September 9, 2014

Mr. Howard Price
AES Consulting Engineers, Inc.
5248 Olde Towne Road, Suite 1
Williamsburg, Virginia 23188

ECS Project No. 07:12431

Reference: Subsurface Exploration and Geotechnical Engineering Analysis
Waller Mill Park Bulkhead and Boat Ramp Exploration
901 Airport Road
City of Williamsburg, Virginia

Dear Mr. Price,

ECS Mid-Atlantic, LLC has completed a subsurface exploration and engineering evaluation of the above referenced project. This report presents the results of the subsurface exploration and engineering analyses for the existing bulkhead and proposed boat ramp.

Introduction

The project site is comprised of a bulkhead about 180-feet in length within the existing Waller Mill Park in the City of Williamsburg, Virginia. You have requested soil borings, laboratory testing, and data report services in order to provide subsurface information to the structural engineer for bulkhead design (Mr. Bill Johnson with TAM Consultants). In addition, a proposed boat ramp will be located on the west-northwest portion of the parking lot. Finished grades are anticipated to be within +/- 2 feet of existing elevations.

At the time of our site visit, the area behind the existing bulkhead was covered with asphalt pavement that was observed to be failing in some areas (settlement, cracking). The area of the proposed boat ramp was located on the edge of a wooded area containing some trees and low lying vegetation.

The purpose of this exploration was to explore the soil and groundwater conditions at the site and to develop soils-related engineering recommendations to guide design and construction of the boat ramp and provide soil borings to the structural engineer. Our exploration included four (4) 15- to 30-foot deep Standard Penetration Test (SPT) borings to explore the subsurface soil and groundwater conditions, performing a site reconnaissance to observe general topography, and analyzing field data to develop appropriate geotechnical engineering recommendations regarding the planned construction. A Boring Location Plan is included in Appendix I.

Field Exploration Procedures

A total of four (4) SPT borings were completed at the project site. Specifically, three (3) 30-foot deep borings (designated as B-1 through B-3) were performed behind the existing bulkhead. One (1) 15-foot deep boring (designated as B-4) was performed within the proposed boat ramp footprint. The soil borings were advanced with an ATV-mounted auger drill rig which utilized split spoon and mud rotary drilling techniques to advance the boreholes. Drilling services were provided by Fishburne Drilling, Inc. of Chesapeake, Virginia.

Representative samples were obtained from the soil borings by means of the split-barrel sampling procedure in accordance with ASTM Specification D 1586-99, (Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils). Soil samples were collected at 2 foot intervals to a depth of 10 feet bsg and at 5 foot intervals thereafter. In this procedure, a 2 inch O.D., split barrel sampler is driven into a soil a distance of 24 inches by a 140-pound hammer falling 30 inches, using an automatic hammer. The first 6-inch depth increment is considered the seating interval. The number of blows required to drive the sampler through the next two 6-inch intervals is designated the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring logs. The Boring Logs are provided in Appendix II of this report and a copy of the Unified Soil Classification System (USCS) and Reference Notes for Boring Logs are included in Appendix III of this report.

After recovery, representative portions of each sample were removed from the sampler, visually classified and placed in sealed glass jars. A field log of the soils encountered in the soil test borings was maintained by ECS personnel and the drill crew. The samples were taken to our laboratory for classification in accordance with ASTM D 2488-00 (Standard Practice for Description and Identification of Soil (Visual-Manual Procedure)) and laboratory testing.

The soil samples will be retained in our laboratory for a period of 60 days after the date of this report, after which, they will be discarded unless other written instructions are received as to their disposition.

Laboratory Analysis Program

Representative jar samples were selected and subjected to classification testing consisting of natural moisture content and gradation (including #200 wash). A laboratory testing summary is included in Appendix IV.

Subsurface Conditions

Experienced personnel from our office classified each soil sample in accordance with the Unified Soil Classification System (USCS). The group symbols for each soil type are indicated in parentheses following the soil descriptions on the boring logs. The

geotechnical engineer grouped the various soil types into the major zones noted on the boring logs. The stratification lines designating the interfaces between earth materials on the boring logs are approximate; in situ, the transitions may be gradual.

Bulkhead Borings (B-1, B-2, and B-3)

The results from our subsurface exploration indicated approximately up to 3-inches of asphalt underlain by up to 3-inches of aggregate base materials at the boring locations. Underlying the asphalt and aggregate base materials, a layer of uncontrolled FILL materials was encountered at boring location B-2 to a depth of 2-feet below the existing site elevations. The uncontrolled FILL materials generally consisted of loose, Silty SAND (SM), containing trace Gravel. Underlying the asphalt, gravel, or FILL materials, the natural subsurface soils were arranged in a 2-layer configuration.

The initial natural subsurface soil layer was cohesive in nature and consisted of Sandy Lean CLAY (CL) to a depth of 4-feet below the existing site elevations. This layer was not encountered at boring location B-1. The SPT results, N-Values, for the cohesive soils ranged from 4 to 12 blows-per-foot (BPF), indicating a soft to stiff consistency.

The second and final natural subsurface soil layer was granular in nature and consisted of Silty SAND (SM) to the boring termination depth of 30-feet below the existing site elevations. The SPT results, N-Values, for the granular soils ranged from 2 to 30 BPF, indicating a very loose to medium dense relative density.

Boat Ramp Boring (B-4)

The results from our subsurface exploration indicated approximately up to 8-inches of topsoil materials, underlain by Silty SAND (SM) to the boring termination depth of 15-feet below the existing site elevations. The SPT results, N-Values, for the granular soils ranged from 2 to 8 BPF, indicating a very loose to loose relative density.

Groundwater

Groundwater was encountered within all of the borings at depths ranging from 0.8 to 5.8 feet below the existing site elevations. Accordingly, groundwater will impact construction activities. The contractor should be prepared to dewater or well point construction areas as necessary.

Please note that groundwater levels are influenced by seasonal conditions and by periods of significant precipitation or prolonged drought. The location of the groundwater table can vary as a result of seasonal fluctuations in precipitation, evaporation, surface water runoff, local topography, and other factors not immediately apparent at the time of the exploration. Groundwater fluctuations of 2 to 4 feet are possible. Due to the near surface fine-grained soils, a perched water condition may also occur during wetter seasonal conditions.

Subgrade Preparation and Earthwork Operations – Boat Ramp

We recommend stripping of any organic matter, unstable soils, or unsuitable FILL material. Up to 8-inches of topsoil material was encountered at the boat ramp boring location. The stripping depth should be evaluated at the time of construction by representatives of the Geotechnical Engineer. If additional stripping becomes necessary below that determined by test pit excavation, suitable methods should be employed to determine additional stripping depths beyond the contract depth (such as elevations determined before and after additional stripping, etc.). Cut and fill operations should extend a minimum of 5 feet beyond the project limits.

After stripping or cutting to the desired grade, and prior to structural fill placement, subgrades should be observed by the Geotechnical Engineer. In an effort to densify the surficial subgrade soils, the stripped area should be rolled with a smooth drum roller with a minimum of two passes in two perpendicular directions, provided in-situ moisture contents are within ±3% of optimum in order to facilitate compaction.

We recommend the contract documents include an allowance for reworking soft near surface soils and replacement with engineered fill. Add/deduct unit prices should also be established so adjustment for the actual volume of undercut can be made.

The boat ramp slab may be supported on approved existing FILL material (if encountered), suitable natural soils and/or new Engineered Fill. Slab subgrades should be re-worked to a depth of 8 inches and be re-compacted to 95% of the Standard Proctor maximum dry density (ASTM D 698). Slab subgrades should be proofrolled by the Geotechnical Engineer or their qualified representative, remediated as required, and approved prior to Engineered Fill placement. Existing FILL should be evaluated to determine its suitability to remain in place below the ramp slab. Approved existing FILL material should be re-worked and re-compacted to achieve stability, as required. In the event that large areas of unstable and unsuitable subgrade are encountered, stabilization utilizing geotextile, geogrid, moderate undercutting or a combination of these remedial type measures could be considered under the advisement of the Geotechnical Engineer.

Generally, it appears that the native near surface sandy soils onsite may be re-used as structural fill. The materials must be moisture conditioned to within +/-3% of the soils optimum moisture. However, this requires time and favorable weather and the contractor must have appropriate equipment to aerate, scarify, and re-compact clayey and sandy soil materials to be successful. All proposed select fill soils should be submitted to the geotechnical engineer for approval prior to their use on the project. We recommend imported engineered fill (select) material consisting of approved inorganic material classified as SM, SM-SP, SP, SC or better containing less than about 50% by weight Silt or Clay and free of debris. This material should be placed in horizontal lifts not exceeding 8 inches in loose thickness, moisture conditioned to within +/- 3% of the optimum moisture content, and compacted to a minimum of 95% of the maximum dry

density obtained in accordance with ASTM D-698, Standard Proctor method. Select fill slopes should be no greater than 3 horizontal to 1 vertical.

Soil Parameters – Bulkhead

We understand the existing bulkhead will be removed and replaced, and the structural engineer will be the designer of record. Anticipated soil parameters for the encountered soils in our boring are included in the table below.

Table 1 – Below Grade Walls Soil Parameters (Borings B-1 through B-3)

Depth (ft)	USCS Soil Classification	Moist Unit Weight (pcf)	Cohesion (C - psf)	Angle of Internal Friction (Ø - degrees)	Active lateral Earth Pressure Coefficient, K_a	Passive lateral Earth Pressure Coefficient, K_p	At Rest Lateral Earth Pressure Coefficient, K_o
0 to 4	CL	110[1]	300	5	0.83	1.2	0.91
4 to 30	SC/SM	120[1]	-	30	0.33	3.0	0.50

Note **1**: The groundwater table was encountered at depths ranging from 2.5- to 5.8-feet below the existing surface elevations at the bulkhead borings. Therefore, soils below these depths can be assumed to be submerged and buoyant unit weight applied.

Construction Considerations

The subgrade materials are moisture sensitive, and exposure to the environment may weaken the subgrade soils if excavations remain open for too long a time; therefore, concrete should be placed the same day that subgrades are excavated. If the bearing soils are softened by surface water intrusion or exposure, the softened soils must be removed prior to placement of concrete. If the excavation must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, we recommend that a 1- to 3-inch thick "mud mat" of lean concrete be placed on the bearing soils before the placement of reinforcing steel.

In a dry and undisturbed state, the soil at the site will provide good subgrade support for fill placement and construction operations; however, when wet, this soil will degrade quickly with disturbance from contractor operations. Good site drainage should be maintained during earthwork operations which would help maintain the integrity of the soil.

Proper compaction control of fill is an important aspect of this project. Therefore, we recommend that all fill operations be observed full-time by a qualified soil technician to determine if minimum compaction requirements are being met.

Groundwater encountered within the borings at depths ranging from 0.8- to 5.8-feet below the existing site elevations. Accordingly, groundwater will impact construction.

The contractor should be prepared to dewater or well point construction areas as necessary.

General Comments

This report has been prepared in order to aid in the evaluation of this site and to assist AES Consulting Engineers, Inc. in the design and planning of the project. The report scope is limited to the specific project and location described, and the project description represents our understanding of the significant aspects relevant to soil and foundation characteristics.

We have appreciated being of service to you during the design phase of this project and look forward to its successful construction. If you should have any questions regarding the information and recommendations contained in this report or if we can be of any further assistance, please contact our office.

Respectfully,

ECS MID-ATLANTIC, LLC

Sara B. Phillips
Project Geologist

COMMONWEALTH OF VIRGINIA
W. LLOYD WARD
Lic. No. 034612
PROFESSIONAL ENGINEER

W. Lloyd Ward, P.E.
VP/Williamsburg Branch Manager

Appendix:
- I. Boring Location Plan
- II. Boring Logs
- III. Unified Soil Classification System and Reference Notes for Boring Logs
- IV. Laboratory Testing Summary

APPENDIX I

Boring Location Plan

N
W E
S

LEGEND

- Approximate Boring Location

SCALE

NTS

SOURCE

Google Earth Aerial Imagery

Dated: 4/23/2014

FIGURE 1
BORING LOCATION PLAN
Wall Mill Park Bulkhead
and Boat Ramp Exploration
901 Airport Road
City of Williamsburg, Virginia

ECS PROJECT NO. 07:12431

APPENDIX II

Boring Logs

CLIENT	JOB #	BORING #	SHEET
AES Consulting Engineers, Inc.	12431	B-1	1 OF 1

PROJECT NAME: Waller Mill Park Bulkhead and Boat Ramp Exploration

ARCHITECT-ENGINEER:

SITE LOCATION: 901 Airport Road, City of Williamsburg, Virginia

NORTHING | EASTING | STATION

CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

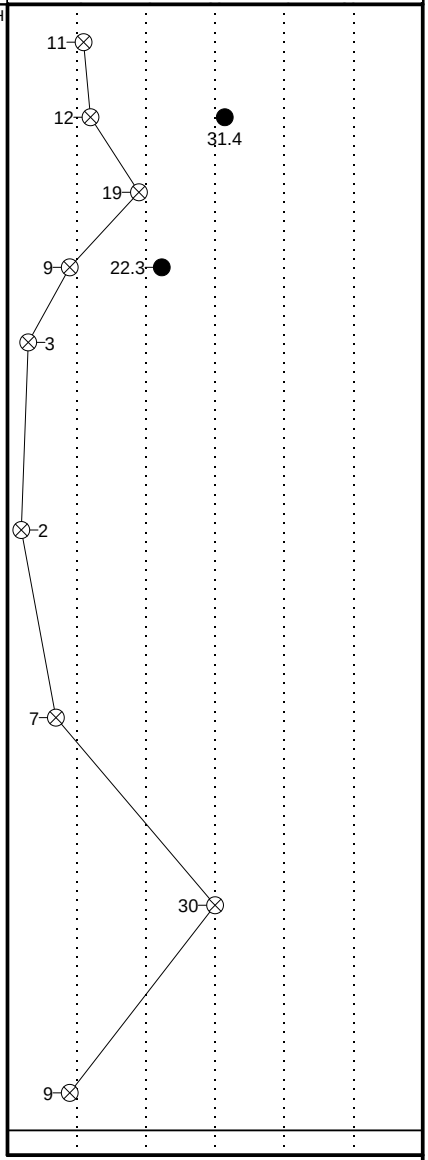
STANDARD PENETRATION BLOWS/FT

ENGLISH UNITS

BOTTOM OF CASING ▶ | LOSS OF CIRCULATION

SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0	S-1	SS	24	3	Asphalt Depth [3"], Gravel Depth [3"] (CL) SANDY LEAN CLAY, Orangish Brown, Moist, Medium Stiff			WOH 6 5 7
	S-2	SS	24	12				5 6 6 8
5	S-3	SS	24	18	(SM) SILTY FINE TO MEDIUM SAND, Trace Clay, Orangish Brown to Tannish Orange, Moist to Wet, Medium Dense to Loose	▽		6 8 11 9
	S-4	SS	24	20				8 5 4 4
	S-5	SS	24	12				2 1 2 1
10								
	S-6	SS	24	14				2 1 1 3
15								
	S-7	SS	24	16				3 2 5 7
20								
	S-8	SS	24	24				9 9 21 35
25								
	S-9	SS	24	12				4 3 6 8
30					END OF BORING @ 30.00'			



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

▽ WL 5.80 WS ☐ WD ☐	BORING STARTED 08/25/14	
▽ WL(BCR) ▼ WL(ACR)	BORING COMPLETED 08/25/14	CAVE IN DEPTH
▽ WL	RIG CME 45 FOREMAN Ed	DRILLING METHOD Rotary "Mud" Wash

CLIENT	JOB #	BORING #	SHEET
AES Consulting Engineers, Inc.	12431	B-2	1 OF 1

PROJECT NAME: Waller Mill Park Bulkhead and Boat Ramp Exploration

ARCHITECT-ENGINEER:

SITE LOCATION: 901 Airport Road, City of Williamsburg, Virginia

NORTHING | EASTING | STATION

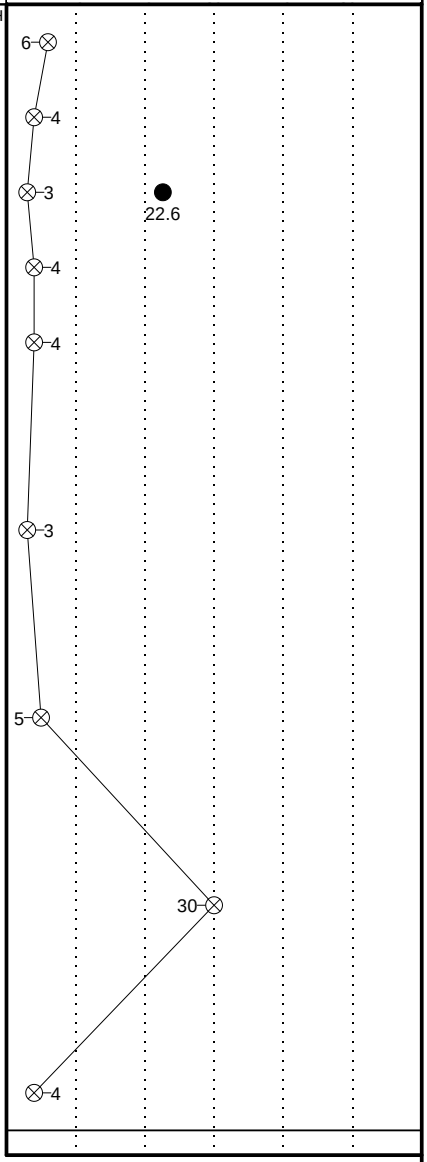
CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC%

PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

STANDARD PENETRATION BLOWS/FT

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL (ENGLISH UNITS; BOTTOM OF CASING; LOSS OF CIRCULATION; SURFACE ELEVATION)	WATER LEVELS ELEVATION (FT)	BLOWS/6"
0	S-1	SS	24	8	Asphalt Depth [3"] (SM FILL) SILTY FINE TO MEDIUM SAND, Trace Gravel, Reddish Orange, Moist, Loose		WOH 3 3 3
	S-2	SS	24	10	(CL) SANDY LEAN CLAY, Orangish Gray, Moist to Wet, Soft		2 2 2 2
5	S-3	SS	24	20	(SM) SILTY FINE TO MEDIUM SAND, Trace Clay, Orangish Brown, Wet, Very Loose to Medium Dense		1 1 2 3
	S-4	SS	24	24			3 2 2 2
	S-5	SS	24	24			3 2 2 2 2
10							
	S-6	SS	24	12			2 2 1 2
15							
	S-7	SS	24	14			2 2 3 4
20							
	S-8	SS	24	16			13 14 16 16
25							
	S-9	SS	24	16			5 1 3 10
30					END OF BORING @ 30.00'		



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL 2.50 WS ☐ WD ☐	BORING STARTED 08/25/14	
WL(BCR) WL(ACR)	BORING COMPLETED 08/25/14	CAVE IN DEPTH
WL	RIG CME 45 FOREMAN Ed	DRILLING METHOD Rotary "Mud" Wash

CLIENT	JOB #	BORING #	SHEET
AES Consulting Engineers, Inc.	12431	B-3	1 OF 1

PROJECT NAME: Waller Mill Park Bulkhead and Boat Ramp Exploration

ARCHITECT-ENGINEER:

SITE LOCATION: 901 Airport Road, City of Williamsburg, Virginia

NORTHING | EASTING | STATION

CALIBRATED PENETROMETER TONS/FT^2

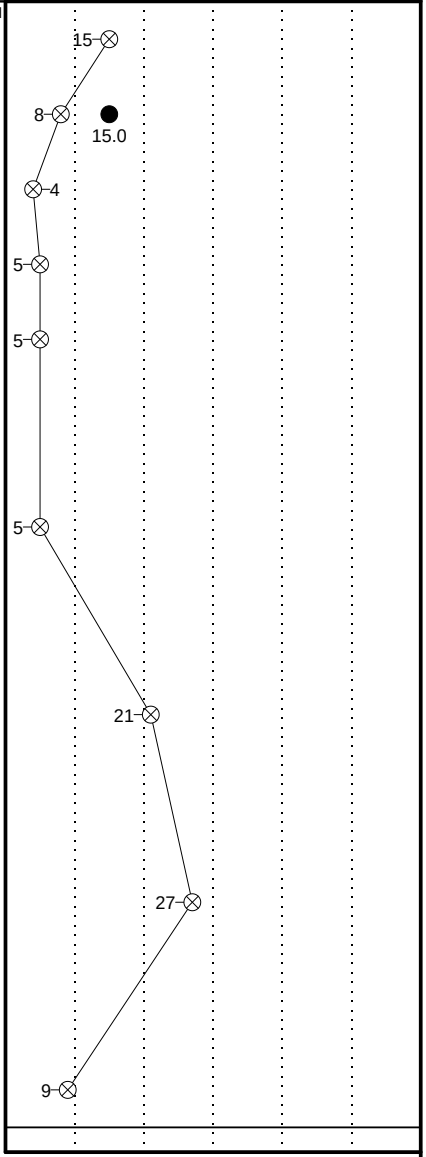
ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC%

PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

STANDARD PENETRATION BLOWS/FT

BOTTOM OF CASING | LOSS OF CIRCULATION | SURFACE ELEVATION | ENGLISH UNITS

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Asphalt Depth [2"]			WOH
	S-1	SS	24	12	(SM) SILTY FINE TO MEDIUM SAND, Trace Clay, Orangish Brown to Orangish Gray, Moist to Wet, Medium Dense to Loose			6 9 6 6 4 4 4
	S-2	SS	24	20				3 2 2 3
5	S-3	SS	24	24				3 2 3 3
	S-4	SS	24	24				2 2 3 3
	S-5	SS	24	24				3
10								
	S-6	SS	24	14				3 3 2 2
15								
	S-7	SS	24	18				7 9 12 13
20								
	S-8	SS	24	20				13 13 14 16
25								
	S-9	SS	24	18				10 4 5 9
30					END OF BORING @ 30.00'			



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL 3.50 WS ☐ WD ☐	BORING STARTED 08/25/14	
WL(BCR) WL(ACR)	BORING COMPLETED 08/25/14	CAVE IN DEPTH
WL	RIG CME 45 FOREMAN Ed	DRILLING METHOD Rotary "Mud" Wash

CLIENT	JOB #	BORING #	SHEET
AES Consulting Engineers, Inc.	12431	B-4	1 OF 1

PROJECT NAME: Waller Mill Park Bulkhead and Boat Ramp Exploration

ARCHITECT-ENGINEER:

SITE LOCATION: 901 Airport Road, City of Williamsburg, Virginia

NORTHING | EASTING | STATION

CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

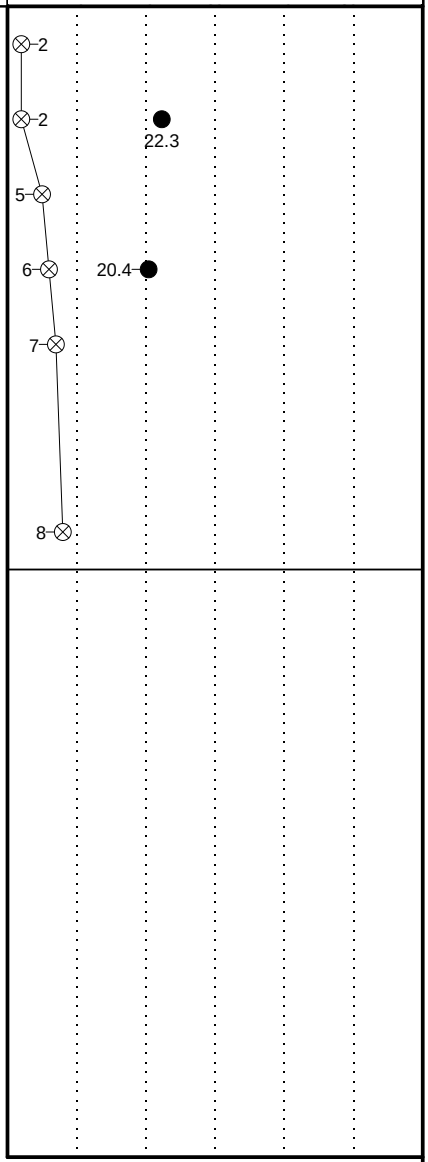
PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

STANDARD PENETRATION BLOWS/FT

ENGLISH UNITS

BOTTOM OF CASING | LOSS OF CIRCULATION | SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0	S-1	SS	24	20	Topsoil Depth [8"] (SM) SILTY FINE TO MEDIUM SAND, Trace Clay, Orangish Brown, Moist to Wet, Very Loose to Loose	▽		2 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 4 4
	S-2	SS	24	16				
5	S-3	SS	24	18				
	S-4	SS	24	24				
	S-5	SS	24	24				
10								
	S-6	SS	24	24				4 4 4 4
15					END OF BORING @ 15.00'			
20								
25								
30								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

▽ WL 0.80 WS ☐ WD ☐	BORING STARTED 08/25/14	
▽ WL(BCR) ▼ WL(ACR)	BORING COMPLETED 08/25/14	CAVE IN DEPTH
▽ WL	RIG FOREMAN Ed	DRILLING METHOD Rotary "Mud" Wash

APPENDIX III

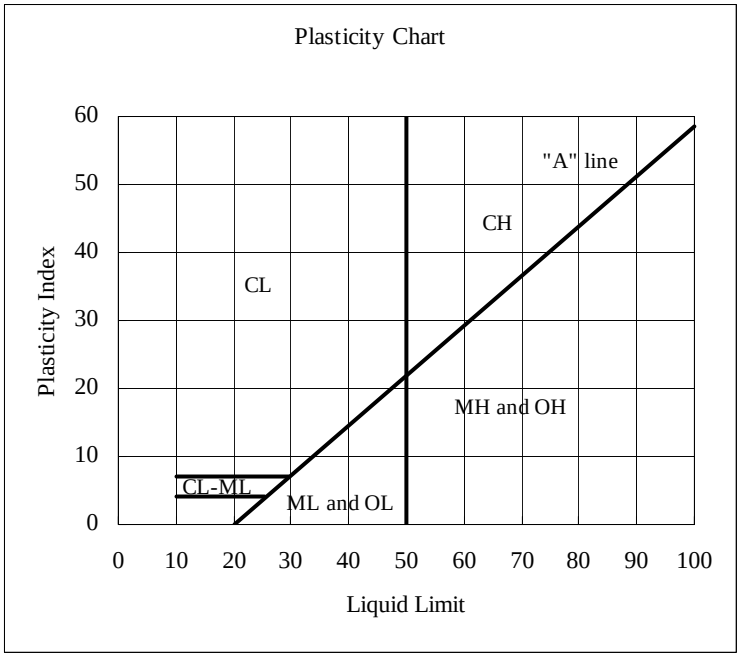
Unified Soil Classification System and Reference Notes for Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria	
Coarse-grained soils (More than half of material is larger than No. 200 Sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = D_{60}/D_{10}$ greater than 4 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM[a]	d	Silty gravels, gravel-sand mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
				u			
			GC		Clayey gravels, gravel-sand-clay mixtures	Atterberg limits below "A" line or P.I. less than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines	$C_u = D_{60}/D_{10}$ greater than 6 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM[a]	d	Silty sands, sand-silt mixtures	Atterberg limits above "A" line or P.I. less than 4	Limits plotting in CL-ML zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
				u			
			SC		Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 Sieve)	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 sandy or silty soils, elastic silts		
			CH		Inorganic clays of high plasticity, fat clays		
			OH		Organic clays of medium to high plasticity, organic silts		
	Highly Organic soils		Pt		Peat and other highly organic soils		

Determine percentages of sand and gravel from grain-size curve.
Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

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



[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

[b] Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC,well-graded gravel-sand mixture with clay binder. (From Table 2.16 - Winterkorn and Fang, 1975)

REFERENCE NOTES FOR BORING LOGS

I. Drilling Sampling Symbols

SS	Split Spoon Sampler	ST	Shelby Tube Sampler
RC	Rock Core, NX, BX, AX	PM	Pressuremeter
DC	Dutch Cone Penetrometer	RD	Rock Bit Drilling
BS	Bulk Sample of Cuttings	PA	Power Auger (no sample)
HSA	Hollow Stem Auger	WS	Wash sample
REC	Rock Sample Recovery %	RQD	Rock Quality Designation %

II. Correlation of Penetration Resistances to Soil Properties

Standard Penetration (blows/ft) refers to the blows per foot of a 140 lb. hammer falling 30 inches on a 2-inch OD split-spoon sampler, as specified in ASTM D 1586. The blow count is commonly referred to as the N-value.

A. Non-Cohesive Soils (Silt, Sand, Gravel and Combinations)

Density		*Relative Properties*	
Under 4 blows/ft	Very Loose	Adjective Form	12% to 49%
5 to 10 blows/ft	Loose	With	5% to 12%
11 to 30 blows/ft	Medium Dense		
31 to 50 blows/ft	Dense		
Over 51 blows/ft	Very Dense		

Particle Size Identification		
Boulders		8 inches or larger
Cobbles		3 to 8 inches
Gravel	Coarse	1 to 3 inches
	Medium	½ to 1 inch
	Fine	¼ to ½ inch
Sand	Coarse	2.00 mm to ¼ inch (dia. of lead pencil)
	Medium	0.42 to 2.00 mm (dia. of broom straw)
	Fine	0.074 to 0.42 mm (dia. of human hair)
Silt and Clay		0.0 to 0.074 mm (particles cannot be seen)

B. Cohesive Soils (Clay, Silt, and Combinations)

Blows/ft	*Consistency*	*Unconfined Comp. Strength Q_p (tsf)*	*Degree of Plasticity*	*Plasticity Index*
Under 2	Very Soft	Under 0.25	None to slight	0 – 4
3 to 4	Soft	0.25-0.49	Slight	5 – 7
5 to 8	Medium Stiff	0.50-0.99	Medium	8 – 22
9 to 15	Stiff	1.00-1.99	High to Very High	Over 22
16 to 30	Very Stiff	2.00-3.00		
31 to 50	Hard	4.00–8.00		
Over 51	Very Hard	Over 8.00		

III. Water Level Measurement Symbols

WL	Water Level	BCR	Before Casing Removal	DCI	Dry Cave-In
WS	While Sampling	ACR	After Casing Removal	WCI	Wet Cave-In
WD	While Drilling	▽	Est. Groundwater Level	⦿▽	Est. Seasonal High GWT

The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in a granular soil. In clay and plastic silts, the accurate determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally applied.

APPENDIX IV

Laboratory Testing Summary

Laboratory Testing Summary

Boring Number	Sample Number	Depth (feet)	MC[1] (%)	Soil Type[2]	Atterberg Limits[3]			Percent Passing No. 200 Sieve[4]	Moisture - Density (Corr.)[5]		CBR Value[6]	Other
					LL	PL	PI		Maximum Density (pcf)	Optimum Moisture (%)		
B-1												
	S-2	2.00 - 4.00	31.4	CL				55.4				
	S-4	6.00 - 8.00	22.3	SM				13.1				
B-2												
	S-3	4.00 - 6.00	22.6	SM				20.7				
B-3												
	S-2	2.00 - 4.00	15.0	SM				17.4				
B-4												
	S-2	2.00 - 4.00	22.3	SM				26.9				
	S-4	6.00 - 8.00	20.4	SM				12.1				

Notes: 1. ASTM D 2216, 2. ASTM D 2487, 3. ASTM D 4318, 4. ASTM D 1140, 5. See test reports for test method, 6. See test reports for test method

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content (ASTM D 2974)

Project No. 12431

Project Name: Waller Mill Park Bulkhead and Boat Ramp Exploration

Client: AES Consulting Engineers, Inc.

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ECS Mid-Atlantic, LLC

Williamsburg, VA