Report of Geotechnical Exploration

Conway Pump Station
Winchester, Virginia

Triad Project No. 07-18-0138

Prepared for:

Ms. Felicia Glapion, P.E., Associate
Hazen and Sawyer
4035 Ridge Top Road, Suite 400
Fairfax, VA 22030

Prepared by:

TRIAD ENGINEERING, INC.

200 Aviation Drive
Winchester, Virginia 22602
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September 12, 2018

September 12, 2018

Ms. Felicia Glapion, P.E., Associate
Hazen and Sawyer
4035 Ridge Top Road, Suite 400
Fairfax, VA 22030

RE: Report of Detailed Geotechnical Exploration
Conway Pump Station
Winchester, Frederick County, Virginia
Triad Project No. 07-18-0138

Dear Ms. Glapion:

Triad Engineering, Inc. (Triad) has completed a geotechnical exploration for the planned pump station to be constructed in Winchester, Frederick County, Virginia. Our scope of services was completed in substantial conformance with our proposal dated May 14, 2018 and authorized by issuance of the signed Professional Services Agreement dated May 22, 2018. This report outlines the results of our field exploration and laboratory tests, and presents our recommendations for design and construction of the geotechnical elements of the project.

The subsurface exploration was performed to evaluate the subsurface conditions encountered at the planned pump station location for the limited purposes of preparing design and construction recommendations for geotechnical aspects of the project. It is emphasized that subsurface conditions may vary dramatically in areas other than the specific boring locations, and Triad makes no representations as to subsurface conditions other than those encountered at the specific boring locations.

This report has been prepared for the exclusive use of Hazen and Sawyer for specific application to the design of the pump station in Winchester, Frederick County, Virginia. Triad's responsibilities and liabilities are limited to our Client and apply only to their use of our report for the purposes described above. To observe compliance with design concepts and specifications, and to facilitate design changes in the event that subsurface conditions differ from those anticipated prior to construction, it is recommended that Triad be retained to provide continuous engineering and testing services during the earthwork and foundation construction phases of the work.

We appreciate the opportunity to provide our services during the design phase of the project. If you should have any questions concerning this report, or if you require any additional information, please do not hesitate to contact us.

Sincerely,

TRIAD ENGINEERING, INC.

Raymond A. Strother II, PE
Geotechnical Practice Leader

Randy L. Moulton, P.E.
Principal Engineer

COMMONWEALTH OF VIRGINIA
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TABLE OF CONTENTS

APPENDIX A

APPENDIX B

APPENDIX C

Report of Detailed Geotechnical Exploration

Conway Pump Station
Winchester, Frederick County, Virginia

Triad Project No. 07-18-0138

FOREWORD

This report has been prepared for the exclusive use of Hazen and Sawyer for specific application to the design of the pump station which will be constructed in Winchester, Frederick County, Virginia. The work has been performed in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

This report should not be used for estimation of construction quantities and/or costs, and contractors should conduct their own exploration of site conditions for these purposes. Please note that Triad is not responsible for any claims, damages or liability associated with any other party's interpretation of the data or re-use of these data or engineering analyses without the express written authorization of Triad. Additionally, this report must be read in its entirety. Individual sections of this report may cause the reader to draw incorrect conclusions if considered in isolation from each other.

The conclusions and recommendations contained in this report are based, in part, upon our field observations and data obtained from the borings at the site. The nature and extent of variations may not become evident until construction. If variations then appear evident, it may be necessary to re-evaluate the recommendations presented herein. Similarly, in the event that any changes in the nature, design, or location of the facilities are planned, the conclusions and recommendations contained herein shall not be considered valid unless the changes are reviewed and the conclusions are modified or verified in writing by Triad. If we are not afforded the privilege of making this review, we will not assume responsibility for misinterpretation of our recommendations, as our recommendations are strictly limited to conditions represented to Triad at the time this report was issued.

SITE AND PROJECT DESCRIPTION

The subject site is located adjacent to the northeastern portion of the Hampton Inn parking lot near the intersection of Conway Street and Ross Street in Winchester, Frederick County, Virginia. The project will include construction of one (1) pump station and a new generator pad. The location of the site is shown on Figure A-1 in Appendix A.

While we have not yet received any detailed plans for the project, we understand that the preliminary bearing depth of the wet well will be between 10 to 12 feet below existing grades. We assume that the valve vaults, which will be situated adjacent to the wet well, will likely extend to depths on the order of 4 to 5 feet below the finished exterior grade. Construction will also include a new generator pad in the southern part of the site. Although structural loads were not provided, we anticipate that maximum applied loads for the structures will be order of 2,500 psf or less.

GEOLOGIC SETTING

Based on our review of the Geologic Map of Frederick County, Virginia (1963), the site is underlain by the Martinsburg Formation of Ordovician Age. The Martinsburg Formation is generally described as brownish, fissile shale and thinly laminated, fine-grained sandstone. Residual soils weathered from the parent bedrock generally consist of a silty and clayey overburden with varying amounts of sand and rock fragments that rapidly grade to very dense decomposed bedrock with increased depth.

FIELD EXPLORATION

As requested, the field exploration included two (2) borings drilled at the proposed wet well and generator pad locations. The approximate boring locations are shown on Figure A-2 in Appendix A. The boring locations were selected by Hazen Sawyer and established in the field by Triad survey personnel. Surface elevations were also determined by Triad.

The test borings included Standard Penetration Testing (SPT) and split barrel sampling (ASTM D 1586) at standard intervals within the overburden. The borings encountered refusal on hard rock at depths of 14 and 15 feet below existing grades. NQ rock coring was performed in boring B-1 after auger refusal was encountered. A geotechnical engineer from our office was present full time during the field exploration to direct the drill crew, log all recovered soil samples and observe groundwater and geologic conditions. The recovered soil samples were transported to our laboratory for further testing.

SUBSURFACE CONDITIONS

Subsurface Strata

The materials encountered in the borings are generally described below. Stratification lines indicated on the logs represent the approximate boundaries between material types.

Topsoil: A 2-inch thick layer of topsoil was encountered at the ground surface of each test boring. The topsoil layer generally consisted of brown silty clay with an appreciable root mat.

Fill: Old fill was encountered in boring B-1 below the topsoil, and the fill extended to a depth of 4 feet below existing grade. The fill generally consisted of lean clay soils with minor amounts of sand, rock fragments and trace amounts of demolition debris. The SPT N-values obtained in the fill ranged from 11 to 15 blows per foot, which indicated a stiff consistency. Based on preliminary and assumed bearing elevations for the wet well and valve vault, we anticipate that the fill encountered in boring B-1 will be removed during construction. Pocket penetrometer readings within the fill indicated unconfined compressive strengths ranging from 0.5 to 1.5 tons per square foot (tsf).

Residuum: Residual soils were encountered in the test borings below the topsoil and/or fill. The residuum extended to the auger refusal depths of 14 feet and 15.5 feet below existing grades. The residuum generally consisted of fine-grained soils derived from highly weathered shale that rapidly graded to very dense bedrock with increased depth. The fine grained residual soils generally consisted of sandy silt and silt with varying amounts of sand and rock fragments. The SPT N-values obtained in the residuum ranged from 6 to over 50 blows per foot, which indicated a medium stiff consistency to a very dense relative density. Pocket penetrometer readings within the residuum were not taken due to the non-cohesive nature of the silty soils.

Bedrock: As mentioned previously, hard rock was encountered at depths of 14 feet and 15.5 feet below existing grades. Rock coring was performed in boring B-1 to evaluate the quality of the bedrock within the wet well excavation. The bedrock consisted of hard shale. Recovery of the rock core was 94 percent. The Rock Quality Designation (RQD) value, which is a general indicator of rock quality, was 26 percent which indicated poor quality rock at the core location. The bedding angles of the bedrock appeared to be flat to steeply dipping from the horizontal axis. The top of hard rock is defined as the auger refusal depth and/or initial coring elevation at each boring location.

Groundwater Observations

The test borings were checked for the presence of groundwater both during and upon completion of the drilling. Groundwater was not detected in any of the borings during or upon completion of the drilling. The water level upon completion of boring B-1 is associated with the remnant water level after rock coring was complete. It is emphasized that variations in groundwater levels are typical of the geologic region and may occur due to changes in environmental conditions, surface drainage and other factors not evident at the time measurements were made and reported herein.

LABORATORY TESTING

Laboratory tests were performed to supplement the field classifications, assess potential volume change characteristics and establish geotechnical design criteria. All laboratory tests were completed in accordance with appropriate ASTM standard test methods. Detailed results of the laboratory tests are contained in Appendix C. A summary of the test results is presented below.

TEST TYPE	TEST RESULTS
Natural Moisture Contents	10.4 to 33.9 %
Atterberg Limits: Liquid Limit Plasticity Index	36 11
Percent Passing #200 Sieve	58 %
USCS Soil Classification	ML

DISCUSSION

Based on the encountered conditions, it is our opinion that the planned structures can be supported on shallow foundations. We assume that excavations required for the wet well will be of sufficient size such that the adjacent valve pits will be supported on controlled backfill placed around the wet well. The generator pad can be supported on a conventional slab-on-grade (mat foundation) without the need for extensive corrective measures to the existing site soils.

DESIGN RECOMMENDATIONS

The geotechnical engineering evaluation of the subsurface conditions at the site, as well as the recommendations for earthwork and foundation construction, are based on our site observations, the field data obtained, and our understanding of the project information as presented in this report. If the information is incorrect, please contact us so that we can review our recommendations. Also, the knowledge of any site or subsurface condition revealed during construction that deviates from the data obtained during the geotechnical exploration should be reported to us for our evaluation.

Foundations

We conclude that the proposed structures can be supported on conventional shallow spread foundations bearing on approved residual materials or new controlled fill. Based on data obtained from the field exploration and our experience with similar projects, we recommend that a maximum allowable bearing pressure of 3,000 psf be utilized for design of spread footings or mat foundations bearing on approved residual soil or new controlled fill. Minimum dimensions of 2 feet and 3 feet should be observed for continuous and isolated footings, respectively, as warranted. Exterior foundations should bear at least 30 inches below the final outside grade for frost protection.

Based on the assumed maximum loads and our experience with similar soils, we estimate that total settlements for foundations bearing on approved residual soils and/or new controlled fill will be one (1) inch or less. Differential settlements are anticipated to be one-half of the total settlements. Differential settlements along continuous wall footings are not expected to exceed an angular distortion of 0.0015 inch/inch.

Slabs-on-Grade

As mentioned previously, we assume that the generator pad will be a mat foundation supported at grade. For evaluation and design of slabs-on-grade, we recommend that a modulus of subgrade reaction, k, of 100 pci be utilized. The mat should include turned down edges extended to 30 inches for frost protection. Construction joints should be provided in accordance with criteria outlined by the American Concrete Institute (ACI) and/or Portland Cement Association (PCA).

Below-Grade Walls

The below grade walls of the wet well will be subject to lateral earth pressures. It is assumed that select on-site materials will be used as structural fill behind the below grade walls. For use of the fine grained on-site materials as backfill, we recommend that an active equivalent fluid pressure (γK_a) of 60 pcf be utilized for design. We recommend that an at-rest equivalent fluid pressure (γK_o) of 90 pcf be used for design if the fine-grained on-site soils are used as backfill for below grade structures.

Reduced lateral pressures can be realized if select structural fill is used as backfill against the walls or if the fine-grained soils in the upper strata are blended with the deeper weathered shale to increase the coarse fraction of the backfill such that the blended material will meet a USCS classification of SM or more granular. For materials that are classified as SM or more granular, we recommend that an active equivalent fluid pressure (γK_a) of 40 pcf and an at-rest equivalent fluid pressure (γK_o) of 65 pcf be utilized for design. A factor of safety of 1.5 has been incorporated into the above recommended equivalent fluid pressures. Sample(s) of off-site material to be utilized as structural backfill material should be tested to determine the appropriate USCS and corresponding active and at-rest pressures.

The designer should give careful consideration when evaluating active and at-rest lateral earth pressures against below grade walls. For example, if the below grade walls will be backfilled prior to placement of decking or lateral support, this suggests that an active lateral earth pressure should be utilized since the below grade walls would be free to translate. However, if lateral support is placed, such that the walls are fixed prior to backfilling, this condition would more appropriately be analyzed for at-rest lateral earth pressures.

Adequate drainage, consisting of ASTM No. 57 limestone, a geosynthetic filter fabric between any stone/soil interface, and slotted drainage pipes should also be installed behind the retaining structure to help remove any water which may infiltrate behind them. We suggest that a solid piece of pipe be connected to any perforated foundation drain pipe and be routed to discharge away from the structure. Installing a permanent drainage system along the exterior of the wet well may not be feasible since the bearing elevations may be well below available discharge points. If a drainage system cannot be designed, the walls should be designed for full hydrostatic and soil pressures.

Below-ground tanks may be subject to floatation from uplift hydrostatic pressures during construction and when the structures are emptied after they are in service. Resisting these pressures may be accomplished by installing rock anchors along the bottom of the structures, providing thicker concrete walls to increase the dead weight of the structures, or constructing a toe on the structure footings. Since the tanks will be empty during construction, and may have to be drained in the future, the fact that they will be filled with liquid should not be considered in the design of the walls. Each wall of the structure should be constructed prior to backfilling behind the subsurface walls. Any below-grade walls should also be sealed against water infiltration. Temporary shoring and bracing may be required to facilitate construction of foundation systems for the wet well. Sloping, benching, and/or shoring of excavations required for construction should be designed and evaluated in accordance with OSHA 29 CFR Part 1926, titled "Occupational Safety and Health Standards - Excavations."

Seismic Activity

The project site is located in Winchester, Frederick County, Virginia which is considered to be a low seismic risk region. We recommend that Site Class "C" be utilized for seismic design of foundations. This recommendation is for the designer utilizing the International Building Code (IBC) 2015 guidelines. Liquefaction potential of the on-site soils is considered to be negligible.

CONSTRUCTION RECOMMENDATIONS

Site Preparation

Initial site preparation should include removal of trees, root mats, topsoil, and any other deleterious material from within the proposed structure footprints and extending at least five (5) feet beyond their perimeter. Any existing utilities should be re-located outside of the new construction area.

Any exposed subgrade which is to receive new fill or construction should be densified and proof-rolled, if feasible, or probed to identify soft, unstable areas. Any soft, unstable areas identified should be over-excavated to firm, stable material and should be replaced with new controlled fill. A qualified representative from Triad should be present to observe the subgrade and verify that appropriate conditions are present.

Site Excavations

Excavations within the overburden should be possible using suitably sized equipment. Large excavation equipment will be necessary to effectively remove weathered rock within some of the excavations. The effectiveness of the excavation equipment will be dependent on the size of the equipment used, size of excavation and the orientation of the bedding and fracturing of the weathered rock. Hard rock removal techniques such as hoe-ram chipping, heavy ripping or blasting may be required to achieve bottom elevations for the planned wet well. Hard rock is considered to be situated below the auger refusal depths noted on the boring logs. Excavated materials should not be stockpiled and construction equipment should not be positioned beside open excavations, since the added load may cause a sudden collapse of the excavation side walls.

The design and construction of all excavations should comply with applicable local, state, and federal safety regulations, including the current requirements of the Occupational Safety and Health Administration (OSHA). In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified by OSHA or any other regulatory agencies or local authorities having jurisdiction at the construction site.

Structural Fill Material

Fill required to attain design grades should be placed as controlled, compacted fill. Satisfactory fill includes approved on-site excavated materials, off-site granular borrow material (residual soils, soil/rock mixtures, and soft weathered rock), or a well-graded commercial stone such as crusher run aggregate. The fill should be free of trash, wood, topsoil, organics, coal, coal mine refuse, pyritic material containing greater than 0.5 percent by weight of pyritic sulfur, frozen material, and pieces of rock greater than 6 inches in any dimension. New fill should be tested and approved prior to placement and compaction.

Fill Placement and Compaction

Before initiating fill placement, the exposed subgrade should be proof-rolled with appropriate construction equipment to locate any soft spots or areas of excessive "pumping." Any such areas should be scarified, aerated, and re-compacted prior to placing fill, or removed and replaced with other structural fill.

During placement, moisten or aerate each layer of fill, as necessary, to obtain the required compaction. Fill should not be placed on surfaces that are muddy or frozen, or have not been approved by prior testing and/or proof-rolling. Free water should be prevented from appearing on the surface during or subsequent to compaction operations.

Soil material which is removed because it is too wet to permit proper compaction may be stockpiled, or spread and allowed to dry. Drying can be facilitated by discing, harrowing, or by pulverizing until the moisture content is reduced to an acceptable level. When the soil is too dry, water may be uniformly applied to the subgrade surface or to the layer to be compacted.

Fill material compacted by heavy compaction equipment should be placed in loose layers having a 9-inch maximum thickness. Fill compacted with lightweight equipment, such as hand-operated tampers or walk-behind rollers, should be placed in loose layers not exceeding 4 inches in thickness. Light compaction equipment should be used to compact fill adjacent to walls and formed foundations such that damage to these structural elements does not occur. Fill placed on sloping areas should be properly benched into the existing slope such that a smooth interface between the new fill and existing slope is not present.

Fill required within the structure footprints, any controlled fill slopes and 5 feet beyond their perimeters, should be compacted to at least 98 percent of the laboratory maximum dry density as determined by the Standard Proctor method (ASTM D 698). Granular materials, such as ASTM No. 57 stone, should be compacted to at least 85 percent of its relative density, as determined by ASTM D 4253 and D 4254 test methods. Fill for general site grading outside of structure areas should be compacted to at least 95 percent of the maximum Standard Proctor dry density. The placement moisture content of all fill should be within 3 percentage points of the optimum moisture content as determined by ASTM D 698. Fill placement should be observed and tested to verify that the fill areas are constructed as recommended in this report.

Foundation Construction

Foundation excavations should be compacted following excavation to densify loose or otherwise disturbed materials present in the base of the excavations. The excavations should be observed by a qualified representative from our office prior to base stone and/or concrete placement to verify that materials capable of providing the recommended bearing capacity are present. Materials exposed in the foundation excavations will be susceptible to softening and/or degradation if exposed to inclement weather. Consequently, foundation concrete should be placed in the excavation as soon as possible once the excavation has been observed and approved. It is also important that areas adjacent to foundations be adequately sloped to facilitate positive drainage away from the foundations both during and after construction.

Quality Assurance and Control

We recommend that the geotechnical engineer-of-record, Triad, be retained to observe the construction activities to verify that the field conditions are consistent with the findings of our exploration. If significant variations are encountered, or if the design is altered, we should be notified.

The geotechnical engineer should provide personnel full-time and/or intermittently, as necessary, to:

- observe final surface material removal and observe and verify proof-rolling of original subgrade prior to initial fill placement;

- observe and test material compaction during fill construction. Field density tests should be performed in accordance with ASTM D 6938 (nuclear method). At least three field density tests should be performed for each lift or at a frequency determined by the geotechnical engineer to be sufficient for the size of the fill area to verify the required soil compaction;

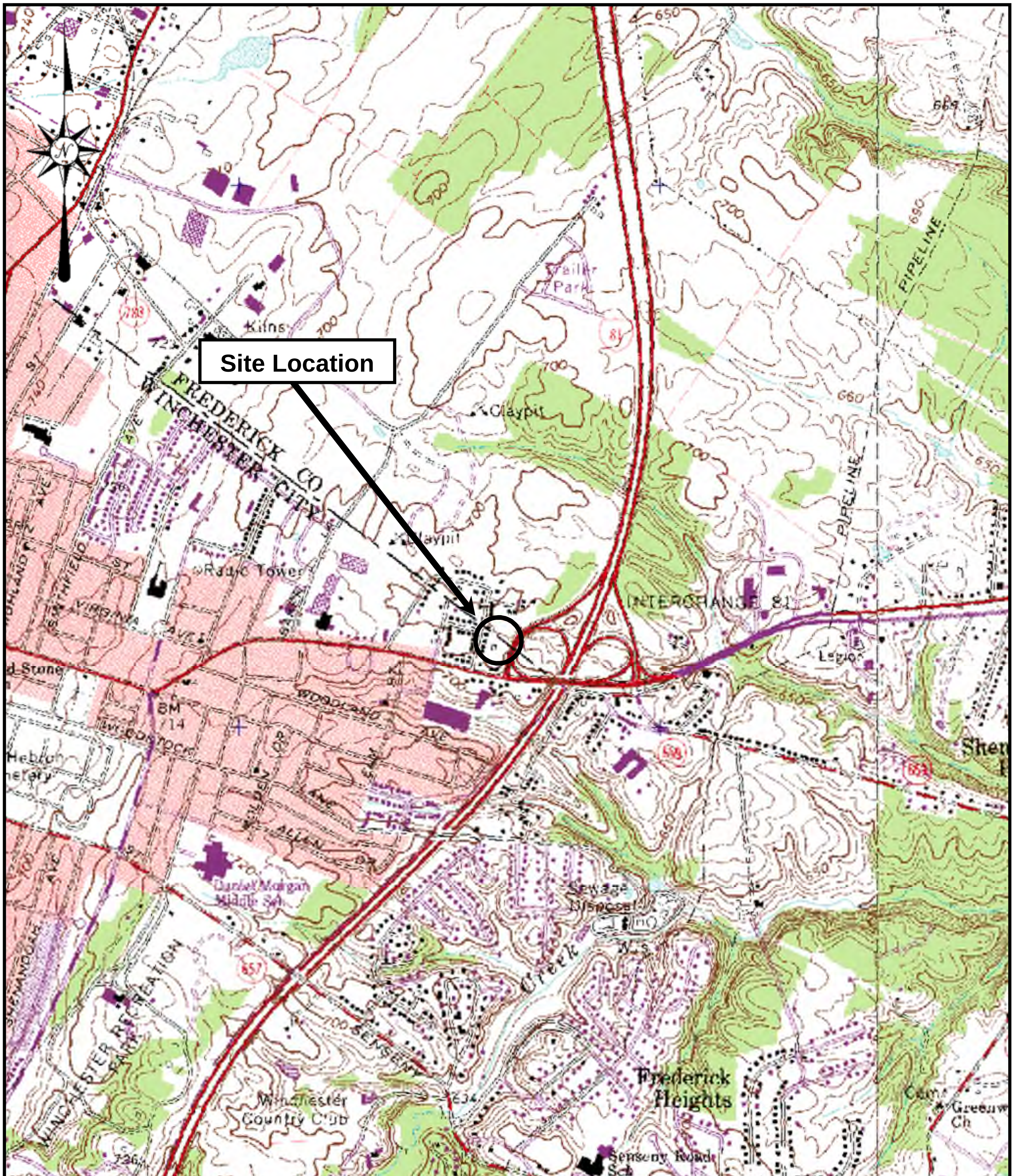
- examine foundation subgrade bearing levels to confirm compliance with our recommendations, and verify that adequate support is available, and;

- test structural concrete placed for the project.

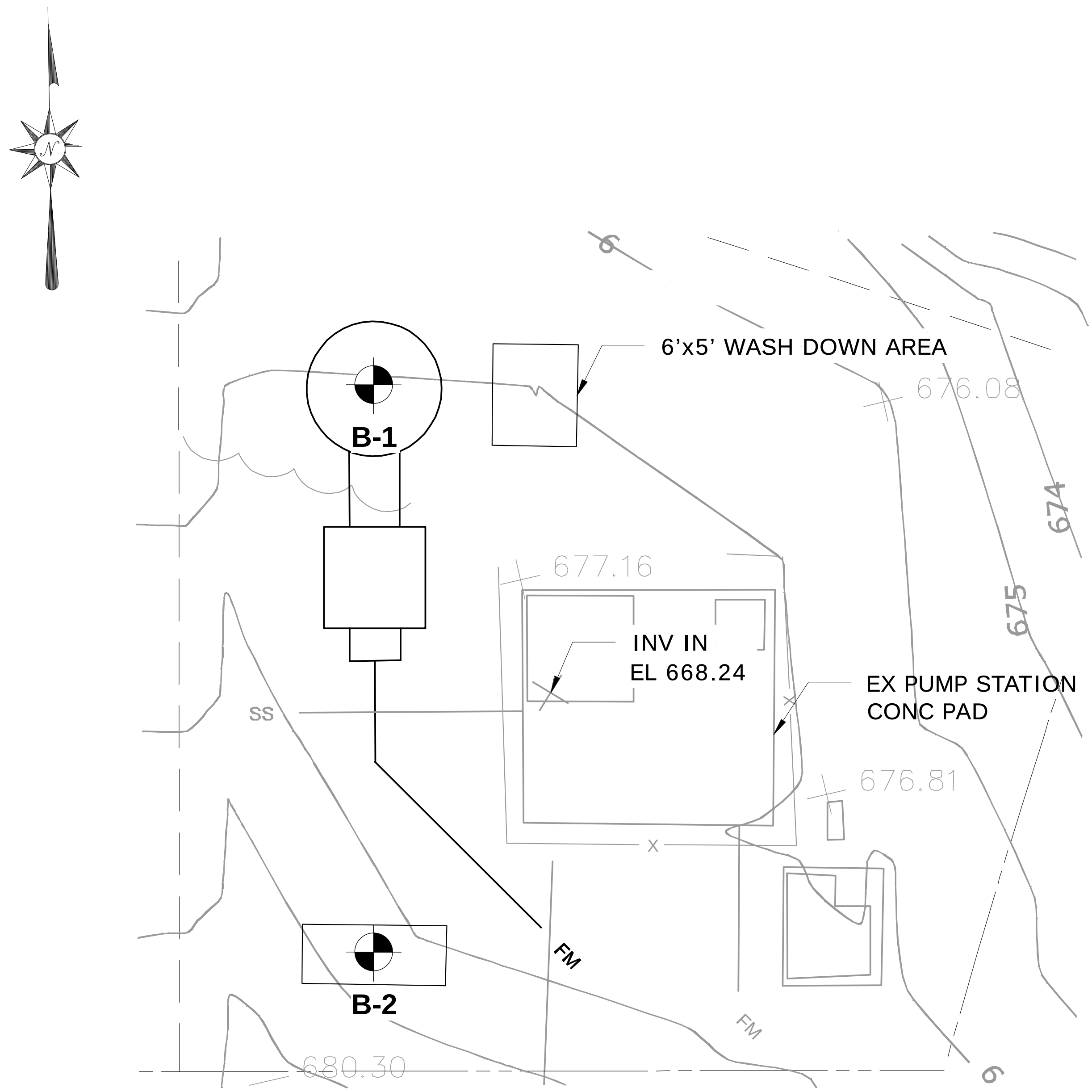
TRIAD ENGINEERING, INC.

APPENDIX A

Illustrations



SOURCE: USGS 7.5 Winchester (VA) 1987; Topographic Maps		CONWAY PUMP STATION WINCHESTER/FREDERICK COUNTY, VIRGINIA	TRIAD ENGINEERING, INC. www.triadeng.com
DRAWN BY: JAG	CHECKED BY: RAS	**SITE VICINITY PLAN**	
DATE: 08-09-2018	SCALE: 1"= 2000'	**TRIAD PROJECT NO. 07-18-0138**	**FIGURE NO.: A-1**



- Approximate Boring Location

Location Plan is Approximate.
For Reference Purposes Only.

SOURCE: Hazen and Sawyer		**CONWAY PUMP STATION WINCHESTER, FREDERICK COUNTY, VIRGINIA**	TRIAD ENGINEERING, INC. www.triadeng.com
DRAWN BY: JAG	**CHECKED BY:** RAS	**BORING LOCATION PLAN**	
DATE: 08-09-2018	**SCALE:** 1"=10'	**TRIAD PROJECT NO: 07-18-0138**	**FIGURE NO.: A-2**

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APPENDIX B

Field Exploration

FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling two (2) test borings with Standard Penetration Tests (SPT) and sampling. The borings were drilled by our subcontractor, Shenandoah Drilling, utilizing a Dietrich D-50 turbo rotary auger drill rig and hollow stem augers to advance the holes. The field exploration was supervised by geotechnical engineering personnel from our office.

SPT and sampling was performed in accordance with ASTM D 1586. The SPTs were performed to depths indicated on the attached boring logs using a split barrel sampler with an outside diameter of two (2) inches and an inside diameter of one and three-eighths (1-3/8) inches. The split barrel sampler was driven eighteen (18) inches with a hammer weighing approximately 140 pounds and falling thirty (30) inches. The number of blows required to drive the split barrel sampler at six (6) inch increments was recorded on the boring logs. The method utilized to classify the soils is defined in Figure No. 1, Key to Identification of Soils and Weathered Rock Samples.

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KEY TO IDENTIFICATION OF SOIL AND WEATHERED ROCK SAMPLES

The material descriptions on the logs indicate the visual identification of the soil and rock recovered from the exploration and are based on the following criteria. Major soil components are designated by capital letters and minor components are described by terms indicating the percentage by weight of each component. Standard Penetration Testing (SPT) and sampling was conducted in accordance with ASTM D1586. N-values in blows per foot are used to describe the *relative density* of coarse-grained soils or the *consistency* of fine-grained soils.

The MAJOR components constitute more than 50% of the sample and have the following size designation.		The MINOR components have the following percentage designation.	
COMPONENT	**PARTICLE SIZE**	**ADJECTIVE**	**PERCENTAGE**
Boulders	12 inches plus		
Cobbles	3 to 12 inches	and	35 - 50
Gravel -coarse	¾ to 3 inches		
-fine	#4 to ¾ inches	some	20 - 35
Sand -coarse	#10 to #4		
-medium	#40 to #10	little	10 - 20
-fine	#200 to #40		
Silt or Clay	Minus #200 (fine-grained soil)	trace	0 - 10

Relative Density – Coarse-grained Soils		**Consistency – Fine-grained Soils**	
Term	***N-Value***	***Term***	***N-Value***
Very Loose	≤ 4	ery Soft	≤ 2
Loose	5 to 10	Soft	3 to 4
Medium Dense	11 to 30	Medium Stiff	5 to 8
Dense	31 to 50	Stiff	9 to 16
Very Dense	>50	Very Stiff	>16

Soil Plasticity	**Plasticity Index (PI)**	**Rock Hardness**	
None	Nonplastic	***Term***	***N-Value***
Low	1 to 5	Very Weathered	≤ 50/.5
Medium	5 to 20	Weathered	50/.4
High	20 to 40	Soft	50/.3
Very High	over 40	Medium hard	50/.2 to 50/.1
		Hard	Auger Refusal

Moisture Description
Dry - Dusty, dry to touch
Slightly Moist - damp
Moist - no visible free water
Wet - visible free water, saturated

FIGURE NO. 1

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KEY TO IDENTIFICATION OF HARD ROCK SAMPLES

The material descriptions on the logs indicate the visual identification of the rock recovered from the NQ/NX coring operations and are based on the following criteria. Core recovery is the ratio of the length of core recovered in each run to the total length of the core run in percent. Rock Quality Designation (RQD) is the ratio of the sum of the lengths of rock core pieces 4 inches or longer divided by the length of the core run in percent.

Relative Degree of Rock Hardness	
Term	***Defining Characteristics***
Very Soft	Can be indented by thumb or crushed under pressure of finger and/or thumb
Soft	Can be scratched by fingernail, peeled by pocket knife or crushed with pressed hammer
Medium Hard	Cannot be scraped or peeled with knife but can be scratched, breaks easily with hammer blow
Hard	Breaks under one or two strong hammer blows or scratched with knife with difficulty
Very Hard	Breaks under several strong hammer blows with very resistant sharp edges

Rock Adjectives	
Seam	Thin layer (12 inches or less)
Interbedded	Thin or very thin alternating seams of bedrock occurring in equal amounts
Some	Significant amount of accessory material (15 to 40 percent)
Few	Insignificant amount of accessary material (0 to 15 percent)

Rock Quality Designation (RQD)		Recovery	
Term	***Percent***	***Term***	***Percent***
Very Poor	≤ 25	Poor	≤ 25
Poor	26 to 50	Low	26 to 50
Fair	51 to 75	Moderate	51 to 75
Good	76 to 90	High	76 to 90
Excellent	>90	Very High	>90

Rock Structure

Degree of Fracturing		Thickness of Bedding	
Term	***Spacing***	***Term***	***Spacing***
Intensely fractured or very broken	2 in.	Thinly bedded	<4 in.
Highly fractured or broken	2 in. to 8 in.	Medium bedded	4 in. to 1 ft.
Moderately fractured or blocky	8 in. to 2 ft.	Thickly bedded	1 ft. to 3 ft.
Slightly Fractured	2 ft. to 6 ft.	Massive	>3 ft.

Dip of Bed or Fracturing	
Flat	0º to 20º
Dipping	20º to 45º
Steeply Dipping	45º to 90º

FIGURE NO. 2

TRIAD ENGINEERING, INC.

TEST BORING LOG

Project Number: 07-18-0138 | Project Name: Conway Pump Station | Boring No.: **B-1**

Logger: KBA | Boring Location: See Figure No. A-2

Date Started: 08/13/18 | Drill/Method: DIEDRICH D50 TURBO

Date Completed: 08/13/18 | Driller: SHENANDOAH | Ground Elev.: 676.80

Legend: Shelby Tube; Standard Split Spoon; Core Sample; Auger Probe; Water Level Upon Completion 2.5 ft.

Depth (feet)	Sample No.	Sample Type	Blow Counts	Recovery (%)	RQD (RUN)	Strata Depth (ft)	MATERIAL DESCRIPTION	RQD (Strata)	Water Level	Graphic Log	Strata Elevation
	S-1	Split Spoon	6-6-5	89%			2" TOPSOIL Tan-brown lean **CLAY**, little sand, trace rock fragments and construction demolition debris (brick fragments), stiff, low plasticity, moist PP=0.5 tsf				
	S-2	Split Spoon	4-7-8	83%		4.0	-some sand and rock fragments, stiff (no evidence of construction/demolition debris in sample) PP=1.5 tsf -FILL-		▼ (2.5 ft)		672.8
5.0	S-3	Split Spoon	7-4-2	61%			Tan-brown-gray sandy **SILT** (highly decomposed shale), trace rock fragments, medium stiff, moist				
10.0	S-4	Split Spoon	10-6-5	94%			-stiff (highly decomposed shale) -Difficult augering between 12 and 14 feet.				
	S-5	Split Spoon	50/5"	0%		14.0	Tan-brown sandy **SILT TO SHALE**, very dense. -RESIDUUM				662.8
15.0		Core Sample		94%	26%	15.0	-AUGER REFUSAL AT 14.0 FEET-				661.8

Remarks: No groundwater encountered during or upon completion of drilling. Cave in at 12.0'. The noted water level is associated with remnant water after rock coring.

TRIAD ENGINEERING, INC.
200 Aviation Drive
Winchester, VA
P: 540.667.9300
F: 540.667.2260

TEST BORING LOG

Project Number: **07-18-0138** Project Name: **Conway Pump Station** Boring No.: **B-1**

Logger: KBA Boring Location: See Figure No. A-2

Date Started: 08/13/18 Drill/Method: DIEDRICH D50 TURBO

Date Completed: 08/13/18 Driller: SHENANDOAH Ground Elev.: 676.80

Legend: Shelby Tube; Standard Split Spoon; Core Sample; Auger Probe; Water Level Upon Completion 2.5 ft.

Depth (feet)	Sample No.	Sample Type	Blow Counts	Recovery (%)	RQD (RUN)	Strata Depth (ft)	MATERIAL DESCRIPTION	RQD (Strata)	Water Level	Graphic Log	Strata Elevation
	S-6	Core Sample		94%	26%	19.0	Gray hard **SHALE**, poor quality, very high recovery, very broken to broken, medium bedded with bedding planes ranging from nearly horizontal to nearly vertical.				657.8
							-BORING TERMINATED AT 19.0 FEET-				
20.0											
25.0											
30.0											

TRIAD_C 07-18-0138 BORINGS.GPJ TRIAD 3.GDT 09/12/18

TRIAD ENGINEERING, INC.

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Remarks: No groundwater encountered during or upon completion of drilling. Cave in at 12.0'. The noted water level is associated with remnant water after rock coring.

TEST BORING LOG

Project Number: **07-18-0138** Project Name: **Conway Pump Station** Boring No.: **B-2**
Logger: KBA Boring Location: See Figure No. A-2
Date Started: 08/13/18 Drill/Method: DIEDRICH D50 TURBO
Date Completed: 08/13/18 Driller: SHENANDOAH Ground Elev.: 678.40

Legend: Shelby Tube; Standard Split Spoon; Core Sample; Auger Probe

Depth (feet)	Sample No.	Sample Type	Blow Counts	Recovery (%)	RQD (RUN)	Strata Depth (ft)	MATERIAL DESCRIPTION	RQD (Strata)	Water Level	Graphic Log	Strata Elevation
	S-1	Standard Split Spoon	3-7-9	89%			2" TOPSOIL Tan-brown **SILT**, little sand, trace rock fragments, stiff, moist PP=0.75 tsf				
	S-2	Standard Split Spoon	3-6-6	33%			-stiff, little to some sand and rock fragments PP=0.75 tsf				
5.0	S-3	Standard Split Spoon	5-5-5	17%			-stiff, little recovery				
						8.0	-RESIDUUM-				670.4
	S-4	Standard Split Spoon	50/5"	11%			Tan-brown weathered **SHALE**, very dense, slightly moist				
10.0							-Difficult augering between 11.5 and 15.5 feet.				
	S-5	Standard Split Spoon	50/3"	0%			-very dense, no recovery -RESIDUUM- -AUGER REFUSAL AT 15.5 FEET-				
15.0						15.0					663.4

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Remarks: No groundwater encountered during or upon completion of drilling.

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APPENDIX C

Laboratory Testing

LABORATORY TESTING

The soil samples obtained during the field exploration were visually classified in the field by geotechnical engineering personnel from Triad. The recovered soils were further evaluated by laboratory testing. Laboratory soil tests were conducted in accordance with applicable ASTM Standards as listed below:

1) Moisture content tests were performed in accordance with ASTM D 2216.

2) Atterberg Limits tests, consisting of the liquid limit, plastic limit, and plasticity index, were performed in accordance with ASTM D 4318.

3) Sieve analyses with washed No. 200 sieve tests were performed in accordance with ASTM D 422.

A summary and details of the laboratory tests are included on the following pages of this appendix.

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SOIL DATA SUMMARY

SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE TYPE	NATURAL MOISTURE (%)	ATTERBERG LIMITS			GRADATION			USCS SOIL CLASS.	PROCTOR		ADDITIONAL TESTS CONDUCTED
				LL	PL	PI	% GRAVEL	% SAND	% FINES		MAX. DD (pcf)	OPT. M (%)	
B-1	2.5-4	SS	15.3										
B-1	5-6.5	SS	33.9	36	25	11	20	22	58	ML			
B-1	8.5-10	SS	17.3										
B-2	0-1.5	SS	10.4										
B-2	5-6.5	SS	10.4										

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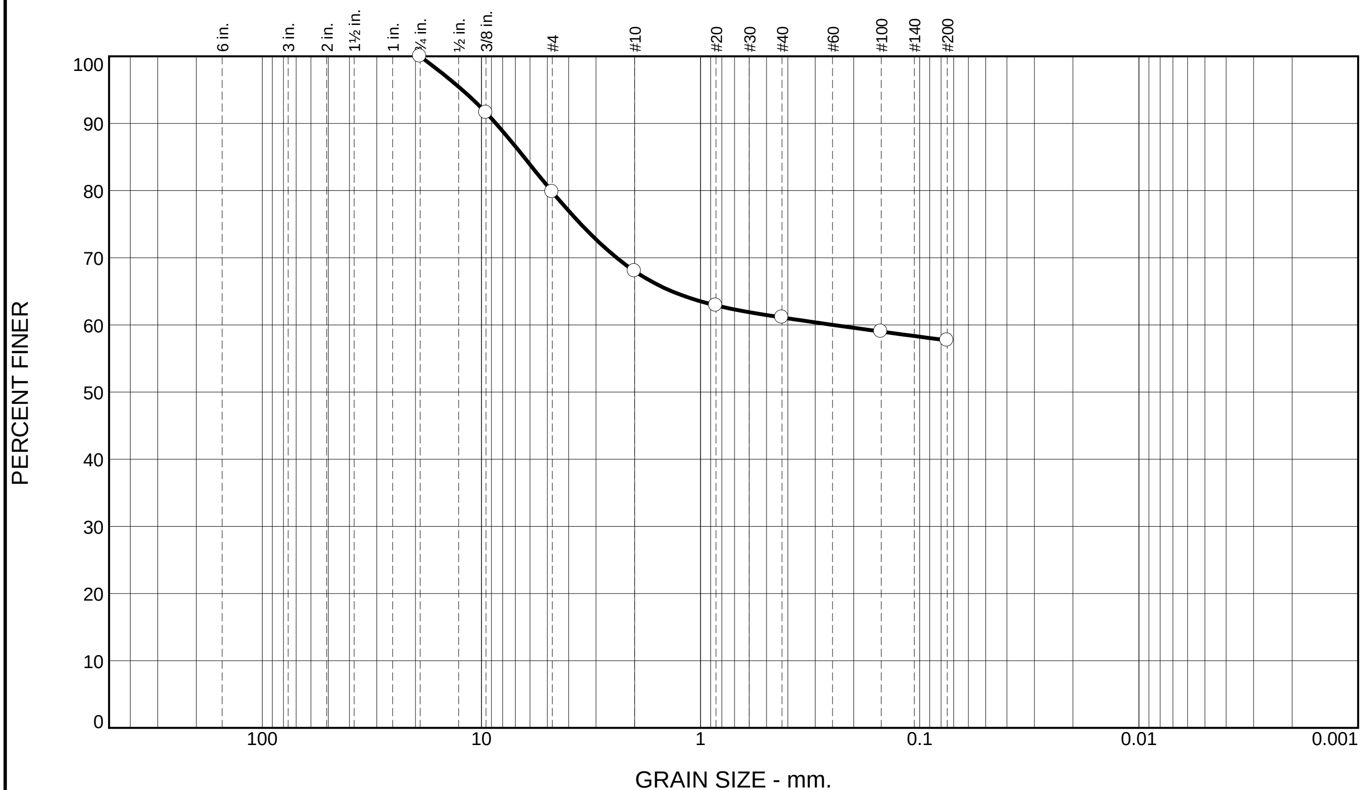
Notes:
1) Soil tests performed in accordance with recognized ASTM testing standards.
2) SS = Split Spoon; UD = Undisturbed

PROJECT NUMBER: 07-18-0138
PROJECT NAME: Conway Pump Station
LOCATION: Winchester, Fred.Co., VA

FIGURE C-1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	20.2	11.8	6.9	3.4	57.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
3/8"	91.6		
#4	79.8		
#10	68.0		
#20	62.9		
#40	61.1		
#100	59.0		
#200	57.7		

* (no specification provided)

Material Description

Tan-brown sandy SILT, some gravel

Atterberg Limits

PL= 25 LL= 36 PI= 11

Coefficients

D_{90}= 8.5881 D_{85}= 6.3970 D_{60}= 0.2499
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-6(5)

Remarks

Source of Sample: B-1 **Depth:** 5.0' - 10.0'

Date: 8-22-2018

Triad Engineering, Inc.

Client: Hazen and Sawyer
Project: Conway Pump Station
Winchester, Frederick County, VA
Project No: 07-18-0138 **Figure** C-2

Tested By: KBA **Checked By:** RAS