

Preliminary Geotechnical Engineering Report

**South Fork Shenandoah River Bank Stabilization
Virginia Route 33 Business, Town of Elkton
Rockingham County, Virginia**

Underhill Project No. 17028.00

October 30, 2017





October 30, 2017

Mr. Kyle Ashmun
Ecosystem Services
304 11th Street NW
Charlottesville, VA 22903

Subject: Preliminary Geotechnical Engineering Report, South Fork Shenandoah River Bank Stabilization, Virginia Route 33 Business, Town of Elkton, Rockingham County, Virginia (Underhill Engineering Project No. 17028.00)

Dear Mr. Ashmun:

Underhill Engineering, LLC (Underhill) is pleased to present this Preliminary Geotechnical Engineering Report for the above referenced project. The geotechnical engineering services for this project are provided in accordance with Underhill Engineering's revised proposal dated September 7, 2017, and accepted September 13, 2017.

Thank you for the opportunity to provide our services. If you have any questions or require additional information, please do not hesitate to contact me.

Sincerely,

UNDERHILL ENGINEERING, LLC

O. Christopher Webster, PE
Principal



1.0 Executive Summary

This report presents the results of the subsurface exploration and preliminary geotechnical engineering analysis for the project site.

Four of the eight borings drilled for our subsurface exploration (B-1 through B-4) revealed existing fill soils (Stratum A1) and waste fill (Stratum A2), commonly containing glass, metal, cinders, and roots, to depths of 7 to 9.5 feet below the surface. The waste fill materials are underlain by Alluvium (Stratum B), commonly consisting of sands, gravels, cobbles, and boulders to depths of 9.9 to 13.1 feet. The remaining borings (B-5 through B-8) revealed probable fill soils (Stratum A3), generally free of deleterious materials, to depths of 9 to 10 feet below the ground surface. These probable fill soils are underlain by Stratum B Alluvium and Residuum (Stratum C) to the maximum depth explored, 25 feet. Groundwater was observed at depth of 17.5 feet, about EL 925.5, in Boring B-5.

Strata A1 and A2 typically consists of soils intermixed with layers of glass, metal, cinders, and root fragments. Soil samples retrieved from the borings were also screened using a multiple-gas monitor and no positive readings were recorded (i.e. results were below the detectable limit (BDL)). Considering this information, we anticipate that the waste fill in the river bank stabilization area may be removed and disposed of at a local landfill, pending Virginia Department of Environmental Quality (DEQ)'s and the receiving facility's approval. If materials different from those encountered in the subsurface exploration are encountered during excavations, Underhill and the other members of the design team should be contacted for further evaluation.

The landfill materials (Strata A1 and A2) are considered unsuitable to leave in place for the bank stabilization area. However, the probable fill soils of Stratum A3, which are generally free of deleterious materials, may be cut to a slope of no steeper than 2.5H:1V, provided that proper surface stabilization is provided. Similarly, these materials may be re-used as compacted fill in the reconstructed bank slopes. Since these materials generally consist of sands interlayered with low plasticity clays and silts, new fill slopes should be constructed no steeper than 2.5H:1 when these materials are compacted to at least 95 percent of Standard Proctor density (ASTM D698). Steeper slopes may be considered when these materials are reinforced with layers of geogrid, off-site select material is imported to the site for construction of the slopes, or riprap and/or gabion systems are used.

Underhill is providing this Executive Summary solely as an overview of our findings and recommendations. Any party that relies of this report must read the full report since the Executive Summary omits several details, including those that are important to the proper interpretation and application of the report.

2.0 Scope of Services

Underhill's revised proposal dated September 7, 2017, defines the scope of services for this project. The scope is limited to the Preliminary Geotechnical Engineering Services as presented:

Subsurface Exploration

- Borings marked and utilities cleared prior to drilling.
- Subsurface Exploration consisting of at least six soil test borings. With the depth of refusal recorded in some borings, we were able to drill two additional borings (for a total of eight) without using the allowance for additional drilling.
 - The borings were drilled to a maximum depth of 25 feet each or to prior refusal depths. Coring of rock was not included in our scope.
 - Continuous split-spoon sampling was performed through the waste materials as requested by VDEQ.
 - Test borings were backfilled with bentonite grout. Excess soil cuttings were left on site.

Field Engineering

- Field Engineering was provided by Underhill's Engineer, who coordinated activities and logged the Subsurface Exploration. HAZWOPER 40-hr OSHA trained geologist personnel were also on site.
 - Standard Penetration Test N values were recorded as borings were advanced and split-spoon samples collected.
 - Soil samples retrieved were screened using a MultiRAE Plus multiple-gas monitor.
 - Representative soil samples were taken for limited soil laboratory testing.
 - Groundwater conditions were documented during the subsurface exploration, including conditions encountered during drilling and at completion of the borings.

Soil Laboratory Testing

Representative soil samples obtained from the subsurface program were selected for limited soil index testing. Soil Laboratory Testing consisting of the following tests:

- Eight natural water contents (ASTM D2216),
- Two Atterberg Limits test (ASTM D4318), and
- Two gradation tests (ASTM D422/D1140).

These samples have been submitted to the laboratory and the results will be submitted under separate cover when these results are complete.

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Preliminary Geotechnical Engineering Study

The preliminary geotechnical engineering study has been performed within the general area of river bank stabilization as identified by Ecosystem Services. The boring locations were selected based on the review of the ElectroMagnetic (EM) Induction Survey conducted by HydroGeo Environmental in August 2017. The preliminary geotechnical engineering study is provided to assist in evaluating the depth and composition of the landfill and the underlying subsurface conditions.

- Underhill's Preliminary Geotechnical Engineering Study includes the following services:
 - Commentary regarding the geology at the subject site.
 - A summary of the subsurface conditions encountered.
 - Preliminary recommendations regarding slope stability in the anticipated reconstructed bank stabilization areas.
 - Recommendations for additional studies based upon our review of the subsurface conditions encountered. The additional studies recommended consist of geotechnical studies to assist in the design of the stabilization slopes. Based on the findings from the subsurface exploration, no additional environmental studies are recommended at this time.
 - This Preliminary Geotechnical Engineering Report, which includes a Site Vicinity Map, a Location Plan, and Boring Logs.

The following services were not included: surveying for line and grade, final geotechnical studies, chemical testing, soil strength testing, installation of wells, environmental services, construction cost estimates, project construction documents, or other services not specifically identified above.

The following services were also not included in Underhill's scope:

- Private utility locating services.
- Rock coring and/or rock core specimen testing.

Underhill has developed the scope of services as presented herein considering the information provided to us by the design team.

3.0 Site Information

3.1 Site Description

The project site is located adjacent to the east bank of the South Fork Shenandoah River, just south of the Virginia Route 33 Business (Old Spotswood Trail) bridge crossing. The subject site area is shown in the Topographic Survey by Kee Mapping & Surveying, performed 10/19/16 to 11/11/16. The site is in the open field just south of the Elkton Boat Launch and the Elkton Recycling Collection facility.

We understand that the site immediately to the east bank of the river was previously occupied by a pre-regulated landfill in the 1960's (i.e. active before Subtitle D landfill design criteria). Only limited information is available as to the landfill's composition, extent, and depth. Representatives from the Virginia Department of Environmental Quality (VDEQ) have informed Underhill that past landfill activities included the dumping of municipal solid waste on the site, burning the waste on site, and spreading the residual matter that remained after burning. The landfill includes a thin soil cover.

The burned solid waste is present along the eroded east bank of the river as well as along portions of a tributary bank, which generally forms the south border of the landfill site. Debris within the waste includes concrete, metal (including car axles), and ceramic.

Presently the site is covered by a grass-covered open field. Ground surface grades in the vicinity of our study were generally level, varying from about EL 938.5 to 943. A Site Vicinity Map is included as Figure 1.

3.2 Proposed Construction

The proposed bank stabilization project includes the removal of the soil cover and underlying waste fill in the area of the proposed bank stabilization with disposal of the waste at a local waste management facility, depending on the findings of this preliminary study. The project also includes re-grading the bank slopes and providing surficial erosion protection. The re-grading activities are anticipated to include cut and some fill placement, in particular to provide new soil cover for the slopes where remaining waste fill may be exposed during excavation.

4.0 Subsurface Exploration Program

Underhill's preliminary geotechnical engineering study included a subsurface exploration program consisting of eight mechanically-advanced test borings. The subsurface exploration program was performed to evaluate the subsurface conditions and develop generalized stratigraphy at the test hole locations. The evaluation of the soils' characteristics included visual classification and evaluation of density or stiffness based on the results of the Standard Penetration Test (SPT) N values obtained.

Underhill's drilling subcontractor, Recon Drilling, Inc., drilled the test borings on October 25, 2017, under the observation of Underhill's Engineer. The approximate locations of the test borings are presented in Figure 2, following the text of this report. The test boring logs are included in Appendix A. Soil samples retrieved from the subsurface exploration program will be held for 45 days unless the Client requests other disposition.

Soil sample retrieved from the borings were screened using a MultiRAE Plus multiple-gas monitor. No positive readings were recorded (i.e. results were below the detectable limit (BDL)).

5.0 Site Geology and Subsurface Conditions

5.1 Site Geology

Geologic data indicate that the anticipated landfill material is underlain by the Cambrian-age Elbrook Formation, consisting of dolomite and limestone with lesser shale and siltstone. Interbedded limestone and dolostone dominate the upper part of the formation. Dolomitic siltstone and shale along with thin-bedded argillaceous limestone dominate the lower part.

The site's overburden stratigraphy consists of alluvium overlying the Elbrook residuum (typically silts and clays), which overlie the parent material. The alluvium represents the alluvial channel of the South Fork of the Shenandoah River and flood plain deposit, consisting of unconsolidated clay, silt, sand, gravel, cobbles, and boulders. Existing fill materials are present above the alluvium as indicated by the subsurface exploration.

5.2 Generalized Subsurface Stratigraphy

Underhill developed the following generalized subsurface stratigraphy based on the results of the subsurface exploration program and our review of the local geology:

Stratum A1 (Landfill Soil Cover):

Borings B-1 through B-4 revealed Stratum A1 existing fill soils to depths of about 2 to 6 feet below the ground surface. Stratum A1 generally consists of sandy silt (ML) FILL and silty sand with gravel (SM) FILL of variable consistency and density. Stratum A1 contains varying concentrations of root fragments. Standard Penetration Test N values from 5 to 40 were recorded in Stratum A1.

Stratum A2 (Landfill Waste Material):

Borings B-1 through B-4 revealed Stratum A2 waste fill soils below Stratum A1 to depths of about 7 to 9.5 feet. Stratum A2 generally consists of sandy lean clay (CL) FILL and sandy silt (ML) FILL, containing high concentrations of root fragments; silty sand (SM) FILL containing cinders; and crushed glass FILL and metal fragment FILL. These materials are also of variable consistency and density. Portions of Stratum A2 also contains wire fragments. Standard Penetration Test N values from 2 to 70/11 inches were recorded in Stratum A2.

Stratum A3 (Probable Fill Grading Soil):

Borings B-5 through B-8 revealed Stratum A3 probable fill to depths of 9 to 10 feet below the ground surface. These probable fill soils likely represent grading fill. The coarse-grained portion of Stratum A3 consists of loose to medium dense clayey gravel with sand (GC) PROBABLE FILL, clayey sand with gravel (SC) PROBABLE FILL, silty sand (SM) PROBABLE FILL, and poorly graded sand with silt (SP-SM) PROBABLE FILL. The fine-grained portion of Stratum A3 consists of stiff to very stiff sandy lean clay (CL) PROBABLE FILL and sandy silt (ML)

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PROBABLE FILL. Standard Penetration Test N values from 5 to 29 were recorded for Stratum A3.

Stratum B (Alluvium):

The borings revealed Stratum B alluvium below Strata A2 and A3 to depths of about 9.9 to 25 feet, the maximum depth of penetration in B-1 through B-7. Stratum B consists of medium to very dense CLAYEY GRAVEL WITH SAND (GC), SILTY GRAVEL WITH SAND (GM), CLAYEY SAND WITH GRAVEL (SC), SILTY SAND WITH GRAVEL (SM), and COBBLES. Standard Penetration Test N values from 6 to 50/1.5 inches were recorded in Stratum B. Auger and/or sampler refusal were recorded in Borings B-1 through B-4 and B-7 at depths of about 9.9 to 22.1 feet.

Stratum C (Elbrook Residuum):

Stratum C consists of stiff to very stiff sandy ELASTIC SILT (MH) and sandy SILT (ML) Residuum. Boring B-5 revealed Stratum C below Stratum B to the maximum depth of penetration, 25 feet. Standard Penetration Test N values from 14 to 28 inches were recorded in Stratum C.

5.3 Groundwater

Groundwater was encountered during drilling at depths of 19 to 20 feet in Borings B-5, B-6, and B-7. Also, groundwater was observed at completion of Boring B-5 prior to removal of the augers at depths of 17.5 feet. Fluctuations in the hydrostatic water table should be expected to occur over time, depending on variations in precipitation, surface runoff, pumping, flooding, evaporation, river levels, and similar factors.

6.0 Preliminary Geotechnical Recommendations

6.1 Discussion

Eight test borings were drilled for our subsurface exploration program. The boring locations were selected based on the review of ElectroMagnetic (EM) Induction Survey results as conducted by HydroGeo Environmental at the abandoned landfill site, under a separate contract. The four southernmost borings (B-1 through B-4) revealed existing fill soils representing the landfill's soil cover (Stratum A1) and waste fill (Stratum A2), commonly containing glass, metal, cinders, and roots, to depths of 7 to 9.5 feet below the surface. The waste fill materials are underlain by Alluvium (Stratum B), commonly consisting of sands, gravels, cobbles, and boulders to depths of 9.9 to 13.1 feet, where the borings encountered auger and/or sampler refusal on likely boulders. The four northernmost borings (B-5 through B-8) revealed probable fill soils (Stratum A3), which consisted of soils generally free of deleterious materials, to depths of 9 to 10 feet below the ground surface. Stratum A3 is underlain by Stratum B Alluvium and Residuum (Stratum C) to the maximum depth explored of 25 feet. Groundwater was observed at depth of 17.5 feet, about EL 925.5, in Boring B-5.

Based on the subsurface exploration data, the waste fill typically consists of soils intermixed with layers of glass, metal, cinders, and root fragments. Soil samples retrieved from the borings were also screened using a MultiRAE Plus multiple-gas monitor and results were below the detectable limit (BDL). Considering this information, we anticipate that the waste fill in the river bank stabilization area may be removed and disposed of at a local landfill, pending VDEQ's and the receiving facility's approval. If materials different from those encountered in the subsurface exploration are encountered during excavations, Underhill and the other members of the design team should be contacted for further evaluation.

The probable fill soils (Stratum A3) appear generally free of deleterious materials, and may be cut to a slope of no steeper than 2.5H:1V, provided that proper surface stabilization is provided. Similarly, these materials may be re-used as compacted fill in the reconstructed bank slopes. Since these materials generally consist of sands interlayered with low plasticity clays and silts, new fill slopes should be constructed no steeper than 2.5H:1V, when these materials are compacted to at least 95 percent of Standard Proctor density (ASTM D698).

6.2 Earthwork

Compacted fill for reconstructed bank slopes should consist of material classifying CL, ML, SC, SM, SP, SW, GC, GM, GP or GW in accordance with ASTM D2487. Fill materials should not contain particles larger than 5 inches. Therefore, cobbles larger than 5 inches and boulders should be raked out of the fill prior to placement, where encountered. We do not consider Strata A1 or A2 suitable for re-use as compacted fill. These materials will need to be removed from the site and hauled to an appropriate waste management facility. Stratum A3 soils appear generally free of deleterious materials and may be re-used as compacted fill.

However, given the limited quantity of the Stratum A3 fill, project planning should anticipate that only a limited amount of on-site soils will be suitable for use as compacted and some off-site borrow materials should be anticipated for the bank stabilization.

Compacted fill for the bank stabilization should be placed in maximum 8-inch thick horizontal, loose lifts and compacted to at least 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor. The contractor should bench compacted structural fill subgrades steeper than 4H:1V to allow placement of horizontal lifts. Compacted structural fill slopes should not be designed and built steeper than 2.5H:1V.

Steeper slopes may be considered when soils are reinforced with layers of geogrid, off-site select material is imported to the site for construction of the slopes, or riprap and/or gabion systems are used. Underhill would be glad to assist the design team with development of the appropriate slope / retainage design. For project planning purposes, additional geotechnical engineering services are anticipated to consist of review of potential fill sources including sufficient soil laboratory testing to aid in the evaluation of recommended soil strength parameters for use in the reinforced slope / retainage design.

The fine-grained soils of Stratum A3 are susceptible to moisture changes, will be easily disturbed, and difficult to compact under wet weather conditions. Drying and reworking of these soils may not be possible during wet winter months. Therefore, it will be important that the earthwork for this project be performed during the warmer, drier times of the year to limit the potential for disturbance of on-site soils and reduce the amount of fill imported to the site.

Traffic on stripped or undercut subgrades should be limited to reduce disturbance of underlying soils. The Contractor should provide site drainage to maintain subgrades free of water and to avoid saturation and disturbance of the subgrade soils before placing compacted structural fill. This will be important during all phases of the construction work. The Contractor should be responsible for reworking of subgrades and compacted structural fill that were ini

The subgrades in the areas that are exposed after waste fill is removed may be wet and easily disturbed. The contractor may need crushed stone and stabilization geotextile working platforms to provide a base on which to place new compacted structural fill. Underhill's Engineer can make recommendations for working platforms in the field, based on observations of the subgrade conditions.

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Earthwork activities may encounter groundwater during excavation to grade, based on the water level observations, especially if earthwork takes place following times of heavy precipitation. Therefore, the Contractor will likely need to provide temporary dewatering such as trenching to control the surface and/or groundwater.

7.0 Limitations

The analyses and recommendations submitted in this report are based on the information revealed by the subsurface exploration. This report attempts to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction.

Underhill has prepared this study to aid in the evaluation of the site. It is intended for use concerning this specific project, and should not be used for other purposes. The recommendations provided within are based on information on the site and proposed construction as described in this report. Changes regarding existing conditions or changes in loads, locations, or grades should be brought to Underhill's attention so that recommendations can be modified as needed. Underhill would appreciate an opportunity to review the plans and specifications as they pertain to the recommendations contained in this report, and to submit comments to you based on this review.

Underhill has endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

References

Evans, Nick H. and Rader, E.K. (1993) Geologic Map of Virginia, Virginia Division of Mineral Resources, Charlottesville, Virginia.

Heller, Matthew J. (2010) Bedrock Geologic Map of the Elkton West Quadrangle, Virginia, Open File Report 10-04, Virginia Division of Mineral Resources, Charlottesville, Virginia

Heller, Matthew J. and Eaton, L. Scott (2010) Surficial Geologic Map of the Elkton West Quadrangle, Virginia, Open File Report 10-05, Virginia Division of Mineral Resources, Charlottesville, Virginia.

King, Philip B. (1950) Geology of the Elkton Area, Geological Survey Professional Paper 230, Department of the Interior, Washington, D.C.

Figures

Figure 1, Site Vicinity Map

Figure 2, Location Plan

FIGURE 1



Image from Google Earth

No Scale



SFSR Bank Stabilization
Town of Elkton
Rockingham County, Virginia

Site Vicinity Map
Project 17028

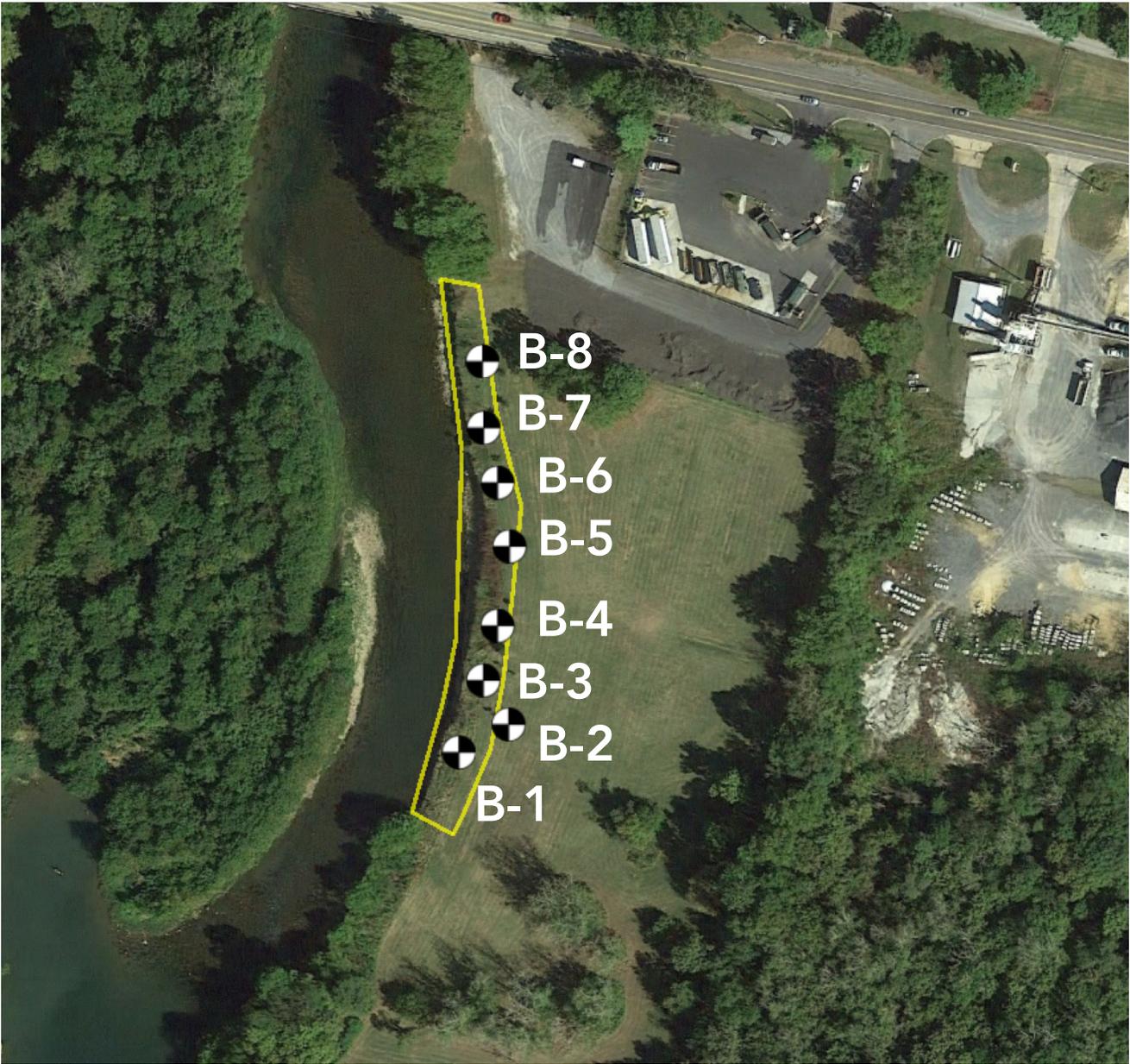


Image from Google Earth



No Scale



SFSR Bank Stabilization
Town of Elkton
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Location Plan
Project 17028

Subsurface Exploration Data

Test Boring Logs, B-1 through B-8

Note: Test borings were located using GPS coordinates by Underhill's subconsultant, HydroGeo Environmental. Elevations at the test boring locations were obtained from LIDAR data available from the public domain. The elevations and locations should be considered no more accurate than the means and methods used to obtain them.

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-1	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
			Logged By: C. Webster			Method: 2-1/4" HSA		
Started: 10/25/17			Groundwater Observations			Hammer: ATH		
Finished: 10/25/17			Encountered	Date	Time	Depth	Casing	
Location: See Location Plan			Completion	10/25/17	10:19 AM	Dry	Caved (feet)	
GS ELEV: 938.5			Casing Pulled	10/25/17	10:42 AM	---	---	
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions			USCS	Remarks
0-2.0		A1	4+8+7+6	6" Topsoil				Augers grinding below 1 ft WASTE FILL
2.0-4.0			5+10+17+13	0.5	Fine to medium sandy silt FILL, trace, gravel, contains root fragments, dry - brown do, Fine to coarse		ML	
4.0-6.0		A2	2+3+5+8	4.5	Crushed glass FILL, contains wire fragments, dry - white and light gray			
6.0-8.0			4+4+15+25	7.0	Fine to coarse CLAYEY SAND, trace gravel, moist - brown		SC	
8.0-9.0			19+50/6"	7.5	Fine to coarse CLAYEY GRAVEL WITH SAND, moist - brown		GC	Augers grinding below 7.5 ft ALLUVIUM
10.0-10.5		B	50/5.5"					
10.5-10.8			50/4"					
Test Boring Terminated @ 10.8 ft								Auger refusal at 10.5 ft on likely boulder

Key:


Standard Penetration Split Spoon Sampler (SPT)



Bulk/ Bag Sample



Shelby Tube



Stabilized Groundwater



Groundwater at time of drilling

Boring Log: Sheet 1 of 1

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-2	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
			Logged By: C. Webster			Method: 2-1/4" HSA		
Started: 10/25/17			Groundwater Observations			Hammer: ATH		
Finished: 10/25/17			Encountered	Date	Time	Depth	Casing	
Location: See Location Plan			Completion	10/25/17	9:00 AM	Dry	Caved (feet)	
GS ELEV: 940.0			Casing Pulled	10/25/17	9:29 AM	---	---	
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions			USCS	Remarks
0-2.0		A1	3+5+5+8	6" Topsoil				Augers scraping at 1 ft High conc. root fragments WASTE FILL
2.0-4.0			10+11+7+10	0.5 Fine to coarse sandy silt FILL, trace, gravel, contains root fragments, moist - brown and gray	ML			
4.0-6.0		A2	5+5+5+7	2.0 Fine to medium sandy lean clay FILL, moist - contains root fragments, moist - red-brown	CL			
6.0-8.0			2+3+4+14	6.0 Fine to medium sandy silt FILL, contains root fragments, moist - brown	ML			
8.0-8.9		B	6+50/5"	8.5 COBBLES, moist - brown and gray moist - brown			Augers grinding below 7.5 ft ALLUVIUM	
9.5-9.9			50/5"				Auger refusal at 9.5 ft on likely boulder	
				Test Boring Terminated @ 9.9 ft				

Key:

-  Standard Penetration Split Spoon Sampler (SPT)
-  Bulk/ Bag Sample
-  Shelby Tube

Boring Log: Sheet 1 of 1

-  Stabilized Groundwater
-  Groundwater at time of drilling

- NOTES:**
- Boring elevations referenced to LIDAR data in public domain
 - Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-3	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
			Logged By: C. Webster			Method: 2-1/4" HSA		
Started: 10/25/17			Groundwater Observations			Hammer: ATH		
Finished: 10/25/17			Encountered	Date 10/25/17	Time ---	Depth Dry	Casing ---	Caved (feet) ---
Location: See Location Plan			Completion	Date 10/25/17	Time 11:20 AM	Depth Dry	Casing ---	Caved (feet) ---
GS ELEV: 940.0			Casing Pulled	Date 10/25/17	Time 11:40 AM	Depth ---	Casing ---	Caved (feet) ---
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors			USCS	Remarks
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	█	A1	2+4+4+8	7" Topsoil				
2.0-4.0	█	A1	12+9+7+3	0.6 Fine to medium sandy silt FILL, contains root fragments, moist - brown do, trace gravel red-brown		ML	WASTE FILL	
4.0-6.0	█	A2	3+1+3+11	4.0 Metal fragment FILL, dry - gray				
6.0-8.0	█	A2	6+10+7+7					
8.0-10.0	█	B	19+5+20+32	8.0 Fine to coarse SILTY GRAVEL WITH SAND, moist - brown and white		GM	ALLUVIUM	
10.5-10.8	█	B	50/4"					
				Test Boring Terminated @ 10.8 ft				Auger refusal at 10.5 ft on likely boulder

Key:

- █ Standard Penetration Split Spoon Sampler (SPT)
- ⊠ Bulk/ Bag Sample
- ▤ Shelby Tube

Boring Log: Sheet 1 of 1

- ▽ Stabilized Groundwater
- ▽ Groundwater at time of drilling

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-4	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
						Method: 2-1/4" HSA		
Logged By: C. Webster			Groundwater Observations			Hammer: ATH		
Started: 10/25/17			Date	Time	Depth	Casing	Caved (feet)	
Finished: 10/25/17			Encountered	10/25/17	---	Dry	---	
Location: See Location Plan			Completion	10/25/17	1:27 PM	Dry	---	
GS ELEV: 940.5			Casing Pulled	10/25/17	1:38 PM	---	---	
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors		USCS	Remarks	
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	█		2+25+15+21	5" Topsoil				
2.0-4.0	█	A1	6+10+4+3	0.4 Fine to coarse sandy silt FILL, trace gravel and cobbles, contains root fragments, moist - brown	ML	Augers grinding at 2 ft		
4.0-6.0	█		5+3+2+2	2.0 Fine to coarse silty sand with gravel FILL, moist - brown	SM	WASTE FILL		
6.0-8.0	█		WOH+1+1+2	do, trace gravel		Augers grinding at 5 ft		
8.0-10.0	█	A2	7+20+50/5"	6.0 Fine to medium silty sand FILL, contains cinders, glass, and metal fragments, moist - brown and black	SM			
10.0-10.5	█		50/6"	9.5 Fine to coarse SILTY GRAVEL WITH SAND, moist - brown and tan	GM	Augers grinding at 10 ft		
11.0-13.0	█	B	26+29+34+32	10.0 BROKEN COBBLES, dry - light gray and brown		ALLUVIUM		
13.0-13.1	█		50/1"	do, brown, red, and tan		Auger refusal at 11 ft (sampler penetrated)		
Test Boring Terminated @ 13.1 ft							Auger & sampler refusal at 13 ft on likely boulder	

Key:



Standard Penetration Split Spoon Sampler (SPT)



Bulk/ Bag Sample



Shelby Tube



Stabilized Groundwater



Groundwater at time of drilling

Boring Log: Sheet 1 of 1

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-5	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
			Logged By: C. Webster			Method: 2-1/4" HSA		
Started: 10/25/17			Groundwater Observations			Hammer: ATH		
Finished: 10/25/17			Encountered	Date	Time	Depth	Casing	Caved (feet)
Location: See Location Plan			Completion	10/25/17	2:44 PM	19.0	---	---
GS ELEV: 943.0			Casing Pulled	10/25/17	3:15 PM	---	---	---
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors			USCS	Remarks
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	█	A3	2+10+10+9	7" Topsoil				PROBABLE FILL
2.0-4.0	█		5+7+5+6	0.6	Fine to coarse clayey sand with gravel PROBABLE FILL, contains root frag., moist - brown		SC	
4.0-6.0	█		3+7+6+6	2.0	Fine to medium silty sand PROBABLE FILL, moist - brown		SM	
6.0-8.0	█		4+4+5+9	6.0	Fine to medium sandy lean clay PROBABLE FILL, moist - brown		CL	
8.0-10.0	█	B	3+2+4+9	9.0	Fine to coarse CLAYEY SAND WITH GRAVEL, moist - brown and tan		SC	Augers grinding at 10 ft ALLUVIUM Augers grinding below 12 ft
10.0-12.0	█		27+19+10+6	10.0	Fine to coarse SILTY GRAVEL WITH SAND, contains sandy lean clay layer, moist - brown		GM	
12.0-14.0	█		20+15+50/4"	do,	brown, yellow, and red			
19.0-21.0	█		8+10+11+8	17.0	Fine to coarse SILTY SAND WITH GRAVEL, wet - brown		SM	
23.0-25.0	█		6+7+8+9					
Test Boring Terminated @ 25.0 ft								

Key:



Standard Penetration Split Spoon Sampler (SPT)



Bulk/ Bag Sample



Shelby Tube



Stabilized Groundwater



Groundwater at time of drilling

Boring Log: Sheet 1 of 1

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-6	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
			Method: 2-1/4" HSA			Hammer: ATH		
Logged By: C. Webster			Groundwater Observations			Started: 10/25/17		
Finished: 10/25/17			Encountered	Date	Time	Depth	Casing	
Location: See Location Plan			Completion	10/25/17	4:13 PM	20.0	---	
GS ELEV: 943.0			Casing Pulled	10/25/17	4:26 PM	Dry	---	
Casing Pulled			10/25/17	4:45 PM	---	---	---	
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors			USCS	Remarks
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	█	A3	2+4+5+6	6" Topsoil				PROBABLE FILL
2.0-4.0	█		5+4+5+4	0.5	Fine to medium sandy silt PROBABLE FILL, contains root fragments, moist - brown		ML	
4.0-6.0	█		6+7+7+6	2.0	Fine to medium silty sand PROBABLE FILL, moist - brown		SM	
6.0-8.0	█		3+4+5+6	4.0	Fine to medium clayey sand PROBABLE FILL, trace gravel, moist - brown		SC	
8.0-10.0	█		3+3+4+33	6.0	Fine to medium sandy lean clay PROBABLE FILL, moist - brown		CL	
10.0-12.0	█	B	14+11+11+36	9.5	Fine to coarse CLAYEY SAND WITH GRAVEL, moist - brown		SC	Augers grinding below 11.5 ft ALLUVIUM
15.0-16.5	█		23+19+18					
20.0-21.5	█		13+11+17	▽	18.0	Fine to coarse SILTY SAND WITH GRAVEL, wet - brown		
23.5-25.0	█		19+20+20					
Test Boring Terminated @ 25.0 ft								

Key:

█ Standard Penetration Split Spoon Sampler (SPT)

⊠ Bulk/ Bag Sample

▤ Shelby Tube

Boring Log: Sheet 1 of 1

▽ Stabilized Groundwater

▽ Groundwater at time of drilling

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

			Project: South Fork Shenandoah River Bank			Boring No.	B-7	
			Stabilization, Rockingham Co., VA			Project No. 17028		
			Drilling Contractor: Recon Drilling, Inc.			Drill Rig Type: CME-550		
			Foreman: W. Rodas			Method: 2-1/4" HSA		
Logged By: C. Webster			Groundwater Observations			Hammer: ATH		
Started: 10/25/17			Date	Time	Depth	Casing	Caved (feet)	
Finished: 10/25/17			Encountered	10/25/17	5:16 PM	20.0	---	---
Location: See Location Plan			Completion	10/25/17	5:28 PM	Dry	---	---
GS ELEV: 942.5			Casing Pulled	10/25/17	5:38 PM	---	---	---
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors		USCS	Remarks	
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	■	A3	2+5+4+3	10" Topsoil		CL	PROBABLE FILL	
2.0-4.0	■		4+4+4+14	0.8	Fine to medium poorly graded sand with silt PROBABLE FILL, contains root fragments, moist - brown			
4.0-6.0	■		8+9+5+7	3.5	Fine to coarse sandy lean clay with gravel PROBABLE FILL, moist - brown			
6.0-8.0	■		3+3+6+5	do,	Fine to medium, trace gravel			
8.0-10.0	■		3+8+12+8					
15.0-16.5	■	B	18+20+12	9.5	Fine to coarse SILTY SAND WITH GRAVEL, moist - brown		Augers grinding below 15 ft ALLUVIUM	
20.0-21.5	■		11+12+32	17.0	Fine to coarse CLAYEY SAND WITH GRAVEL, wet - brown			
22.0-22.1	■		50/1.5"					
Test Boring Terminated @ 22.1 ft							Auger & sampler refusal at 22 ft	

Key:

■ Standard Penetration Split Spoon Sampler (SPT)

⊠ Bulk/ Bag Sample

▤ Shelby Tube

Boring Log: Sheet 1 of 1

▼ Stabilized Groundwater

▽ Groundwater at time of drilling

- NOTES:** 1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion

 geotechnical geothermal geoconstruction			Project: South Fork Shenandoah River Bank Stabilization, Rockingham Co., VA			Boring No.	B-8	
			Drilling Contractor: Recon Drilling, Inc.			Project No. 17028		
			Foreman: W. Rodas			Drill Rig Type: CME-550		
						Method: 2-1/4" HSA		
Logged By: C. Webster			Groundwater Observations			Hammer: ATH		
Started: 10/25/17			Date	Time	Depth	Casing	Caved (feet)	
Finished: 10/25/17			Encountered	10/25/17	---	Dry	---	
Location: See Location Plan			Completion	10/25/17	6:39 PM	Dry	---	
GS ELEV: 943.0			Casing Pulled	10/25/17	6:48 PM	---	---	
Depth (feet)	Sample Type	Stratum	Blow Counts (blows/foot)	Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors		USCS	Remarks	
				Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions				
0-2.0	■	A3	4+4+3+4	4" Topsoil			PROBABLE FILL	
2.0-4.0	■		3+2+3+6	0.3	Fine to medium silty sand PROBABLE FILL, contains root fragments, moist - brown			SM
4.0-6.0	■		5+12+9+7	4.0	Fine to medium clayey gravel with sand PROBABLE FILL, moist - brown			GC
6.0-8.0	■		3+4+5+6	6.0	Fine to medium sandy lean clay PROBABLE FILL, moist - brown			CL
8.0-10.0	■		10+17+12+17					
10.0-12.0	■	B	4+12+28+14	10.0	Fine to coarse CLAYEY SAND WITH GRAVEL, moist - brown and dark brown		GC	Augers grinding below 10 ft ALLUVIUM
15.0-16.5	■	C	8+6+8	15.0	Fine to medium sandy ELASTIC SILT, moist - red, brown, and light gray		MH	RESIDUUM
20.0-21.5	■		5+7+12	17.0	Fine to medium sandy SILT, moist - red and brown		ML	
23.5-25.0	■		9+12+16					
Test Boring Terminated @ 25.0 ft								

Key:



Standard Penetration Split Spoon Sampler (SPT)



Bulk/ Bag Sample



Shelby Tube



Stabilized Groundwater



Groundwater at time of drilling

Boring Log: Sheet 1 of 1

- NOTES:**
1. Boring elevations referenced to LIDAR data in public domain
 2. Boring backfilled with bentonite grout upon completion