*	**Boring Location Plan** 31st Street Parking Lot Arlington Department of Environmental Services Arlington, Virginia	DRAWN: WBK	SOURCE: Plans titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Ferns Street and S. Eads Street*, dated February 14, 2020 and prepared by the Arlington Department of Environmental Services	Drawing No. 3
		SCALE: NTS	F&R No. 72Y0060	DATE: April 2020



Note: Drawing adapted from the Geologic Map of the Washington West 30' x 60' Quadrangle, Maryland, Virginia and Washington D.C., by Lyttle, Aleinikoff, Burton, Drider, et. al, 2017

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DATE: April 2020	SCALE: NTS
SOURCE: See Note	
DRAWN: WBK	F&R # 72Y0060

Geologic Map of Project Site
31st Street S. Parking Lot
Arlington, Virginia
Arlington Department of Environmental Services

Drawing No.
3

APPENDIX II

KEY TO SOIL CLASSIFICATION

Correlation of Penetration Resistance with Relative Density and Consistency

Sands and Gravels		Silts and Clays	
No. of Blows, N	Relative Density	No. of Blows, N	Consistency
0 - 4	Very loose	0 - 2	Very soft
5 - 10	Loose	3 - 4	Soft
11 - 30	Medium dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
Over 50	Very dense	16 - 30	Very stiff
		31 - 50	Hard
		Over 50	Very hard

Particle Size Identification

(Unified Classification System)

Boulders:	Diameter exceeds 12-in. (300-mm)
Cobbles:	3-in. (75-mm) to 12-in. (300-mm) diameter
Gravel:	**Coarse** - ¾-in. (19-mm) to 3 in. (75-mm) diameter **Fine** - No. 4 (4.75-mm) sieve to ¾-in. (19-mm) diameter
Sand:	**Coarse** – No. 10 (2.0-mm) to No. 4 (4.76 mm) sieve **Medium** – No. 40 (0.425-mm) to No. 10 (2.0-mm) sieve **Fine** - No. 200 (0.075-mm) to No. 40 (0.425-mm) sieve
Silt and Clay:	Less than No. 200 (0.075-mm) sieve

Modifiers

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

Approximate Content	Modifiers
≤ 5%:	Trace
5 to 10%:	Few
15 to 25%:	Little
30 to 45%:	Some
50 to 100%	Mostly

	Field Moisture Description
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487

(Based on Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retaining on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well graded gravel [F]
			Cu < 4 and/or 1> Cc >3 [E]	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12 % fines[C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K,L,M]
		Organic	Liquid limit - oven dried <0.75 Liquid limit - not dried	OL	Organic clay [K,L,M,N]
					Organic silt [K,L,M,O]
	Silts and Clays Liquid Limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [K,L,M]
			PI plots below "A" line	MH	Elastic silt [K,L,M]
		Organic	Liquid limit - oven dried <0.75 Liquid limit - not dried	OH	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in (75 mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2/(D_{10}*D_{60})$

[F] If soil contains ≥ 15% sand, add "with sand" to the group name

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM

[H] If fines are organic, add "with organic fines" to the group name

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name

[J] If Atterberg limits plot in hatched area, soils is a CL-ML, silty clay

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant

[L] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name

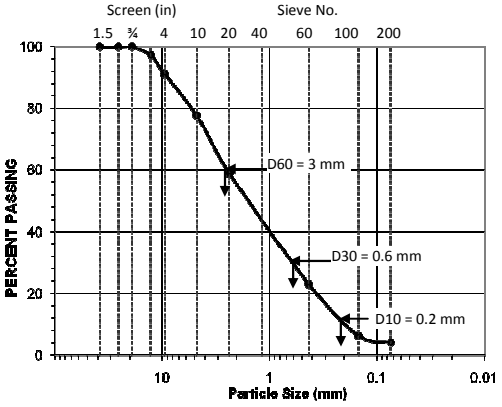
[N] PI ≥ 4 and plots on or above "A" line

[O] PI < 4 or plots below "A" line

[P] PI plots on or above "A" line

[Q] PI plots below "A" line

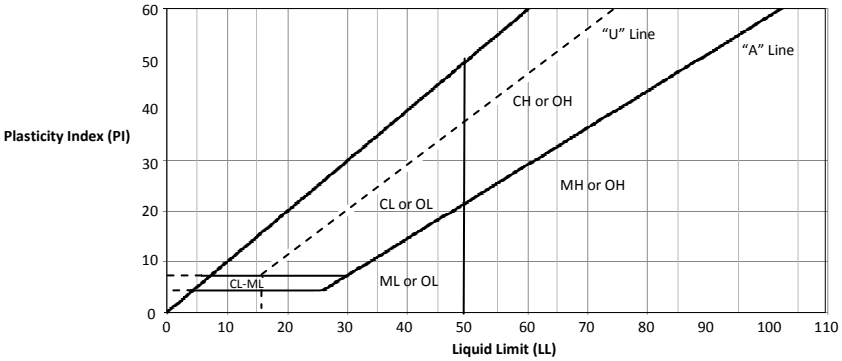
SIEVE ANALYSIS



$Cu = D_{60}/D_{10} = (3/0.2) = 15$

$Cc = (D_{30})^2/(D_{10}*D_{60}) = (0.6^2)/(0.2*3) = 0.6$

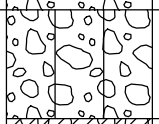
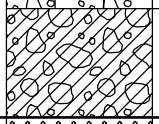
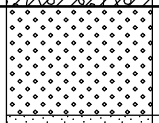
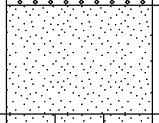
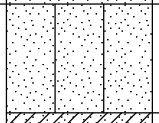
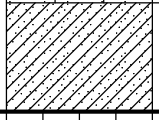
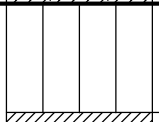
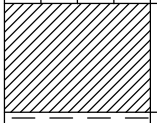
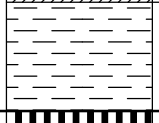
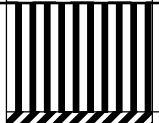
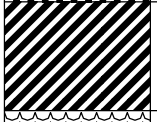
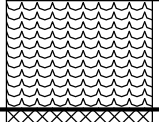
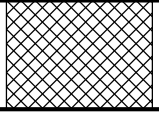
For classification of fine-grained soils and fine-grained fraction of coarse-grained soils:



Equation of "A" line: Horizontal at PI = 4 to LL = 22.5, then PI = 0.73*(LL-20)

Equation of "U" line: Vertical at LL = 16 to PI = 7, then PI = 0.9*(LL-8)

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
EXISTING FILL				FILL	EXISTING FILL MATERIALS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

SINCE 1881

Froehling & Robertson, Inc.

BORING LOG

Boring: B-1 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 57.8 ± [1]
Total Depth: 8.5'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
57.6	0.2	2 inches of **SURFICIAL SOIL**	3-4-3 -3	0.0	7	
		COASTAL DEPOSITS: Mottled gray, red brown, and brown, medium, CLAYEY SAND (SC), loose to medium dense, moist	8-4-3 -3	2.0	7	LL : 54 | PI : 28 | <#200: 21.1 | MC : 12.9
			3-3-4 -6	4.0	7	
			3-8-9 -13	6.0	17	
				8.0		
49.3	8.5	Boring terminated at 8.5 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling				Boring dry upon completion of drilling Boring dry 24 hours after completion of drilling Cave-in depth at 8 feet 24 hours after completion of drilling

1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.

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

SINCE 1881

Froehling & Robertson, Inc.

Boring LOG

Boring: B-2 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 59.4 ± [1]
Total Depth: 6.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
59.2	0.2	2 inches of **SURFICIAL SOIL** **FILL:** Mottled light brown and gray, medium, CLAYEY SAND (SC), loose, moist	2-3-3 -2	0.0	6	
		With organic matter at 2 feet	6-6-5 -3	2.0	11	
55.4	4.0	**COASTAL DEPOSITS:** Mottled light brown and gray, medium, POORLY-GRADED SAND (SP), medium dense, moist	4-6-6 -3	4.0	12	
53.4	6.0	Boring terminated at 6 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling 1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.		6.0		Boring dry upon completion of drilling Boring dry 24 hours after completion of drilling Cave-in depth at 6 feet 24 hours after completion of drilling

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

SINCE 1881

Froehling & Robertson, Inc.

Boring LOG

Boring: B-3 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 58.3 ± [1]
Total Depth: 6.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
58.1	0.2	2 inches of **SURFICIAL SOIL** **FILL:** Light brown and dark brown, medium, CLAYEY SAND (SC), little gravel, with organic matter, medium dense, moist	6-9-8 -12	0.0	17	
56.3	2.0	Light yellow brown, coarse, POORLY-GRADED GRAVEL WITH SAND (GP), trace organic matter, trace metal shavings, with quartz fragments, very dense, dry	21-34-23 -21	2.0	57	
54.3	4.0	**COASTAL DEPOSITS:** Mottled red brown and light brown, SANDY LEAN CLAY (CL), trace roots, very stiff, moist	13-14-4 -5	4.0	18	
52.3	6.0	Boring terminated at 6.0 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling 1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.		6.0		Boring dry upon completion of drilling Boring dry 24 hours after completion of drilling Cave-in depth at 6 feet 24 hours after completion of drilling

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

Froehling & Robertson, Inc.

Boring LOG

Boring: B-4 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 58.7 ± [1]
Total Depth: 6.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
58.5	0.2	2 inches of **SURFICIAL SOIL** **FILL:** Light gray and dark gray, medium, CLAYEY SAND (SC), trace glass fragments, loose, moist	4-5-5 -5	0.0	10	
56.7	2.0	**COASTAL DEPOSITS:** Light gray, fine to medium, SILTY SAND (SM), loose to medium dense, moist	5-3-7 -10	2.0	10	
			7-9-9 -9	4.0	18	Subsurface water encountered at 4.7 feet 24 hours after completion of drilling
52.7	6.0	Boring terminated at 6 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling 1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.		6.0		Boring dry upon completion of drilling Cave-in depth at 5.6 feet 24 hours after completion of drilling

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

SINCE 1881

Froehling & Robertson, Inc.

Boring LOG

Boring: B-5 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 57.5 ± [1]
Total Depth: 6.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
57.3	0.2	2 inches of **SURFICIAL SOIL**	4-5-6 -8	0.0	11	
		FILL: Red brown and dark gray, fine to medium, SILTY SAND (SM), contains pocket of lean clay, trace gravel, medium dense, moist				
55.5	2.0	**COASTAL PLAIN DEPOSITS:** Mottled light brown and light gray, fine to medium, CLAYEY SAND (SC), medium dense, moist	5-6-6 -7	2.0	12	LL: 50 | PI : 22 | <#200 : 22 | MC : 17.1
			6-7-8 -9	4.0	15	Subsurface water encountered at 5 feet 24 hours after completion of drilling Subsurface water encountered at 5.9 feet during drilling.
51.5	6.0	Boring terminated at 6 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling		6.0		Cave-in depth at 5.8 feet 24 hours after completion of drilling

1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.

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

Froehling & Robertson, Inc.

Boring LOG

Boring: B-6 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 59.8 ± [1]
Total Depth: 6.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
		FILL: Light gray and dark brown, SANDY LEAN CLAY (CL), little gravel, with wood fragments, very stiff, moist	8-9-9 -11	0.0	18	
			6-13-10 -12	2.0	23	
55.8	4.0	**COASTAL DEPOSITS:** Mottled gray brown and red brown, fine to medium, CLAYEY SAND (SC), medium dense, moist	7-9-8 -11	4.0	17	
53.8	6.0	Boring terminated at 6 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling		6.0		Boring dry upon completion of drilling. Boring dry 24 hours after completion of drilling Cave-in depth at 5.6 feet 24 hours after completion of drilling

1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.

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

Froehling & Robertson, Inc.

Boring LOG

Boring: B-7 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 56.2 ± [1]
Total Depth: 10.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
		FILL: Light brown and dark gray, medium, CLAYEY SAND (SC), little gravel, medium dense, moist	17-11-10 -9	0.0	21	
		Trace glass and organic odor at 2 feet	14-10-13 -10	2.0	23	
52.2	4.0	Red brown, SANDY LEAN CLAY (CL), little gravel, firm, moist	7-4-4 -4	4.0	8	
50.2	6.0	**POSSIBLE FILL:** Light brown, medium, CLAYEY SAND (SC), little organic matter, very loose, wet	2-1-1 -8	6.0	2	
48.2	8.0	**COASTAL DEPOSITS:** Light gray, fine, SILTY SAND (SM), medium dense, wet	6-7-11 -12	8.0	18	Subsurface water encountered at 9.7 feet at completion of drilling
46.2	10.0	Boring terminated at 10 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling		10.0		Boring dry 24 hours after completion of drilling
		1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.				Cave-in depth at 8.9 feet 24 hours after completion of drilling

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

Froehling & Robertson, Inc.

Boring LOG

Boring: B-8 (1 of 1)

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia

Elevation: 58.3 ± [1]
Total Depth: 8.0'
Location: See Boring Location Plan

Drilling Method: HSA 2.25"
Hammer Type: Automatic
Date Drilled: 4/2/20
Driller: North

Elevation	Depth	Description of Materials (Classification)	* Sample Blows	Sample Depth (feet)	N-Value (blows/ft)	Remarks
		FILL: Dark gray and red brown, medium, CLAYEY SAND WITH GRAVEL (SC), little brick fragments, dense, moist	10-22-10 -11	0.0	32	
56.3	2.0	Dark gray, LEAN CLAY WITH GRAVEL (CL), little sand, firm, moist	5-3-4 -6	2.0	7	
			5-6-2 -3	4.0	8	
52.3	6.0	**COASTAL DEPOSITS:** Mottled light gray and light brown, medium, CLAYEY SAND (SC), loose, moist	2-3-4 -13	6.0	7	
50.3	8.0	Boring terminated at 8 feet. Boring backfilled with soil cuttings 24 hours after completion of drilling		8.0		Boring dry upon completion of drilling. Boring dry 24 hours after completion of drilling Cave-in depth at 7.2 feet 24 hours after completion of drilling

1. Elevations taken from the drawings titled *Soil Boring Locations, 31st Street S. Parking Lot, WPB5, Between S. Fern Street and S. Eads Street* prepared by Arlington County Department of Environmental Services and dated February 14, 2020.

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

APPENDIX III

Froehling & Robertson, Inc.

LABORATORY TEST SUMMARY SHEET

Project No: 72Y0060

Client: Department of Environmental Services

Project: 31st Street Parking Lot

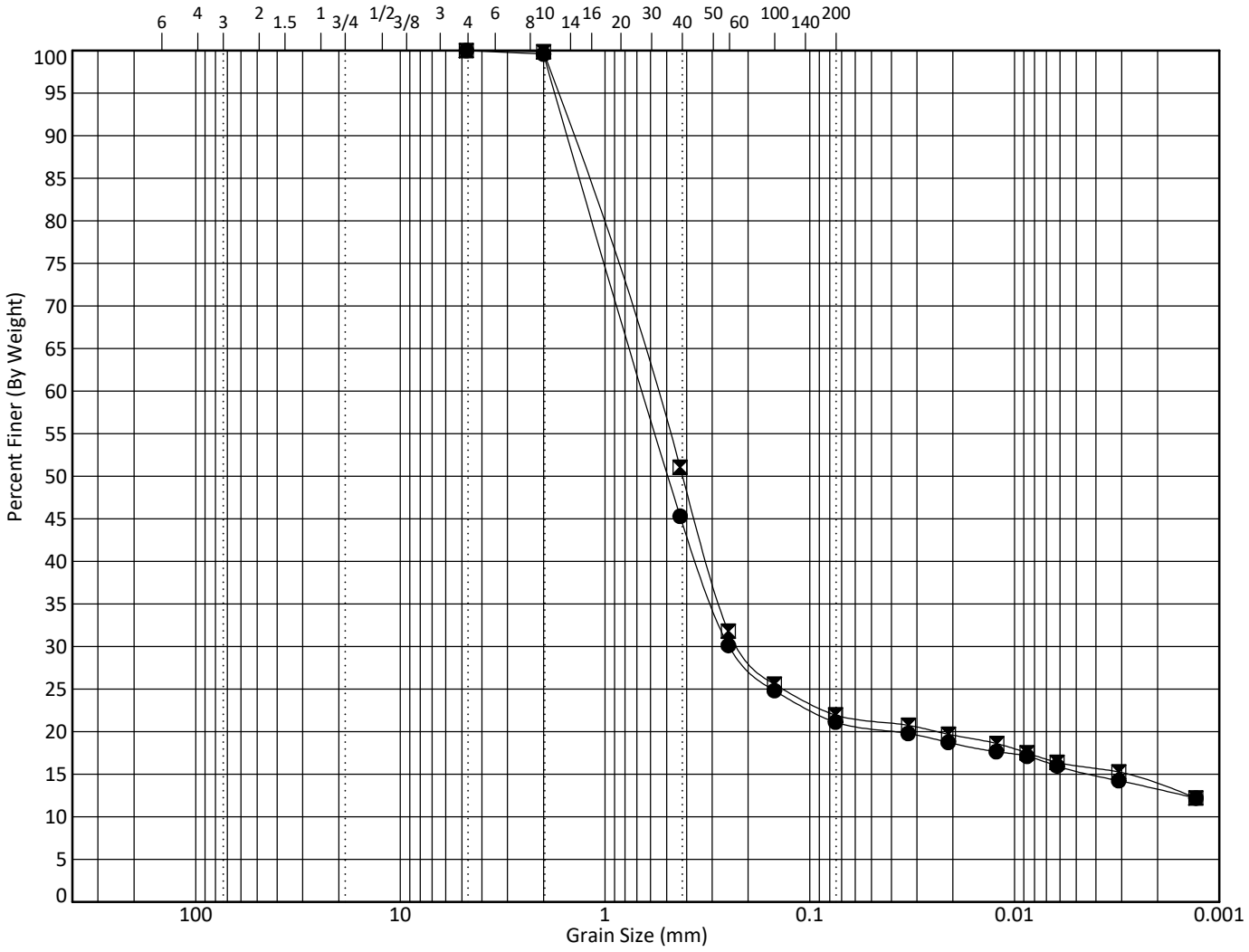
City/State: Arlington County, Virginia

Boring/ Sample No.	Depth (m)	LL	PL	PI	Water Content (%)	% Gravel	% Sand	% Fines	USCS Class.	AASHTO Class.	Maximum Dry Density (pcf)	Optimum Water Content (%)	CBR Value @ 0.1
B-1	2.0	54	26	28	12.9	0.0	78.9	21.1	SC	A-2-7			
B-5	2.0	50	28	22	17.1	0.0	78.0	22.0	SC	A-2-7			

Froehling & Robertson, Inc.

GRAIN SIZE DISTRIBUTION

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring No.		Depth	Classification	LL	PL	PI	Cc	Cu
●	B-1	at	2.0	CLAYEY SAND (SC)	54	26	28		
⊠	B-5	at	2.0	CLAYEY SAND (SC)	50	28	22		
		at							
		at							
		at							

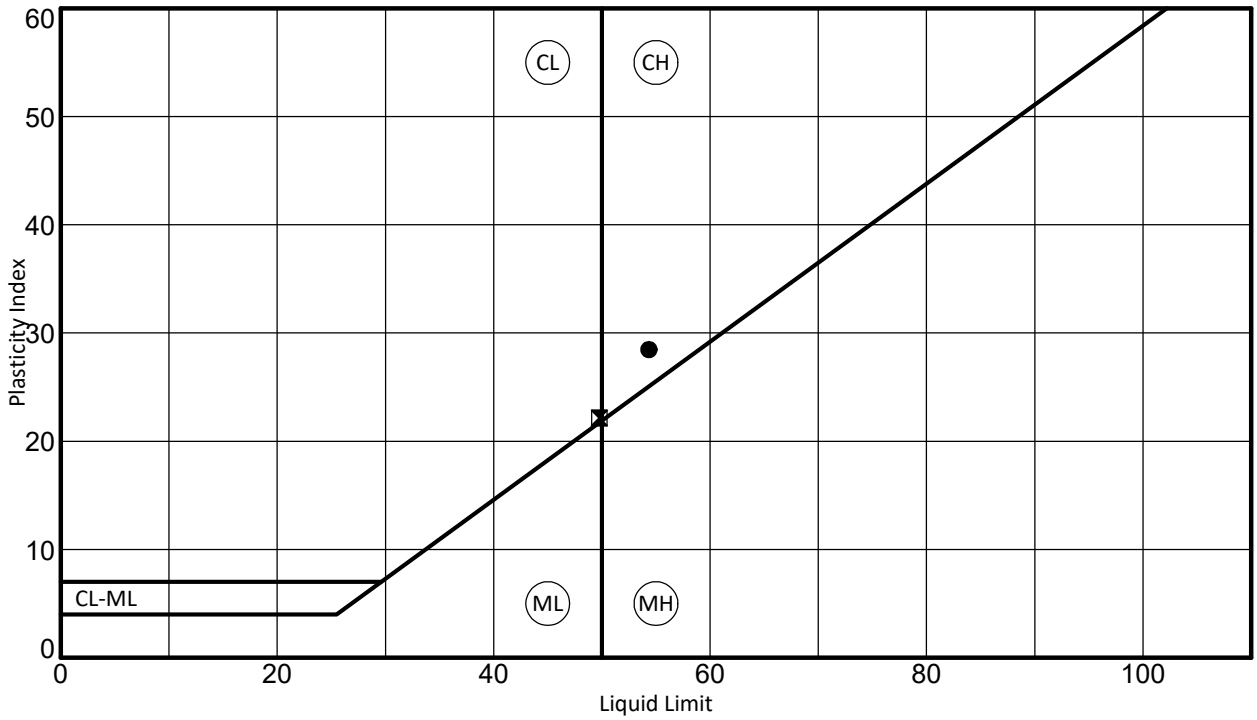
	Boring No.		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	at	2.0	4.76	0.652	0.247		0.0	78.9	5.7	15.4
⊠	B-5	at	2.0	4.76	0.57	0.215		0.0	78.0	5.9	16.1
		at									
		at									
		at									

US_GRAIN_SIZE 72Y0060.GPJ F&R.GDT 4/13/20

Froehling & Robertson, Inc.

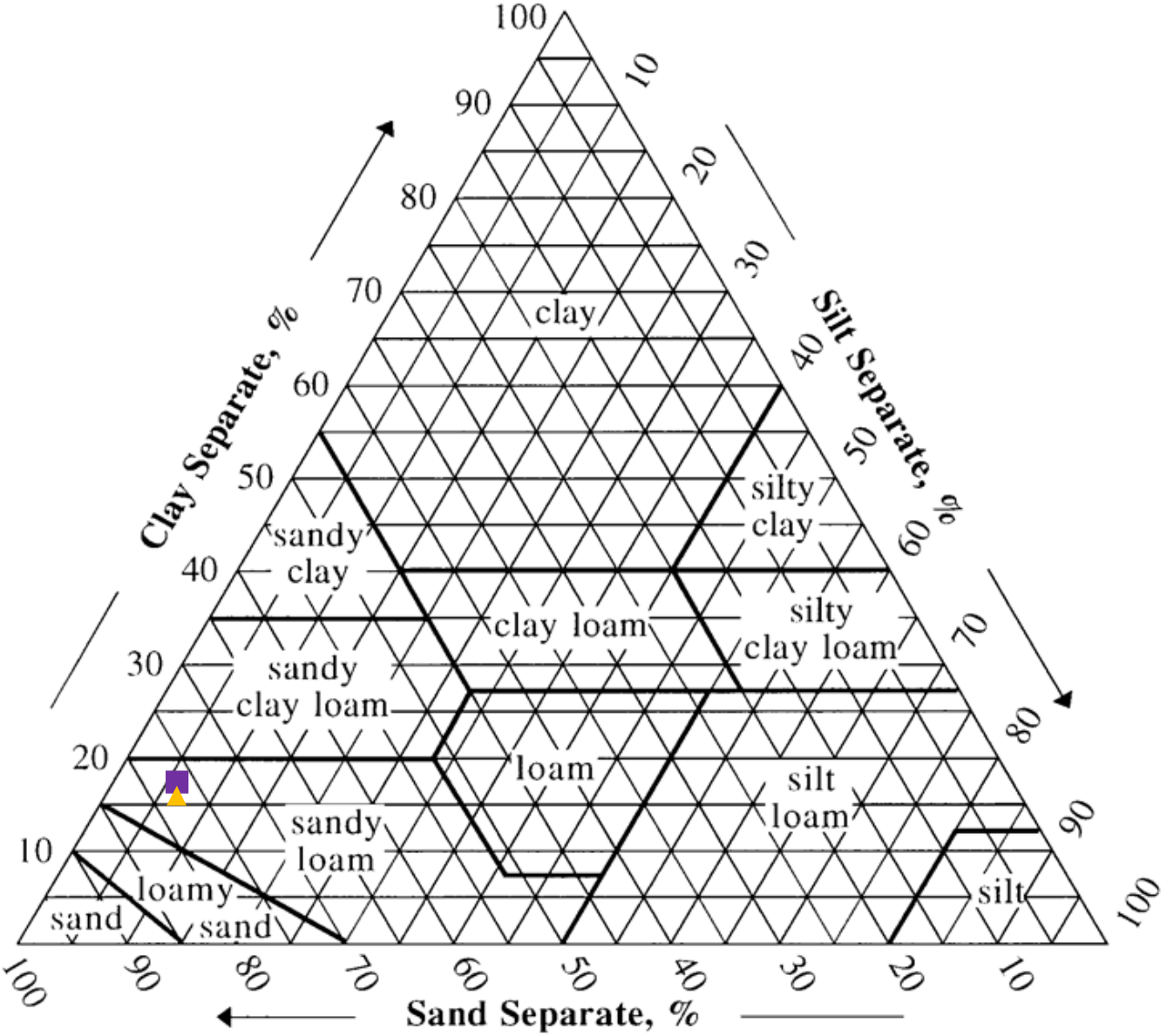
ATTERBERG LIMITS

Project No: 72Y0060
Client: Department of Environmental Services
Project: 31st Street Parking Lot
City/State: Arlington County, Virginia



Boring No.		Depth	LL	PL	PI	Fines	Classification	% Natural Water Content
● B-1	at	2.0	54	26	28	21.1	CLAYEY SAND (SC)	12.9
⧓ B-5	at	2.0	50	28	22	22.0	CLAYEY SAND (SC)	17.1

ATTERBERG_LIMITS_USCS 72Y0060.GPJ F&R.GDT 4/13/20



Boring	Depth (ft)	% Sand	% Silt	% Clay	USDA Classification	Symbol
B-1	0.0 – 2.0	78.9	5.7	15.4	Sandy Loam	▲
B-2	0.0 – 2.0	38.3	36.3	25.4	Loam	■

FROEHLING & ROBERTSON, INC.
Engineering Stability Since 1881
22923 Quicksilver Drive, Suite 111
Sterling, VA 20166
T 703.996.0123 I F 703.996.0124

USDA Textural Triangle	
Client: Arlington Department of Environmental Services	
Project: 31st Street S. Parking Lot	
F&R Project No. 72Y0060	
Date: April 15, 2020	Drawing No.: 4

APPENDIX IV

Important Information about This

Geotechnical-Engineering Report

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

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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