Appendix F - Geotechnical Recommendations Report

Geotechnical Recommendations Report Church Road Interconnects

PennEast Pipeline Project

January 24, 2020

PennEast Pipeline

Mott MacDonald
111 Wood Avenue South
Iselin NJ 08830-4112
United States of America

T +1 (800) 832 3272
F +1 (973) 376 1072
mottmac.com

PennEast Pipeline Project
835 Knitting Mills Way
Wyomissing, PA 19610
610-373-7999

Geotechnical Recommendations Report Church Road Interconnects

PennEast Pipeline Project

January 24, 2020

PennEast Pipeline

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	01-24-2019	B. Kalpouzos	T. Rajah	V. Shah, PE	Issue for FERC

Document reference: 353753-MM-E-E-128

Information class: Standard

Contents

Tables

Figures

Executive summary

At the request of the PennEast Pipeline Company, LLC. (PennEast), Mott MacDonald has conducted a geotechnical recommendation report for the foundation design of the proposed natural gas interconnects in Bethlehem Township along Route 33 in Northhampton County, PA. A site-specific geotechnical investigation was performed for this area in January 2017 by Mott MacDonald. The information from that investigation, including boring B-JBRS33-1 and geophysical test results, were reviewed to prepare geotechnical recommendations for this site.

Mott MacDonald evaluated two foundation types which may be used at the site including sonotubes or slab-on-grade. Assuming the bottom of the sonotube is at 3 feet BGS, we recommend an allowable bearing capacity of 2,000 psf. This recommendation is made considering a minimum 18-inch diameter sonotube foundation embedded 3 feet BGS. We recommend 12-inch of structural fill be placed below the foundation. We recommend an allowable bearing capacity of 1,500 psf for slab-on-grade foundations. This recommendation is made considering a 3-foot by 5-foot concrete slab with a thickness of at least 8 inches. Our analysis assumed one foot of native soil will be excavated and backfilled with compacted structural fill.

The allowable capacity will likely, in our opinion, experience a total settlement of 1-inch or less. Should foundation dimensions or construction be different than that provided above, Mott MacDonald should be consulted to evaluate the effect of changes in above recommendation, if any. The structural fill shall be built up to the proposed elevation in 8-inch lifts and compacted to 95% of its maximum dry density as determined by the Modified Proctor Test (ASTM D1557). The existing site soils may be used for reused as general backfill only.

Infiltration testing for stormwater management design has not been completed at the time of this report.

1 Introduction

PennEast Pipeline Company, LLC. (PennEast) is proposing natural gas interconnects in Bethlehem Township along Route 33 in Northhampton County, PA. The facility will support its 120-mile, 36-inch diameter high pressure natural gas pipeline that spans from Luzerne County, Pennsylvania to Mercer County, New Jersey.

A site-specific geotechnical investigation was performed for this area in January 2017 by Mott MacDonald. The information from that investigation, including boring B-JBRS33-1 and geophysical test results, were reviewed to prepare geotechnical recommendations for this site. At the time of this report, a conceptual site plan of the proposed station is not included in Appendix A. A boring location plan and boring log for B-JBSR33-1 are provided in Appendix B and C, respectively. Figure 1, shown below, depicts the approximate site location, while Figure 2 shows an enhanced view of the proposed site.

Figure 1 - Site Vicinity Map

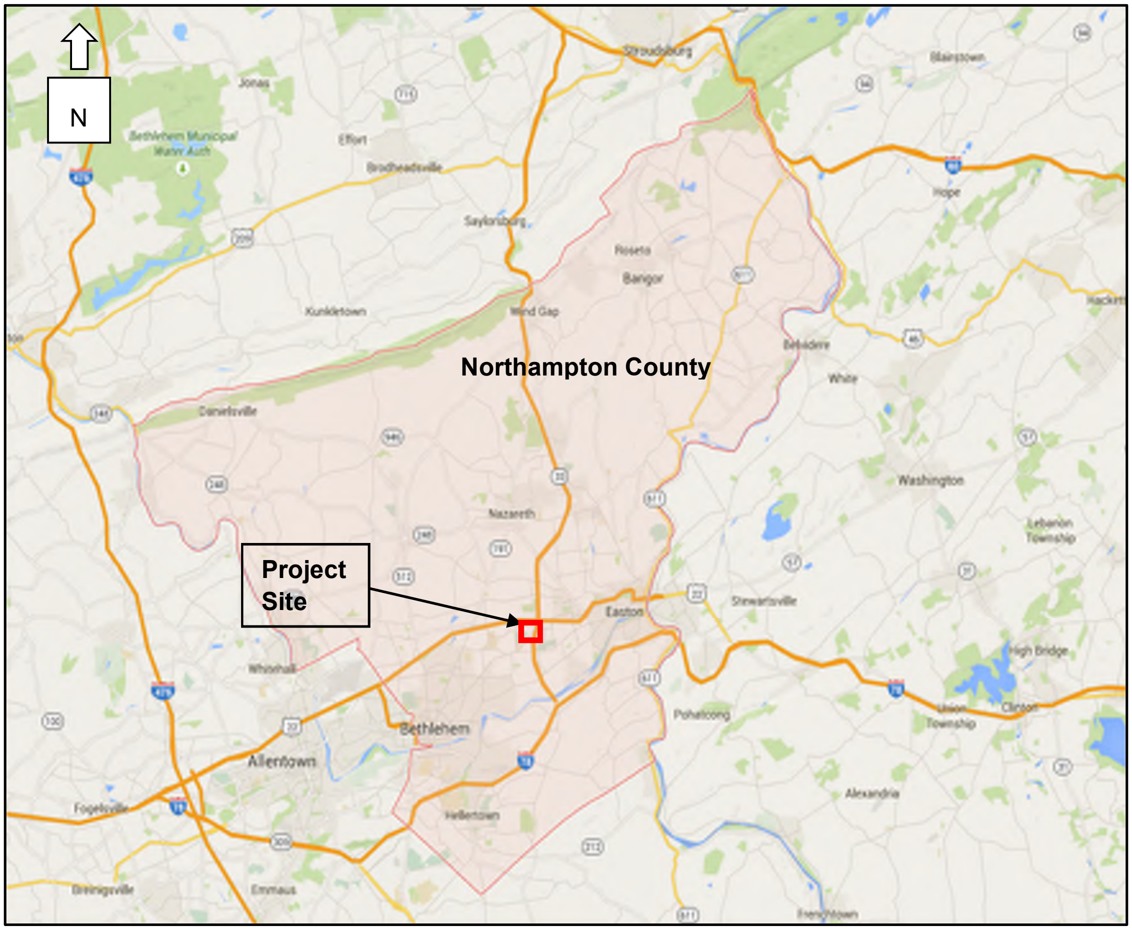
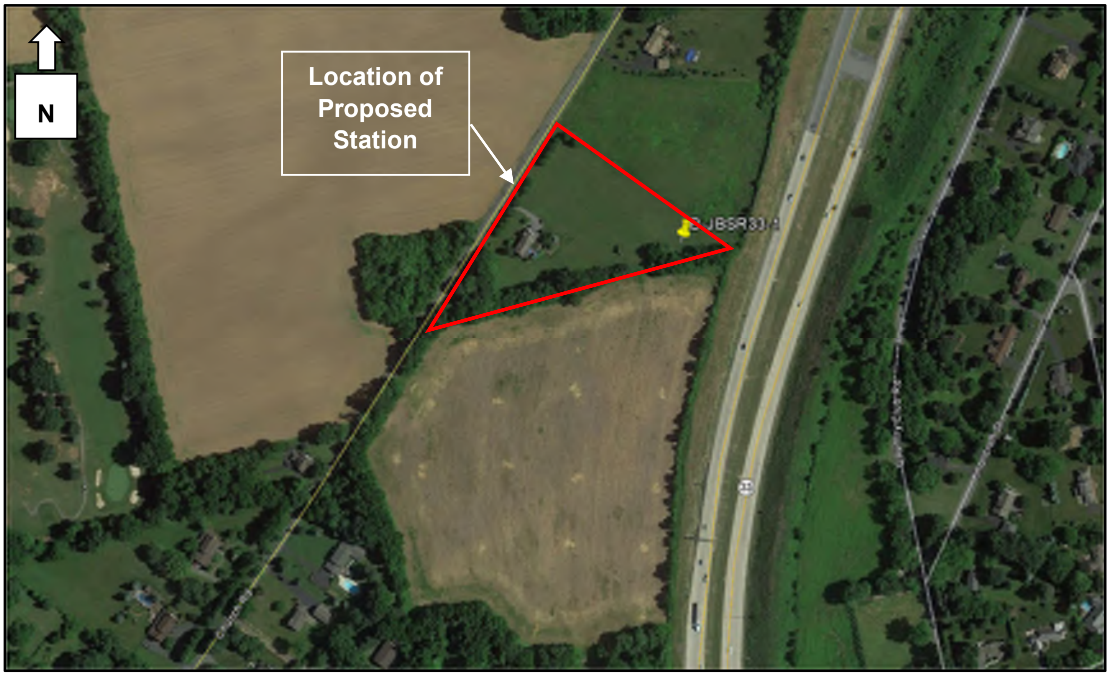


Figure 2 - Site Location Map



2 Local Geology

Mott MacDonald performed a desktop evaluation of publicly-available geologic data prior to evaluating the project site.

2.1 Surficial Geology

Based on the Natural Resources Conservation Service (NRCS) Web Soil Survey, the surficial overburden within the area of interest consists primarily Urban land and Washington series silt loam. The Washington series consists of well drained soils formed from a Pre-Wisconsin Age glacial drift and colluvium (limestone and granitic gneiss).

2.2 Bedrock Geology

Based on geological mapping through the Pennsylvania Department of Conservation and Natural Resources (PA DCNR), the proposed site location lies within the Rickenbach and Allentown Formations of Ordovician age consisting of medium to dark gray coarse-grained dolomite and limestone with occasional chert beds and nodules.

It is possible that other formations or rock types could occur within the vicinity of the interconnects, due to the nature of USGS maps.

Mapped geologic data is provided in Appendix D.

2.3 Karst Formations and Abandoned Mines

Mapped karst features in the vicinity of the proposed interconnects are depicted in Figure 3. Pennsylvania Department of Conservation & Natural Resources (PA DCNR) mapping indicate that there are more than 100 surface depressions and 29 sinkholes within 0.5 miles of the proposed site location. There are two documented surface depressions on site, and one documented sinkhole near the site.

Figure 3 – Karst Formations

Source: PA DCNR Interactive Online Map

2.4 Presence of Faults

PA DCNR and United Stated Geological Survey (USGS) mapping indicate that one fault line exists approximately one mile south of the site vicinity. This can be seen on the bedrock map located in Appendix D. This fault is not considered to be an active fault as earthquake activity has not been mapped within the site vicinity. Mott MacDonald does not believe this presents a risk to the proposed site improvements.

3 Subsurface Description

3.1 Subsurface conditions

The major strata encountered in boring B-JBSR33-1 are described in the general profile below. The profile is described in approximate order found, from existing ground surface to the boring termination depth. Refer to the typed boring log provided in Appendix C for a more detailed description.

- **TOPSOIL with roots:** encountered at the top of boring and was approximately 0.3 feet thick.
- **SILT:** encountered below the topsoil and was generally described as soft to medium stiff, brownish yellow to reddish brown, and extended to 4 feet BGS.
- **CLAY:** encountered underlying the silt stratum. This stratum was described as medium stiff to very stiff, light brown to brownish yellow clay with varying amounts of gravel and sand.
- **CLAYEY SAND:** interbedded within the clay stratum and described as very loose to medium dense, brownish yellow to reddish brown, clayey sand with varying amounts of gravel.
- **DECOMPOSED ROCK:** encountered below the clay stratum at 50.5 feet BGS to the boring termination depth of 51 feet BGS and was described as decomposed dolomite.

3.2 Groundwater

Groundwater was not encountered within the boring at the time of our investigation. It should be noted that groundwater depths are ephemeral and may fluctuate sue to weather or seasonal influences.

3.3 Geophysical Survey

A geophysical survey was performed at the site on September 24 and 27, 2018 by Hager-Richter Geoscience, Inc to identify and map the stratigraphy for possible karst zones. The resistivity data was acquired using an AGI SuperSting R8 with Dipole-Dipole electrode configuration with 56 electrodes and 8-foot electrode spacing. The results of this geophysical survey are provided as Appendix E. The geophysical survey did not record the presence of possible karst formations within the alignment surveyed at the project site.

4 Geotechnical Assessment and Recommendations

4.1 Project Information

A site plan of the proposed interconnects is currently being finalized at the time of this report. A sonotube and slab-on-grade foundations are expected and have been analyzed for the proposed site improvements.

4.2 Bearing Capacity and Settlement

4.2.1 Sonotube Foundation

The station's foundation should be designed using the resistances presented below. The factored resistances were calculated in accordance with the Allowable Capacity Design (ASD). Based on the site location, the frost depth is expected to be at 30 inches BGS. Assuming the bottom of the sonotube is at 3 feet BGS, we recommend an allowable bearing capacity of 2,000 psf. This recommendation is made considering a minimum 18-inch diameter sonotube foundation embedded 3 feet BGS. We recommend 12-inch of structural fill be placed below the foundation.

4.2.2 Slab-on-Grade Foundation

We recommend an allowable bearing capacity of 1,500 psf for slab-on-grade foundations. This recommendation is made considering a 3-foot by 5-foot concrete slab with a thickness of at least 8 inches. Our analysis assumed one foot of native soil will be excavated and backfilled with compacted structural fill.

It is our professional opinion that applied pressures within this limit will cause a settlement of one-inch or less. However increasing the dimensions of the slab may cause larger settlement.

It should be noted that additional borings throughout the site could be performed to confirm subsurface conditions.

Should the foundation dimensions be different than those evaluated above, Mott MacDonald should be consulted to evaluate the effect of the change in the above recommendations, if any. Bearing resistances and settlement calculations supporting these recommendations are provided as Appendix H.

4.3 Seismic Design Considerations

4.3.1 Liquefaction

Liquefaction is the full or partial loss of shear strength of granular or cohesionless soil during an earthquake event. Liquefiable soils can be loose sands, silty sands, and soft silts. The general soils observed at the site consisted mainly of stiff clay with decomposed rock. Based on our assessment liquefaction is unlikely during a seismic event.

4.3.2 Site Classification

Mott MacDonald utilized data obtained from the soil boring, B-JBSR33-1, to determine the seismic site class of the site. In accordance with the SPT average N-value method as prescribed in Chapter 20 of the ASCE Standard 7-10 design manual, site class D for “stiff soil” should be utilized across the project site.

The following Site Class D seismic ground motion values were obtained from the USGS Seismic Hazard Maps, referenced in ASCE 7-10 Standard, for this site:

- 0.2 second spectral response acceleration, S_S= 0.2 g
- 1 second spectral response acceleration, S_1= 0.063 g
- Maximum spectral acceleration for short periods, S_{MS}= 0.32 g
- Maximum spectral acceleration for a 1-second period, S_{M1}= 0.15 g
- 5% damped design spectral acceleration at short periods, S_{DS}= 0. 213 g
- 5% damped design spectral acceleration at 1-second period, S_{D1}= 0.1 g

USGS seismic ground motion data is provided as Appendix G.

5 Construction Recommendations

5.1 General

Selections for recommended designs are based on project-specific conditions obtained from the data collected from the soil boing.

5.2 Temporary Excavation Support

Excavation openings shall follow local building code requirements, or OSHA Standard 1926.651 and all applicable regulations. The contractor should be prepared to provide adequate drainage at the base of any excavation and during sub base preparation to maintain the in-place density of subgrade soils as well as provide a safe and stable working area. All storm water runoff should be directed away from any excavation to avoid ponding of water.

5.3 Dewatering

Based on the historic boring, it is not expected that dewatering of groundwater is likely to be required for activities related to the foundation construction; however, the contractor should be prepared to control runoff from precipitation by using local sumps and pumps. It should be noted that depth to groundwater is ephemeral and is subject to seasonal variation.

5.4 Foundations and Backfilling

A foundation analysis comparing sonotubes and slab-on-grade designs was performed. The designs considered an 18-inch sonotube foundation embedded a depth of 3 feet below grade and a slab-on-grade foundation with 3-foot by 5-foot dimensions.

Any soil material which contains organic and deleterious material shall be removed under any foundation structure. Prior to the installation of the foundation, it is recommended that the foundation subgrade be confirmed by a qualified geotechnical engineer.

Native material on site may be used as general backfill for cut and fill activities on site. However, due to its fine grain content, it will not be suitable for use beneath structural components. The use of native and imported general backfill below non-structural elements may be built up in 6 to 8-inch loose lifts and compacted to 90% Modified Proctor density as determined in accordance with ASTM D1557.

Mott MacDonald recommends over excavation of a minimum one foot below each foundation element and backfilled with compacted structural fill to meet the final subgrade elevations. Any placed structural fill shall be built up to the proposed elevation in 8-inch loose lifts and compacted to 95% of its maximum dry density as determined by the Modified Proctor Test in accordance with the testing procedures found in the most recent version of ASTM D1557. Any material used as structural fill shall be free draining, structurally sound, and free from deleterious material. The recommended gradation for structural fill is shown in the table below.

Table 1: Recommended Gradation for Structural Fill

Sieve Size	Percent Passing
1 ½ inch	60 – 100
No. 4	30 – 60
No. 200	0 – 10

6 Limitations

The results and recommendations presented in this report are based on subsurface information from a limited amount of explorations and our use of generally accepted analytical procedures. If further investigation reveals significant differences in the subsurface conditions, or if foundation elevations or locations are revised, Mott MacDonald should be given the opportunity to review and modify our recommendations, if appropriate.

Appendices

A. Conceptual Site Plan (not included)

B. Boring Location Plan

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

MOTT MACDONALD

Mott MacDonald
111 Wood Avenue South
Iselin, NJ 08830-4112
United States of America

T +1 973 379 3400
F +1 973 912 2400
mottmac.com

Certificate No. 24GA28016600

Client

PennEast PIPELINE

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/18/2019				

0 75 150 300 450 600 Feet

Reference Scale: 1:3,600

Absolute Scale: 1 inch = 300 feet

Project Number: 507353754

B/O: 1

Total: 1

Designed: BK

Drawn: AGW

Dwg Check: TR

Eng check:

Coordination:

Approved: VAS

Scale at 11" x 17": AS SHOWN

Status:

Rev:

Security:

Drawing Number: BLP-1

Title

BORING LOCATION

CHURCH ROAD INTERCONNECTS

PENNEAST PIPELINE
BETHLEHEM, PENNSYLVANIA

P:\353754 PennEast\Geotechnical\009-Stations\12 - Church Rd Interconnect\I - Drawings\Location Plans\MXD\Boring Location Plan.mxd

IMAGE SOURCE: OGRIP

C. Boring Logs

MOTT MACDONALD

SOIL BORING LOG

BORING NO.: **B-JBSR33-1**
Page **1** of **3**

Project: PennEast Pipeline Project
Location: Bethlehem, PA
Client: PennEast Pipeline
Drilling Co.: Uni-Tech Drilling Co., Inc.
Driller/Helper: Jay Blemings /Gene Blemings

Project No.: 353754
Project Mgr: Vatsal Shah
Field Eng. Staff: Jonathan Nelson
Date/Time Started: January 10, 2017 at 9:20 am
Date/Time Finished: January 10, 2017 at 12:00 pm

Elevation: 403.4 ft.
Vertical Datum: NAVD 1988
Boring Location: Church Road, Bethlehem, PA
Coord.: **N:** 40.67568268 **E:** -75.29259395
Horizontal Datum: NAD 1983

Item	**Casing**	**Sampler**	**Core Barrel**
Type	HW	SS	NQ2
Length (ft)	5	2	5
Inside Dia. (in.)	4	1.375	2.0
Hammer Wt. (lb.)	140	140	-
Hammer Fall (in.)	30	30	-

Rig Make & Model: CME-55LC			**Hammer Type**	**Drilling Fluid**	**Drill Rod Size:**
☐ Truck	☐ Tripod	☐ Cat-Head	☐ Safety	☐ Bentonite	**Casing Advance**
☐ ATV	☐ Geoprobe	☑ Winch	☐ Doughnut	☐ Polymer	Hollow Stem Auger
☑ Track	☐ Air Track	☐ Roller Bit	☑ Automatic	☑ Water	
☐ Skid	☐ ________	☑ Cutting Head	☐ ________	☐ None	

Depth/ Elev. (ft)	Sample No. / Interval (ft)	Rec. (in)	Sample Blows per 6"	Stratum Graphic	USCS Group Symbol	**Visual - Manual Identification & Description** (Density/consistency, color, Group Name, constituents, particle size, structure, moisture, optional descriptions, geologic interpretation, Symbol)	Field Tests: Dilatancy	Toughness	Plasticity	Dry Strength	Remarks
	S-1 0.0'- 2.0'	19	2 2 2 2		ML	0.3 4" - TOPSOIL Soft, Brown to brownish yellow SILT, dry (ML)	-	-	-	-	PP= 1.6 tsf TV= 0.0 tsf
400	S-2 2.0'- 4.0'	17	2 3 3 4		ML	Medium stiff, Reddish brown SILT, moist (ML) 4.0	-	-	-	-	PP= 3.6 tsf TV= 0.35 tsf
5	S-3 4.0'- 6.0'	21	3 3 4 3		SC	Loose, Brownish yellow Clayey SAND with Gravel, moist (SC) 6.0	-	-	-	-	PP= 1.0 tsf TV= N/A Gravel is Dolomite and Quartz fragments. Sieve and Hydrometer analysis performed WC = 14.6%
	S-4 6.0'- 8.0'	24	2 4 4 2		CL	Stiff, Brownish yellow Sandy CLAY, trace Gravel, moist (CL)	-	L	L	M	
	S-5 8.0'- 10.0'	23	2 3 5 5		CL	Stiff, Brownish yellow to light brown CLAY, moist (CL)	-	L	L	M	LL = 37 PL = 20 PI = 17 WC = 24.9%
10	S-6 10.0'- 12.0'	22	5 7 7 7		CL	Stiff, Light brown to brownish yellow CLAY with Gravel, moist (CL)	-	L	L	L	PP= 3.9 tsf TV= 0.39 tsf Gravel is Chert and Quartz fragments.
390											
15	S-7 15.0'- 17.0'	20	4 5 5 6		CL	Stiff, Light brown to brownish yellow CLAY with Gravel, moist (CL)	-	L	L	M	PP= 4.5 tsf TV= 0.46 tsf Gravel is Dolomite fragments. LL = 38 PL = 22 PI = 16 WC = 25.5%

Water Level Data

Date	Time	Elapsed Time (hr)	Depth in feet to: Bot. of Casing	Bottom of Hole	Water

Sample Type

O	Open End Rod
T	Thin-Wall Tube
U	Undisturbed Sample
S	Split Spoon Sample
G	Geoprobe

Notes:
PP = Pocket Penetrometer
TV = Torvane
LL = Liqiud Limit
PL = Plastic Limit
PI = Plasticity Index
WC = Water Content

Boring No.: **B-JBSR33-1**

Field Test Legend: Dilatancy: N - None S - Slow R - Rapid Plasticity: NP - Non-Plastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High Dry Strength: N - None L - Low M - Medium H - High VH - Very High

NOTES: 1.) "ppd" denotes soil sample average diametral pocket penetrometer reading. 2.) "ppa" denotes soil sample average axial pocket penetrometer reading.
3.) Maximum Particle Size is determined by direct observation within limitations of sampler size. 4.) Soil identifications and field tests based on visual-manual methods per ASTM D2488.

Depth/ Elev. (ft)	Sample No. / Interval (ft)	Rec. (in)	Sample Blows per 6"	Stratum Graphic	USCS Symbol Group	Visual - Manual Identification & Description (Density/consistency, color, Group Name, constituents, particle size, structure, moisture, optional descriptions, geologic interpretation, Symbol)	Field Tests: Dilatancy	Field Tests: Toughness	Field Tests: Plasticity	Field Tests: Dry Strength	Remarks*
	S-8 20.0'- 22.0'	20	4 4 4 4		CL	Stiff, Light brown to brownish yellow CLAY with Gravel, moist (CL)	-	L	L	M	PP= 3.5 tsf TV= 0.55 tsf
380											
25	S-9 25.0'- 27.0'	23	4 4 3 2		CL	Medium stiff, Brownish yellow to light brown CLAY with Gravel, moist (CL)	-	L	L	M	PP= 2.0 tsf TV= N/A LL = 37 PL = 20 PI = 17 WC = 25.9%
						28.5					
30	S-10 30.0'- 32.0'	24	4 5 7 7		SC	Medium dense, Brownish yellow Clayey SAND, moist (SC)	-	L	L	L	PP= 3.9 tsf TV= N/A
370											
						33.5					
35	S-11 35.0'- 37.0'	24	3 5 4 4		CL	Stiff, Brownish yellow CLAY, trace Gravel, moist (CL)	-	L	L	M	PP= 1.5 tsf TV= 0.31 tsf Gravel is Dolomite fragments. LL = 36 PL = 19 PI = 17 WC = 25.2%
						38.5					
40	S-12 40.0'- 42.0'	15	5 2 2 3		SC	Very loose, Brownish yellow Clayey SAND, moist (SC)	-	L	L	L	
360											
						43.5					
45	S-13 45.0'- 47.0'	24	18 13 8 8		CL	Very stiff, Brownish yellow to reddish brown Sandy CLAY, moist (CL)	-	L	L	M	PP= 3.6 tsf TV= N/A

NOTES:

NOTES: 1.) "ppd" denotes soil sample average diametral pocket penetrometer reading. 2.) "ppa" denotes soil sample average axial pocket penetrometer reading.
3.) Maximum Particle Size is determined by direct observation within limitations of sampler size. 4.) Soil identifications and field tests based on visual-manual methods per ASTM D2488.

Depth/ Elev. (ft)	Sample No. / Interval (ft)	Rec. (in)	Sample Blows per 6"	Stratum Graphic	USCS Symbol Group	**Visual - Manual Identification & Description** (Density/consistency, color, Group Name, constituents, particle size, structure, moisture, optional descriptions, geologic interpretation, Symbol)	Field Tests: Dilatancy	Toughness	Plasticity	Dry Strength	Remarks*
50	S-14 50.0'-51.0'	12	23 50/5"		CL	50.5 Top (6") Brownish yellow Sandy CLAY, moist (CL)	-	L	L	M	
						51.0 Bottom (6") Gray DECOMPOSED ROCK fragments					
						End of Boring at 51 feet BGS. Borehole grouted with cement and bentonite hole plug.					Decomposed Rock is Dolomite fragments.
350											
55											
60											
340											
65											
70											
330											
75											

NOTES:

NOTES: 1.) "ppd" denotes soil sample average diametral pocket penetrometer reading. 2.) "ppa" denotes soil sample average axial pocket penetrometer reading.
3.) Maximum Particle Size is determined by direct observation within limitations of sampler size. 4.) Soil identifications and field tests based on visual-manual methods per ASTM D2488.

D. Geologic Background Information

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Northampton County, Pennsylvania

Church Road Interconnects

December 18, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


75° 17' 41" W
75° 17' 30" W
475090
475110
475130
475150
475170
475190
475210
475230
475250
475270
475290
475310
475330
40° 40' 36" N
40° 40' 30" N
4502910
4502890
4502870
4502850
4502830
4502810
4502790
4502770
Church Rd
WaA
WaB
UudB
Soil Map may not be valid at this scale.
Map Scale: 1:1,190 if printed on A landscape (11" x 8.5") sheet.
N
0
15
30
60
90
Meters
0
50
100
200
300
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- ■ Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- ■ Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Northampton County, Pennsylvania
Survey Area Data: Version 12, Sep 17, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 20, 2010—Aug 28, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
UudB	Urban land-Udorthents, limestone complex, 0 to 8 percent slopes	0.0	0.0%
WaA	Washington silt loam, 0 to 3 percent slopes	3.1	99.5%
WaB	Washington silt loam, 3 to 8 percent slopes	0.0	0.5%
Totals for Area of Interest		**3.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Northampton County, Pennsylvania

UudB—Urban land-Udorthents, limestone complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 227x6
Elevation: 300 to 1,000 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 80 percent
Udorthents, limestone, and similar soils: 15 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform: Hills, valleys
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Interfluve, side slope, nose slope, head slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Pavement, buildings and other artifically covered areas

Typical profile

H1 - 0 to 6 inches: variable

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 to 99 inches to lithic bedrock
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Description of Udorthents, Limestone

Setting

Landform: Valleys, hills
Landform position (two-dimensional): Shoulder, footslope, backslope, summit
Landform position (three-dimensional): Interfluve, side slope, nose slope, head slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Graded areas of argillaceous limestone

Typical profile

H1 - 0 to 6 inches: clay loam

H2 - 6 to 60 inches: clay

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 99 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Duffield

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

WaA—Washington silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l7dt
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Washington and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Washington

Setting

Landform: Valleys

Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from limestone and/or old glacial drift

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 42 inches: clay loam
H3 - 42 to 61 inches: gravelly loam
H4 - 61 to 71 inches: bedrock

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 5 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Ryder

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Thorndale

Percent of map unit: 1 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave

Hydric soil rating: Yes

Penlaw

Percent of map unit: 1 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

WaB—Washington silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l7dv
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Washington and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Washington

Setting

Landform: Valleys
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from limestone and/or old glacial drift

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 42 inches: clay loam
H3 - 42 to 61 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 2 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Loudonville

Percent of map unit: 1 percent
Landform: Till plains
Landform position (three-dimensional): Head slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Ryder

Percent of map unit: 1 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Thorndale

Percent of map unit: 1 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Chemical Soil Properties–Northampton County, Pennsylvania								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
UudB—Urban land-Udorthents, limestone complex, 0 to 8 percent slopes								
Urban land	0-6	—	—	—	0	0	0	0
Udorthents, limestone	0-6	19-25	—	5.1-6.5	0	0	0	0
	6-60	23-34	—	5.1-6.5	0	0	0	0
WaA—Washington silt loam, 0 to 3 percent slopes								
Washington	0-9	10-20	—	5.6-7.3	0	0	0	0
	9-42	10-16	—	5.6-7.3	0	0	0	0
	42-61	7.0-13	—	5.6-7.3	0	0	0	0
	61-71	—	—	—	0	0	0	0
WaB—Washington silt loam, 3 to 8 percent slopes								
Washington	0-9	10-20	—	5.6-7.3	0	0	0	0
	9-42	10-16	—	5.6-7.3	0	0	0	0
	42-61	7.0-13	—	5.6-7.3	0	0	0	0

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

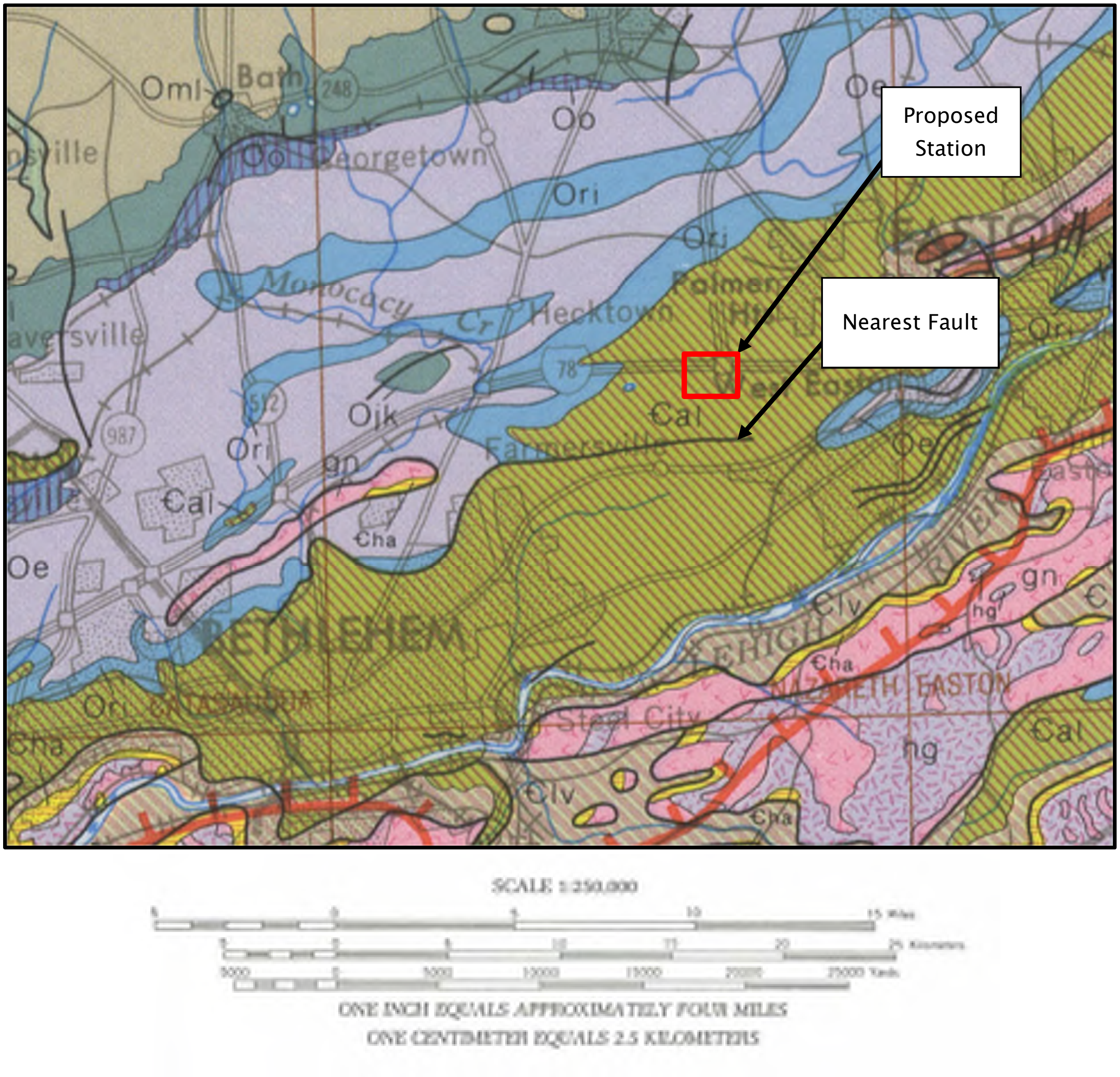
United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Bedrock Geology

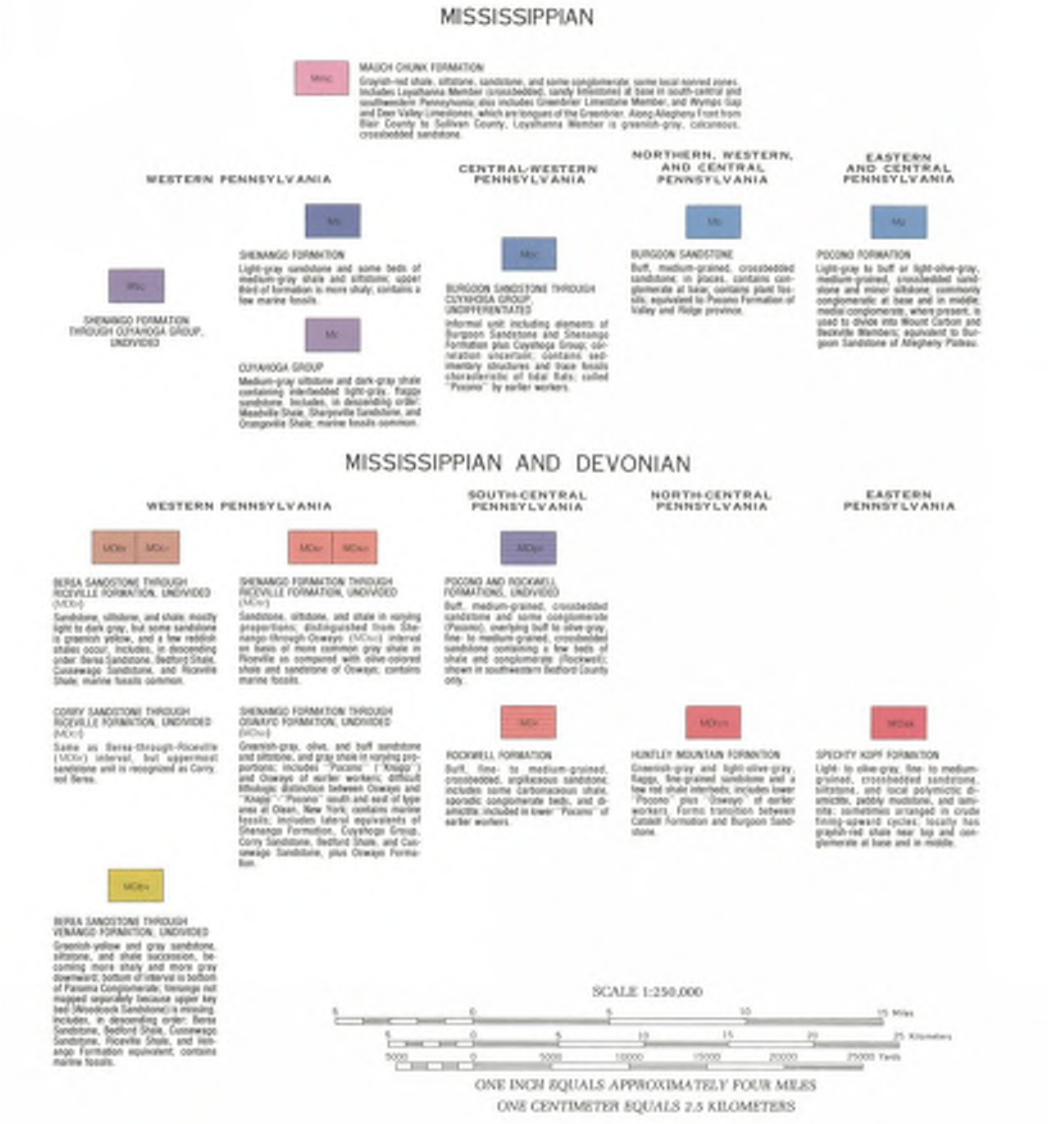


Source:
Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geological Map of Pennsylvania: Bedrock Formation Legend

1. Note: Geologic Legend taken from:
    a. Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geological Map of Pennsylvania: Bedrock Formation Legend



MISSISSIPPIAN

MAUCH CHUNK FORMATION
Grayish-red shale, siltstone, sandstone, and some conglomerate; some local nonred zones. Includes Loyalhanna Member (crossbedded, sandy limestone) at base in south-central and southwestern Pennsylvania; also includes Greenbrier Limestone Member, and Wymps Gap and Deer Valley Limestones, which are tongues of the Greenbrier. Along Allegheny Front from Blair County to Sullivan County, Loyalhanna Member is greenish-gray, calcareous, crossbedded sandstone.

WESTERN PENNSYLVANIA

SHENANGO FORMATION THROUGH CUYAHOGA GROUP, UNDIVIDED

SHENANGO FORMATION
Light-gray sandstone and some beds of medium-gray shale and siltstone; upper third of formation is more shaly; contains a few marine fossils.

CUYAHOGA GROUP
Medium-gray siltstone and dark-gray shale containing interbedded light-gray, flaggy sandstone. Includes, in descending order: Meadville Shale, Sharpsville Sandstone, and Orangeville Shale; marine fossils common.

CENTRAL-WESTERN PENNSYLVANIA

BURGOON SANDSTONE THROUGH CUYAHOGA GROUP, UNDIFFERENTIATED
Informal unit including elements of Burgoon Sandstone and Shenango Formation plus Cuyahoga Group; correlation uncertain; contains sedimentary structures and trace fossils characteristic of tidal flats; called "Pocono" by earlier workers.

NORTHERN, WESTERN, AND CENTRAL PENNSYLVANIA

BURGOON SANDSTONE
Buff, medium-grained, crossbedded sandstone; in places, contains conglomerate at base; contains plant fossils; equivalent to Pocono Formation of Valley and Ridge province.

EASTERN AND CENTRAL PENNSYLVANIA

POCONO FORMATION
Light-gray to buff or light-olive-gray, medium-grained, crossbedded sandstone and minor siltstone; commonly conglomeratic at base and in middle; medial conglomerate, where present, is used to divide into Mount Carbon and Beckville Members; equivalent to Burgoon Sandstone of Allegheny Plateau.

MISSISSIPPIAN AND DEVONIAN

WESTERN PENNSYLVANIA

BEREA SANDSTONE THROUGH RICEVILLE FORMATION, UNDIVIDED
Sandstone, siltstone, and shale; mostly light to dark gray, but some sandstone is greenish yellow, and a few reddish shales occur. Includes, in descending order: Berea Sandstone, Bedford Shale, Cussewago Sandstone, and Riceville Shale; marine fossils common.

CORRY SANDSTONE THROUGH RICEVILLE FORMATION, UNDIVIDED
Same as Berea-through-Riceville interval, but uppermost sandstone unit is recognized as Corry, not Berea.

BEREA SANDSTONE THROUGH VENANGO FORMATION, UNDIVIDED
Greenish-yellow and gray sandstone, siltstone, and shale succession, becoming more shaly and more gray downward; bottom of interval is bottom of Panama Conglomerate; Venango not mapped separately because upper key bed (Woodcock Sandstone) is missing. Includes, in descending order: Berea Sandstone, Bedford Shale, Cussewago Sandstone, Riceville Shale, and Venango Formation equivalent; contains marine fossils.

SHENANGO FORMATION THROUGH RICEVILLE FORMATION, UNDIVIDED
Sandstone, siltstone, and shale in varying proportions; distinguished from Shenango-through-Oswayo interval on basis of more common gray shale in Riceville as compared with olive-colored shale and sandstone of Oswayo; contains marine fossils.

SHENANGO FORMATION THROUGH OSWAYO FORMATION, UNDIVIDED
Greenish-gray, olive, and buff sandstone and siltstone, and gray shale in varying proportions; includes "Pocono" ("Knapp") and Oswayo of earlier workers; difficult lithologic distinction between Oswayo and "Knapp"-"Pocono" south and east of type area at Olean, New York; contains marine fossils; includes lateral equivalents of Shenango Formation, Cuyahoga Group, Corry Sandstone, Bedford Shale, and Cussewago Sandstone, plus Oswayo Formation.

SOUTH-CENTRAL PENNSYLVANIA

POCONO AND ROCKWELL FORMATIONS, UNDIVIDED
Buff, medium-grained, crossbedded sandstone and some conglomerate (Pocono), overlying buff to olive-gray, fine- to medium-grained, crossbedded sandstone containing a few beds of shale and conglomerate (Rockwell); shown in southwestern Bedford County only.

ROCKWELL FORMATION
Buff, fine- to medium-grained, crossbedded, argillaceous sandstone; includes some carbonaceous shale, sporadic conglomerate beds, and diamictite; included in lower "Pocono" of earlier workers.

NORTH-CENTRAL PENNSYLVANIA

HUNTLEY MOUNTAIN FORMATION
Greenish-gray and light-olive-gray, flaggy, fine-grained sandstone and a few red shale interbeds; includes lower "Pocono" plus "Oswayo" of earlier workers. Forms transition between Catskill Formation and Burgoon Sandstone.

EASTERN PENNSYLVANIA

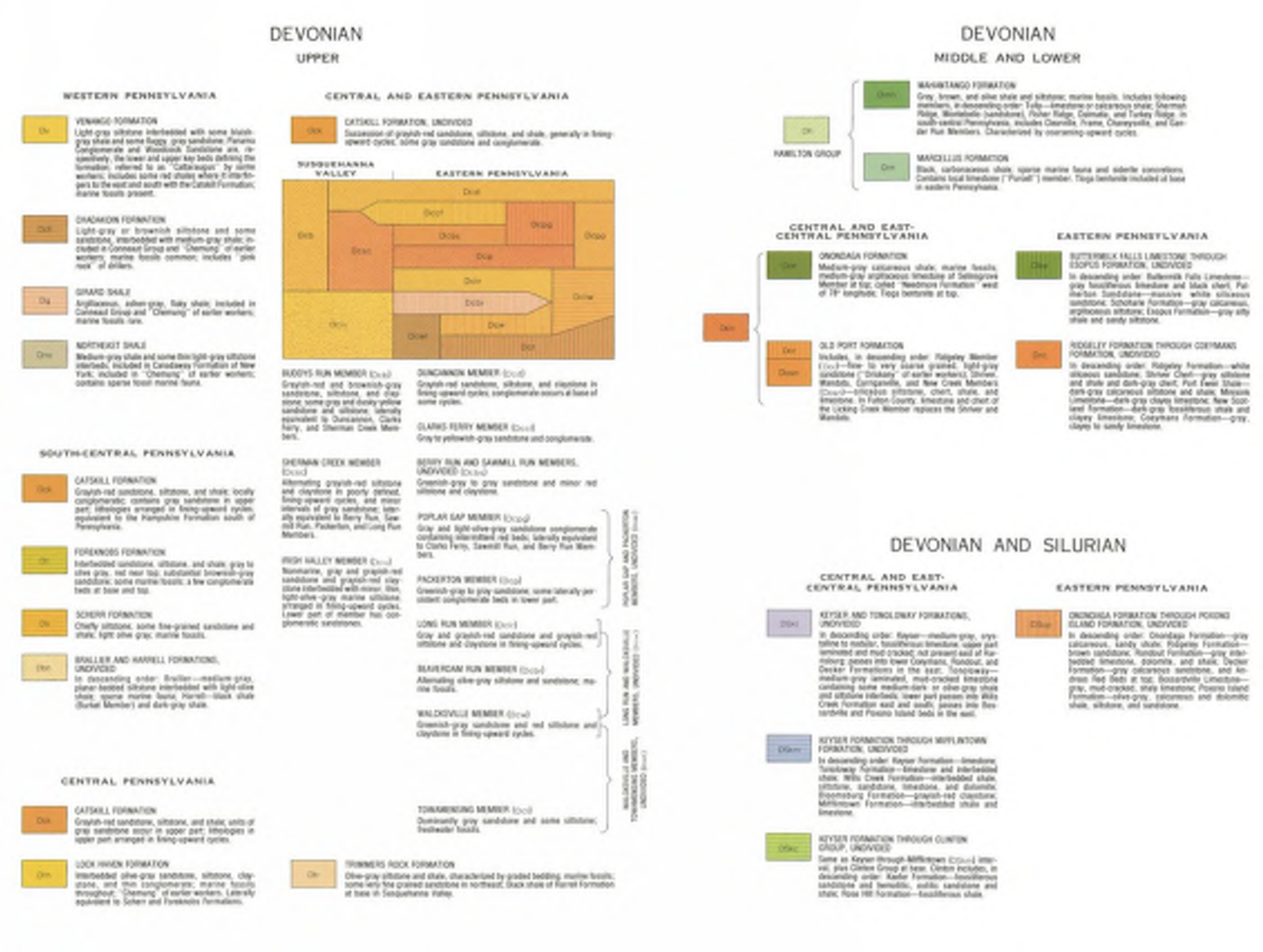
SPECHTY KOPF FORMATION
Light- to olive-gray, fine- to medium-grained, crossbedded sandstone, siltstone, and local polymictic diamictite, pebbly mudstone, and laminite; sometimes arranged in crude fining-upward cycles; locally has grayish-red shale near top and conglomerate at base and in middle.

SCALE 1:250,000

ONE INCH EQUALS APPROXIMATELY FOUR MILES
ONE CENTIMETER EQUALS 2.5 KILOMETERS

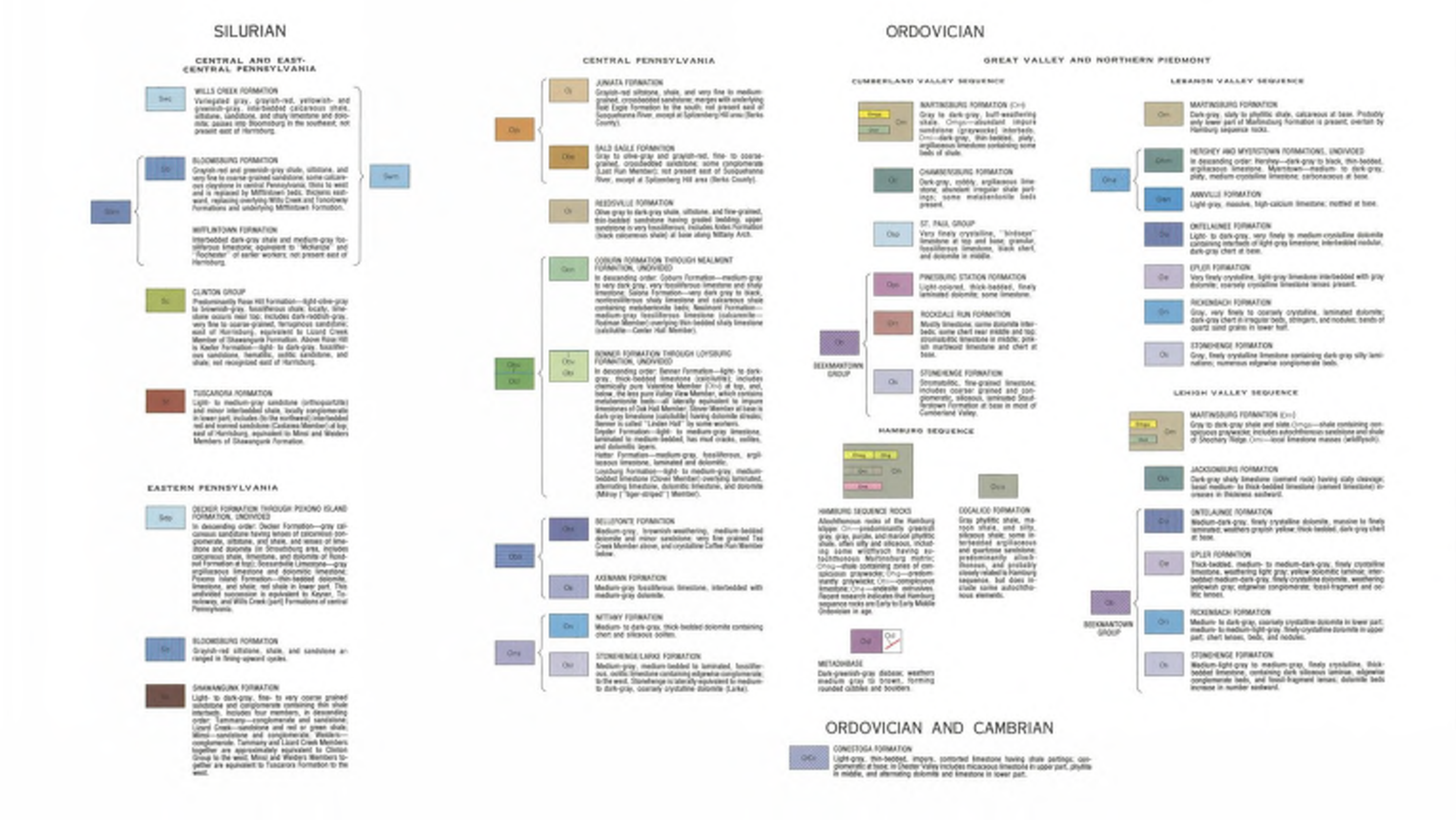
1. Note: Geologic Legend taken from:
   a. Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geological Map of Pennsylvania: Bedrock Formation Legend



1. Note: Geologic Legend taken from:
    a. Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geological Map of Pennsylvania: Bedrock Formation Legend



SILURIAN

CENTRAL AND EAST-CENTRAL PENNSYLVANIA

EASTERN PENNSYLVANIA

ORDOVICIAN

CENTRAL PENNSYLVANIA

GREAT VALLEY AND NORTHERN PIEDMONT

CUMBERLAND VALLEY SEQUENCE

LEBANON VALLEY SEQUENCE

HAMBURG SEQUENCE

LEHIGH VALLEY SEQUENCE

ORDOVICIAN AND CAMBRIAN

1. Note: Geologic Legend taken from:
    a. Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geological Map of Pennsylvania: Bedrock Formation Legend

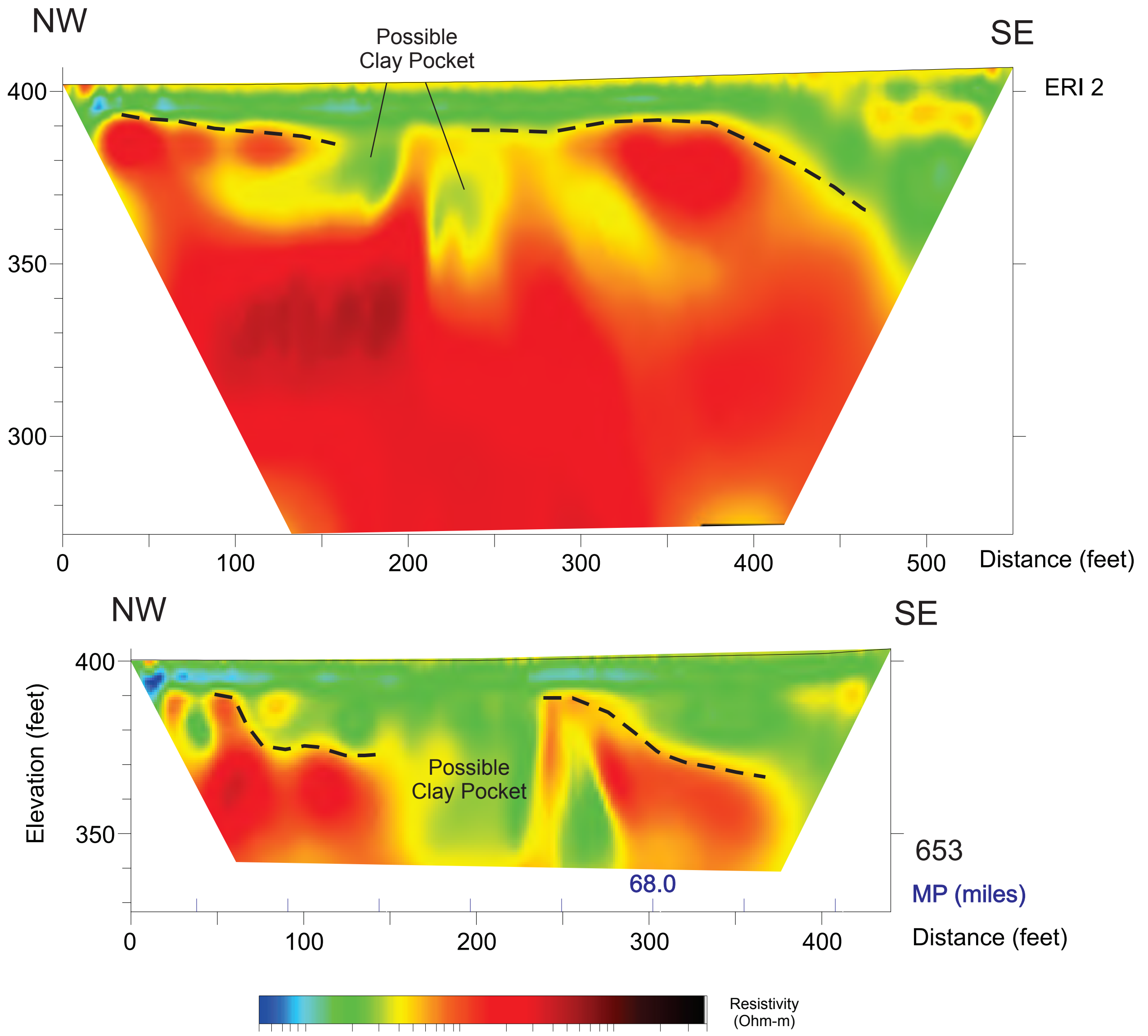
1. Note: Geologic Legend taken from:
    a. Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets, scale 1:250,000.

E. Geophysical Survey

LEGEND

– – – – POSSIBLE COMPETENT BEDROCK SURFACE

POSSIBLE KARST ZONE



LEGEND

🟥	COMPLETED AS OF MAY 2016
🟨	COMPLETED AS OF MAY 2018

NOT TO SCALE

NOTES:

1. Surface elevations determined from GPS measurements
2. Resistivity data acquired using a AGI SuperSting R8 with the Dipole–Dipole electrode configuration, 56 electrodes, and 8 & 10–foot electrode spacing.
3. Resistivity data processed and inverted using Earthimager2D Software by AGI.

HORIZONTAL SCALE (feet)
0 100 200
Vertical Exaggeration = 2X

Figure 1
Resistivity Lines ERI 2 and 653
PennEast Pipeline Karst Investigation
Carbon, Northampton,
& Bucks Counties, Pennsylvania

File 15JCC19 June 2018

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey

F. Calculations

MOTT MACDONALD

Project Name PennEast
Project # 325353354
Subject Church Rd Interconnect
Calculated by B. KALPOUZOS
Checked by
Page 1 **of** 5
Sheet #
Date 12/12/2019
Date

SONOTUBE

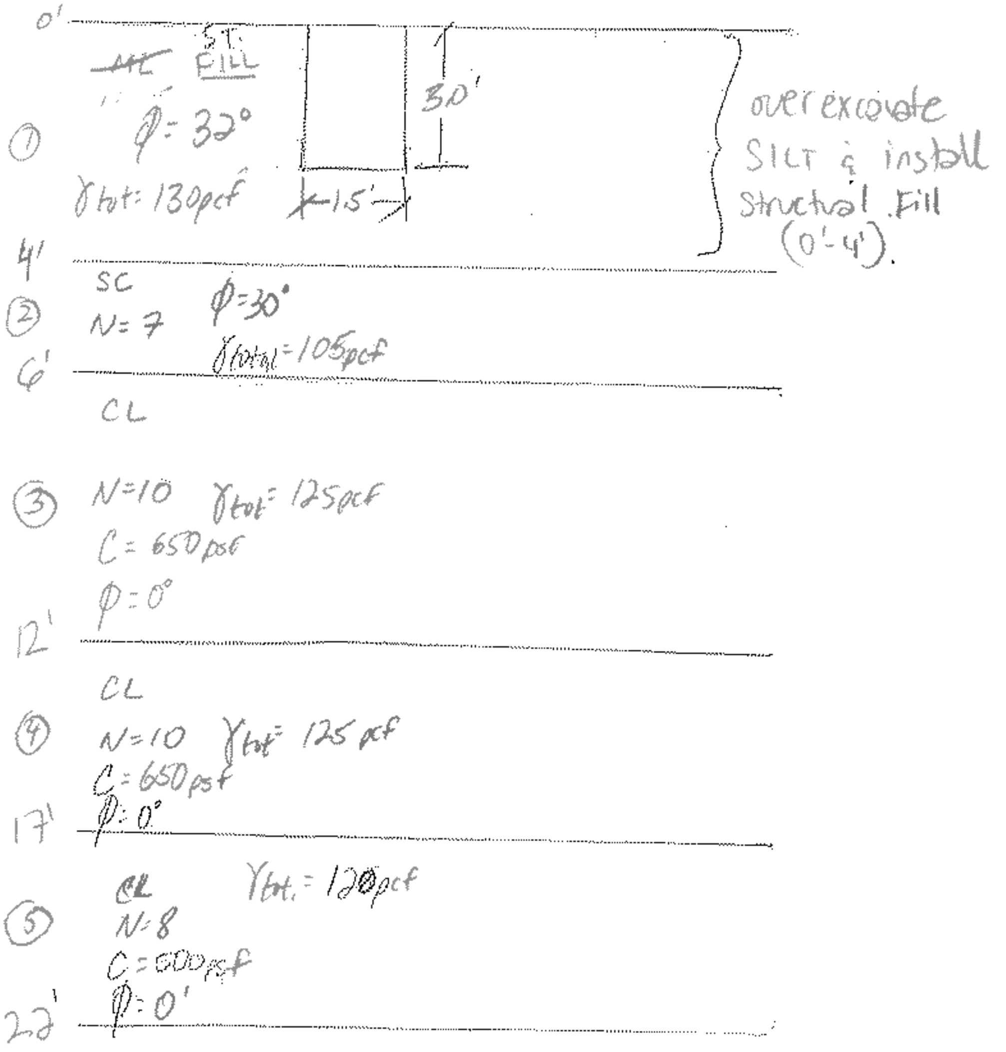
General Assumptions:

- → Soil freeze Depth for foundations = 30"
- → Depth to water table is assumed based on presence of wet Soil during subsurface exploration.

Sources:

- → AASHTO Bridge Specifications
- → Geotechnicalinfo.com.
- → Historic boring B-JBSR33-1 performed in January of 2017. by MM.

Soil Profile



MOTT MACDONALD

Project Name Penneast
Project # 505353754 Page 2 of 5
Subject Church Rd. Interconnect Sheet #
Calculated by B. KALPOUTOS Date 12/12/19
Checked by Date

1.0 BEARING CAPACITY AASHTO 10.6.3.1.2a-1

- Due to presence of soft fine grained soils to 4 feet below grade, it is recommended to excavate native soil to approximately 4 feet below grade and backfill with engineered fill.

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5 \gamma B N_{\gamma m} C_{w\gamma}$

$N_{cm} = N_c s_c i_c$ (10.6.3.1.2a-2)
$N_{qm} = N_q s_q d_q i_q$ (10.6.3.1.2a-3)
$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ (10.6.3.1.2a-4)

Sonotubes bearing on compacted engineered fill, Cohesion resistance $c = 0$.

$q_n = \gamma D_f N_{qm} C_{wq} + 0.5 \gamma B N_{\gamma m} C_{w\gamma}$

$N_q = 23.2$ $N_\gamma = 30.2$ (Table 10.6.3.1.2a-1)

$s_q = 1 + \left(\frac{B}{L} \tan\phi\right)$ $s_\gamma = 1 - 0.4\left(\frac{B}{L}\right)$ (Table 10.6.3.1.2a-3)
$1 + \left(\frac{1.5}{1.5} \tan 32\right) = 1.62$ $1 - 0.4\left(\frac{1.5}{1.5}\right) = 0.6$

$d_q = D_f/B = 3/1.5 = 2$ $d_q = 1.30$ (Table 10.6.3.1.2a-4)

Assume inclination factors = 1.0.
$C_{wq} = 1.0$ $C_{w\gamma} = 1.0$ (Table 10.6.3.1.2a-2)

$q_n = 130\text{pcf}(3\text{ft})(23.2)(1.62)(1.30)(1.0)(1.0) + 0.5(130\text{pcf})(1.5\text{ft})(30.2)(0.6)(1.0)(1.0)$

$q_n = 19{,}055 + 1{,}766 = 20{,}821 \text{ lbs/ft}^2 = 20 \text{ ksf}$

$q_{ult} = 20 \text{ ksf}$
$q_{all} = 6.9 \text{ ksf}$

2.0 SETTLEMENT

2.1 VERTICAL STRESS IN SOILS UNDER SONOTUBE

Layer 1 • Structural backfill
- assumed 0" settlement.

Layer 2 • Loose SC γ_{tot} = 105pcf
midpoint under sonotube = 5 ft.
$\sigma'_v = (4' \times 130pcf) + (1ft \times 105pcf) = 625psf$

Layer 3 Stiff CL γ_{tot} = 125pcf
midpoint = 9 feet.
$\sigma'_v = 520psf + 210psf + 3'(125pcf) = 1{,}105psf$

LAYER 4 Stiff (CL) γ_{tot} = 125pcf
midpoint = 14.5 ft.
$\sigma'_v = 520psf + 210psf + 750 + 2.5'(125pcf) = 1{,}792.5psf$

Layer 5 STIFF (CL) γ_{tot} = 120pcf
midpoint = 19.5 ft.
$\sigma'_v = 520psf + 210psf + 750psf + 625 + 2.5'(120pcf) = 2{,}405psf$

2.2 Stress Distribution

Layer	H_c(ft)	Z(ft)	Z/R	Boussinesq Factor (CERM A-113)
1	N/A	N/A	N/A	N/A
2	2	2	2.67	0.24
3	6	6	8	0.024
4	5	11.5	15.3	0.0065
5	5	14.5	19.3	<0.0065

Project Name Penneast
Project # 505353754 Page 4 of 5
Subject Church Rd. Interconnect Sheet #
Calculated by B. KALPOUZOS Date 12/13/19
Checked by Date

2.3 INITIAL & LONG TERM SETTLEMENT

$S_t = S_e + S_c + S_s$ AASHTO 10.6.2.4.1-1

*ASSUME S_s TO BE MINIMAL & CAN BE IGNORED.

Elastic Settlement, S_e

$S_e = \Sigma \Delta H$ . . . . AASHTO 10.6.2.4.2-2

$\Delta H = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$ . . . . AASHTO 10.6.2.4.2-3

Consolidation Settlement, S_c

$S_c = \left[\frac{H_c}{1+e_o}\right] C_c \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$ . . . AASHTO 10.6.2.4.3-2

Assumed soil properties

Layer	e_o	C'	C_c	
1	N/A	N/A	N/A	
2	—	45	—	$S_c = 0$
3	0.4	37	0.20	
4	0.4	35	0.20	
5	0.4	30	0.20	

MOTT MACDONALD

Project Name Penneast
Project # 505353754
Page 5 of 5
Subject Church Rd. Interconnect
Sheet #
Calculated by B. KALPOUZOS
Date 12/13/19
Checked by
Date

4.3 INITIAL & LONG TERM SETTLEMENT

Layer	S_e $\left[H_c \cdot \frac{1}{C'} \cdot 12(in/ft)\right]$	S_c $\left[H_c/1+e_0 \cdot C_c \cdot 12(in/ft)\right]$
1	—	—
2.	0.53	—
3.	1.95	10.28
4	1.71	8.57
5.	2	8.57

4.4 SOLVE FOR MAXIMUM STRESS, $S_t < 1.0$ inch

4.4.1 TRY, 2.0 ksf

Layer	σ'_0 (ksf)	Boussinesq factor	$\Delta\sigma_v$ (ksf)	$\frac{\sigma'_0+\Delta\sigma_v}{\sigma'_0}$	Se (in)	Sc (in)
1	/	/	/	/	0	0
2	.625	0.24	0.48	1.768	0.13	0
3	1.105	0.024	0.048	1.043	0.035	0.187
4	1.792	0.0065	0.013	1.007	0	0.027
5	2.405	<0.0065	0.013	1.007	0	0.027
				total=	0.165"	0.241"

$S_t = 0.4" < 1.0$ ok ✓

Project Name Penneast

Project # 5125353754

Page 1 of 4

Subject Church Rd. Interconnect

Sheet #

Calculated by B. KAZPOUTOS

Date 10/16/2019

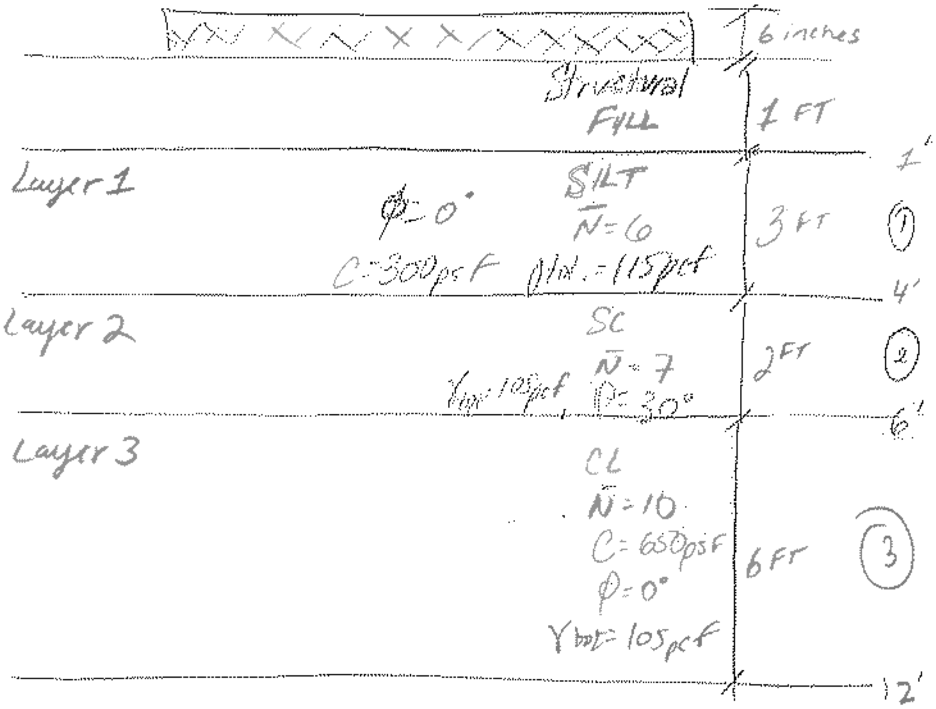
Checked by

Date

SLAB-ON-GRADE

→ Assume 1 ft of structural Fill is placed.

Assumed Slab dimensions : B = 3 FT L = 5 FT concrete slab.



MOTT MACDONALD

Project Name Penneast
Project # 505 353754
Page 2 of 4
Subject Church Rd. Interconnect
Sheet #
Calculated by B. KALIOUSTOS
Date 12/16/19
Checked by
Date

1.0 BEARING CAPACITY

\# SLAB-ON-GRADE ; Bearing of Silt underlying structural Fill layer

$D_f = 1.0$ foot (structural Fill).

$$q_n = c' N_{cm} + \gamma D_f N_{qm} C_{wq} + \cancel{0.5 B N_{\gamma m} C_{w\gamma}} \rightarrow 0$$

$\phi = 0° \therefore N_c = 5.14 \quad N_q = 1.0 \quad N_\gamma = 0$

$N_{qm} = N_q \cdot s_q \cdot d_q \cdot i_q$

$s_q = 1.0$

$d_q = 1.0$

$i_q = 1.0$

$N_{cm} = N_c \cdot s_c \cdot i_c = 5.14(1.2) = 6.17$

$s_c = 1 + \left(\frac{3}{3(5)}\right) = 1.2$

$i_c = 1.0$

$C_{wq} = 1.0$

$q_n = 300\text{psf}(6.17) + 115\text{pcf}(1.0)(1.0)(1.0) = 1966 \text{ psf} = 1.966 \text{ ksf}$

$q_{ult} = 2.0 \text{ksf}$

Project Name Pennеast
Project # 505353754
Subject Church Rd. Interconnect
Calculated by B. KALPOUZOS
Checked by
Page 3 **of** 4
Sheet #
Date 12/16/15
Date

2.0. SETTLEMENT

SLAB-ON-GRADE

ZONE OF INFLUENCE = 4B = 4(3) = 12 FT

* Assume: 2V:1H FOR INCREAS BASE WIDTH FROM FILL.

$B' = 3 + 1 = 4$ FT.
$L' = 5 + 1 = 6$ FT

$$\frac{BL\,(1.5\,\text{ksf})}{B'L'} = \frac{3(5)(1.5)}{4(6)} = 0.94\ \text{ksf}$$

* ASSUME SETTLEMENT IN STRUCTURAL FILL TO BE NEGLIGABLE.

Layer 1 = 1.5FT MIDPOINT.

$\sigma'_0 = 115\,\text{pcf}\,(1.5\text{ft}) = 345\ \text{psf} = 0.172\ \text{ksf}$

$C_N = 0.77 \log\left(\frac{40}{.172}\right) = 1.82(6) \approx 11 \therefore C' = 45$

Influence factor (Appendix 40A, Cern) $I = 0.4$

$$S_e = 3\,\text{FT}\left(\frac{1}{45}\right) \cdot \log\left[\frac{0.172 + 0.94\,\text{ksf}\,(0.4)}{0.172}\right] = 0.033' = 0.4\ \text{inches}$$

Layer 2 4FT MIDPOINT

$\sigma'_0 = 3(115\,\text{pcf}) + 1(105\,\text{pcf}) = 450\ \text{psf} = 0.45\ \text{ksf}$

$C_N = 0.77 \log\left(\frac{40}{.45}\right) = 2.53(7) \approx 18 \therefore C' = 55$

Influence factor, $I = 0.18$

$$S_e = 2\,\text{FT}\left(\frac{1}{55}\right) \cdot \log\left[\frac{0.45 + 0.94(0.18)}{0.45}\right] = 0.005' = 0.06\ \text{inches}$$

Layer 3 8 feet Midpoint

$\sigma'_0 = 3(115\,pcf) + 2(105\,pcf) + 3(105\,pcf) = 870\ psf = 0.87\ ksf$

$CN = 0.77\log\left(\frac{40}{.87}\right) = 1.66(10) \simeq 17 \therefore C' = 50$

Influence factor, $I = 0.05$

$S_e = (6\,ft)\left(\frac{1}{50}\right)\cdot\log\left[\frac{0.87+0.94(0.05)}{0.87}\right] = 0.002' = 0.03$ inches

$S_{e_{total}} = 0.4'' + 0.06'' + 0.03'' = 0.49$ inches

Layer 3, Consolidation Settlement, S_c

$$S_c = \frac{H_c}{1+e_0} C_c \log\left(\frac{\sigma'_0 + \Delta\sigma_v}{\sigma'_0}\right)$$

Assumed properties: $e_0 = 0.4$ $C_c = 0.20$

$S_c = \frac{6\,ft}{1.4}(0.2)\log\left(\frac{0.87+0.94(.05)}{0.87}\right) = 0.02' = 0.23$ inches

$S_T = S_e + S_c = 0.49'' + 0.23'' = 0.72$ inches < 1.0 inch ✓ O.K.

$\boxed{\text{USE 1.5 KSF FOR DESIGN}}$

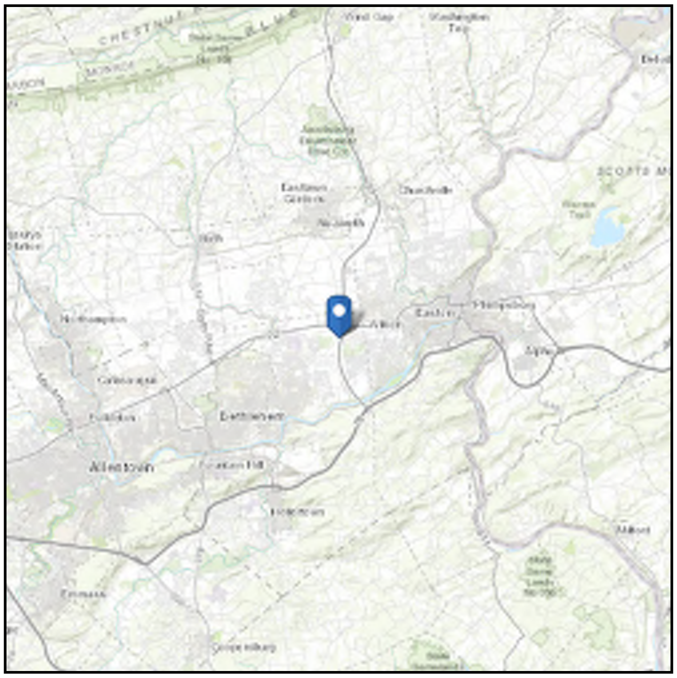
G. Seismic Site Classification

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard: ASCE/SEI 7-10
Risk Category: IV
Soil Class: D - Stiff Soil

Elevation: 401.4 ft (NAVD 88)
Latitude: 40.676319
Longitude: -75.293357



AMERICAN SOCIETY OF CIVIL ENGINEERS

Seismic

Site Soil Class: D - Stiff Soil

Results:

S_S :	0.2	S_{DS} :	0.213
S_1 :	0.063	S_{D1} :	0.1
F_a :	1.6	T_L :	6
F_v :	2.4	PGA :	0.108
S_{MS} :	0.32	PGA_M :	0.17
S_{M1} :	0.15	F_{PGA} :	1.585
		I_e :	1.5

Seismic Design Category C

Data Accessed: Fri Dec 13 2019

Date Source: USGS Seismic Design Maps based on ASCE/SEI 7-10, incorporating Supplement 1 and errata of March 31, 2013, and ASCE/SEI 7-10 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-10 Ch. 21 are available from USGS.

The ASCE 7 Hazard Tool is provided for your convenience, for informational purposes only, and is provided “as is” and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE 7 standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

ASCE does not intend, nor should anyone interpret, the results provided by this Tool to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this Tool or the ASCE 7 standard.

In using this Tool, you expressly assume all risks associated with your use. Under no circumstances shall ASCE or its officers, directors, employees, members, affiliates, or agents be liable to you or any other person for any direct, indirect, special, incidental, or consequential damages arising from or related to your use of, or reliance on, the Tool or any information obtained therein. To the fullest extent permitted by law, you agree to release and hold harmless ASCE from any and all liability of any nature arising out of or resulting from any use of data provided by the ASCE 7 Hazard Tool.