



ECS Midwest, LLC

Geotechnical Engineering Report

Proposed Self-Supporting Tower
NW Tower Site (N44.5235° W88.2305°)

Cooper Road
Oneida, Outagamie County, Wisconsin

ECS Project No. 59:3565

August 14, 2023





August 14, 2023

Ms. Sara Bushie
Mission Support Services, LLC
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ECS Project No. 59:3565

Reference: Report of Subsurface Exploration and Geotechnical Engineering
Proposed Self-Supporting Tower (NW Tower Site)
Cooper Road
Oneida, Outagamie County, Wisconsin

Dear Ms. Bushie:

ECS Midwest, LLC (ECS) has completed the subsurface exploration, laboratory testing, and geotechnical engineering analyses for the above-referenced project. Our services were performed in general accordance with our agreed to scope of services. This report presents our understanding of the geotechnical aspects of the project along with the results of the field exploration and laboratory testing conducted, and our design and construction recommendations.

It has been our pleasure to be of service to you during the design phase of this project. We would appreciate the opportunity to remain involved during the continuation of the design phase, and we would like to provide our services during construction phase operations to verify subsurface conditions assumed for this report. Should you have questions concerning the information contained in this report, or if we can be of further assistance to you, please contact us.

Respectfully submitted,

ECS Midwest, LLC

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[https://ecslimited365.sharepoint.com/Sites/59greenbay/59Data/{Projects}/3500s/3565 - Mission Support Services, LLC - Oneida Broadband NW Tower/Report/3565 - Proposed Self Supporting Tower Report - Oneida, WI.Docx](https://ecslimited365.sharepoint.com/Sites/59greenbay/59Data/{Projects}/3500s/3565-Mission%20Support%20Services,%20LLC-Oneida%20Broadband%20NW%20Tower/Report/3565-Proposed%20Self-Supporting%20Tower%20Report-Oneida,%20WI.Docx)

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EXECUTIVE SUMMARY

The following summarizes the main findings of the exploration, particularly those that may have a cost impact on the planned development. Further, we summarized our principal foundation recommendations. Information gleaned from the Executive Summary should not be utilized in lieu of reading the entire geotechnical report.

- Undocumented fill and possible fill soils were observed in both soil borings, extending to depths ranging from 4 to 8½ feet below the existing grades. Given the depth of fill/possible fill soils and no compaction test results data, there is higher than typical risk of total and differential settlement of structures supported on these fill/possible fill soils. ECS recommends the proposed tower and equipment building structures be supported on natural in situ soils or lean concrete/compacted low plasticity structural fill soils that extend through the existing fill/possible fill soils.
- The proposed self-supporting tower can be supported on a mat foundation bearing on competent natural soils, or on structural fill overlying competent natural soils, at a depth of about 8 feet below the existing grade, which may be designed for a maximum net allowable soil bearing pressure of 4,000 psf (pounds per square foot). Competent natural soils can be identified on the test boring logs as glacial till or lacustrine soils, having Standard Penetration Test (SPT) N-values of at least 15 bpf (blows per foot) or an unconfined compressive strength (Q_u) of at least 2.25 tsf (tons per square foot). Alternatively, the proposed self-supported tower could be supported by deep foundations such as drilled shafts bearing within stiff to hard lean clays at depths ranging from 20 to 25 feet below the existing grade.
- The proposed equipment building can be supported on shallow foundations bearing on competent natural soils or on compacted structural fill (extending through the existing fill), which may be designed for a maximum net allowable soil bearing pressure of 2,000 psf. Alternatively, to minimize the removal and replacement of existing fill/possible fill soils, the proposed structure could be supported on improved ground such as with helical piles.
- Three (3) design alternatives for preparation of the subgrade below ground supported slabs and pavements with varying anticipated cost and level of risk are provided in the Slabs on Grade Section of this report.

1.0 INTRODUCTION

ECS prepared this report for the purpose of providing the results of our subsurface exploration and laboratory testing, site characterization, engineering analysis, and geotechnical recommendations for the design and construction of self-supported tower and equipment building foundations. The recommendations developed for this report are based on project information supplied by Ms. Sara Bushie with Mission Support Services, LLC.

ECS provided geotechnical engineering services in accordance with ECS Proposal No. 59:4606-GP (revision 01), dated May 31, 2023, and authorized by Mission Support Services, LLC Purchase Order dated June 01, 2023.

This report contains the procedures and results of our subsurface exploration and laboratory testing programs, review of existing site conditions, engineering analyses, and recommendations for the design and construction of the proposed infrastructure. The report includes the following items:

- A brief review and description of our field and laboratory test procedures and results.
- A review of the observed surface topographical features and site conditions.
- A review of area and site geologic conditions.
- A review of subsurface soil stratigraphy with pertinent available physical properties.
- Final test boring logs.
- Recommended allowable soil bearing pressure(s) for conventional shallow foundations (spread footings) and estimates of potential foundation settlement.
- Recommendations for slab-on-grade construction including subgrade modulus.
- Recommendations for uplift resistance, lateral earth pressures, sliding resistance coefficients, drainage, and foundation backfill.
- Seismic Site Classification in accordance with applicable International Building Code based on the SPT 'N' blow counts and provide applicable seismic site coefficients (no liquefactions analysis).
- Pavement section (unsurfaced) recommendations based on anticipated traffic loading information.
- Soil electrical resistivity test results.
- Evaluation and recommendations relative to groundwater control.
- Recommendations for site preparation and construction of compacted fills, including an evaluation of on-site soils for use as compacted fills and identification of potentially unsuitable soils and/or soils exhibiting excessive moisture at the time of sampling.
- Recommendations for additional testing and/or consultation that might be required to complete the geotechnical assessment and related geotechnical engineering for this project.

2.0 PROJECT INFORMATION

2.1 PROJECT LOCATION/CURRENT SITE USE/PAST SITE USE

The project site is located on the east side of Cooper Road, approximately 2,500 feet north of Pearl Street in Oneida, Outagamie County, Wisconsin. The site location is shown in the figure below and on the Site Location Diagram in Appendix A of this report:



Site Location (approximately outlined in red)

Based on the historical aerial and street views, the site was previously developed with a single-story residential structure sometime during the mid-1950's. ECS understands that the residential structure was demolished within the last 1 to 2 years. However, it is not reported whether the existing foundations, slabs and below grade structures have been completely removed or left in place. A small, prefabricated, Quonset structure is still present at the site, located immediately east of the proposed tower and equipment building.

Site-specific topographic information was not available at this time. However, based on publicly available information such as *Google Earth*, the site grades range from about EL. 767 to EL. 768 feet MSL (above Mean Sea Level) within the proposed development areas.

2.2 PROPOSED CONSTRUCTION

Based on the provided information and Preliminary Site Plan, the information listed in the Table below summarizes our understanding and assumptions of the structures and its loads:

DESIGN INFORMATION		
Subject	Design Characteristic	
Self-supported Tower	The proposed tower is anticipated to be 3-legged tower with approximate height of 180 feet. The proposed tower is anticipated to be supported on reinforced concrete mat foundation with monolithic piers.	R/B
Tower Loads	Maximum Compression: 240 kips Maximum Uplift: 200 kips Maximum Shear: 40 kips	B
Equipment Building	Grade supported equipment building, encompassing approximately 12 feet by 24 feet in plan area. The proposed building is anticipated to be supported by grade supported slab and continuous wall/beam foundations. ECS anticipates continuous wall loads of less than 2 kips per foot.	R/B
Settlement Tolerance	Estimated to be 1-inch total and ¼-inch differential	B
Grade Supported Slab Loads	120 psf	B
Finished Floor Elevation	Within 2 feet from the highest existing grades	B
Grading Operations	Less than 2 feet	B
Pavement	Unsurfaced/crushed aggregate access road	B

R: Reported by client and/or Design Team

B: Based on ECS estimate in the absence of information from the Client and/or Design Team

Where the borings encountered subsurface conditions that might be detrimental to the support of the proposed construction, ECS anticipates the owner will have an acceptable risk level if the detrimental material remains in place. This report anticipates the owner would only be willing to accept a low risk for foundation settlement less than 1 inch and a moderate risk for reduced pavement performance.

If ECS' understanding of the project or the owner's anticipated acceptable risk level are not correct or the design changes, then please contact ECS so that we may review these changes and revise our recommendations, as appropriate.

3.0 FIELD EXPLORATION AND LABORATORY TESTING

Our exploration procedures are explained in greater detail in Appendix B including the insert titled "Subsurface Exploration Procedures." Our scope of services included drilling two (2) Standard Penetration Test (SPT) soil borings, extending to a depth of approximately 30 feet below existing grade. ECS located the soil borings using conventional measuring techniques referenced from existing site features and the approximate locations are shown on the Boring Location Diagram in Appendix A.

The ground surface elevation at the boring locations were not surveyed by a licensed surveyor and ECS estimated the surface elevations from *Google Earth*. Ground surface elevations and boring locations determined without professional survey are approximate and may not be appropriate for final design.

ECS utilized a truck-mounted drilling rig equipped with continuous flight, hollow stem augers. The soil borings were extended to a depth of about 30 feet below the existing grades. Standard penetration tests (SPTs) were conducted in the borings at regular intervals in general accordance with ASTM D1586. The drill crew backfilled the boreholes upon completion of the drilling operations. Settlement of borehole backfill can occur over time resulting in a trip hazard. Monitoring the boreholes after initial drilling activities is not within our scope but should be done by the client or property owner.

3.1 SUBSURFACE CHARACTERIZATION

Much of the County is covered by glacial sediments, including lake deposits, till, outwash and loess. Occasionally the drift will yield some interesting minerals such as "drift" copper, banded iron formation and "Lake Superior" agates. Outagamie County bedrock consists of Cambrian and Ordovician sedimentary rocks, primarily Cambrian sandstone in the northwest, and dolostones in the southeast. The rocks dip gently to the east, off the Wisconsin Arch. The dolostones are quarried where exposed and can yield interesting crystals including calcite, quartz, strontianite, dolomite, pyrite, and marcasite. Well construction records for wells installed near the site indicate bedrock to be at a depth of between 20 and 50 feet.

According to the Soil Survey from the USDA - Natural Resources Conservation Service (websoilsurvey.nrcs.usda.gov), which provides soil information to a shallow depth (generally less than 5 feet), the near surface soils are mapped as Solona silt loam (SoA). Soil survey mapping of the site vicinity is presented in Appendix A of this report. The parent material for these soils consists of loamy tills that are generally somewhat poorly drained, classified as being in Hydrologic Soil Group B/D, and have a moderate to high potential for frost action.

The encountered subsurface conditions in the soil borings appeared to match published geological mapping except for the existing fill and possible fill. For subsurface information at a specific test boring location, refer to the boring logs in Appendix B. The following sections provide generalized characterizations of the soil strata:

GENERALIZED SOIL PROFILE CHARACTERISTICS				
Approximate Depth Range(ft)	Stratum	Description	Range of SPT ⁽¹⁾ N-values (bpf)	Range of Unconfined Compressive Strength, Q _p ⁽²⁾ (tsf)
0 to ½ Surface cover	N/A	Topsoil: approximately 3 to 4 inches	N/A	N/A
½ to 8½	I	Fill/Possible Fill: very stiff to hard SANDY LEAN CLAY (CL)	4 to 13	3.5 to 4.0
8 ½ to 13½	II	Glacial Till: very stiff to hard, LEAN CLAY/LEAN CLAY WITH SAND (CL)	11 to 57	3.5 to 4.5
13½ to 30 (End of Boring)	III	Lacustrine: stiff to hard, LEAN CLAY (CL)	9 to 17	1.5 to 2.5

Notes:

- (1) Standard Penetration Testing
- (2) Estimated from calibrated hand penetrometer.

Where the drill crew used discontinuous material sampling intervals at the test borings, ECS inferred conditions between sample intervals. The soil stratification shown on the boring logs represents the interpreted soil conditions at the actual boring locations. Variations in the stratification can occur between sample intervals and boring locations. The subsurface conditions at other times and locations on the site may differ from those found at the boring locations. If different site conditions are encountered during construction, ECS should be contacted to review our recommendations relative to the new information.

Because of the limitations of the split-spoon sampler, which has a 1 $\frac{3}{8}$ -inch inside diameter, the soil classifications noted on the boring logs may not be representative of the entire soil matrix. Materials larger than the 1 $\frac{3}{8}$ -inch inside diameter of the split-spoon sampler cannot be collected and observed directly. Where possible, the drill crew noted the estimated depth of larger diameter materials, such as cobbles and boulders, based on things such as changes in the observed drilling resistance and auger cuttings.

3.2 GROUNDWATER OBSERVATIONS

The drill crew observed the boreholes for a measurable groundwater level during sampling and at the completion of drilling. None of the soil borings contained a groundwater level either during drilling or immediately upon completion of the soil borings.

Based upon our interpretation of the subsurface data, including water level measurements, the borings didn't encounter saturated (water table) aquifer. Perched groundwater is distinguished differently from the water table aquifer as defined below:

“Perched water is typically of limited quantity, replenished or recharged very slowly. When encountered in an excavation, perched water will typically drain off very quickly, with limited continuous flow or bleeding, unless a source of recharge, such as a leaking utility is present.”

From: Construction Dewatering and Groundwater Control – New Methods and Applications, 3rd Addition

A water table aquifer is distinguished from a perched groundwater table based on the recharge ability of the water table aquifer, which may be limitless but can be lowered temporarily through adequate dewatering techniques such as deep wells and well points. Perched groundwater is often alleviated in excavations by pumping from sump pits and French drains.

The highest groundwater observations are normally encountered in late winter and early spring and our current groundwater observations likely differ from the seasonal maximum water table. In addition, variations in both groundwater types (perched and groundwater table aquifer) can occur because of seasonal variations in precipitation, evaporation, surface water runoff, lateral drainage conditions, construction activities, and other factors. The time of year and the weather history during the advancement of the borings should be considered when estimating groundwater levels at other points in time.

3.3 IN-SITU ELECTRICAL RESISTIVITY

Electrical resistivity (ER) testing was performed using a Wenner four-electrode array and followed *ASTM G57 Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method* guidelines. The ER testing was performed using electrode spacings of $2\frac{1}{2}\pm$ feet, $5\pm$ feet, $10\pm$ feet, and $20\pm$ feet orientated in both east-west and north-south directions at the proposed tower location at the project site. The electrodes were installed by hammering approximately 18-inch-long stainless-steel stakes approximately 12 inches into the ground at each electrode location. The ER survey was conducted using a Fluke 1625 GEO Earth Ground Tester with 4 electrodes using accepted geophysical industry procedures. The resistivity data was recorded in the field and post-processed in our office. Results are included on the data sheets enclosed in Appendix B.

3.4 LABORATORY SERVICES

The laboratory services performed by ECS for this project included select tests performed on samples retained from the field exploration operations. Classification and index property tests were performed on representative soil samples obtained from the test borings to aid classification of the soils and to estimate engineering properties. The following paragraphs briefly describe the completed laboratory services program.

- A geotechnical engineer classified each soil sample retained from the test borings on the basis of texture and plasticity using the Unified Soil Classification System (USCS) and ASTM D-2488 (Description and Identification of Soils-Visual/Manual Procedures) as a guide. After classification, the geotechnical engineer grouped the various soil types into the major zones noted on the boring logs in Appendix B. The group symbols for each soil type are indicated in parentheses along with the soil descriptions on the boring logs. The stratification lines designating the interfaces between earth materials on the boring logs are approximate; in situ, the transitions may be gradual.
- Moisture content determination was performed on fine-grained soil samples in accordance with ASTM D 2216.
- Calibrated hand penetrometer (Q_p) tests were performed on cohesive soil samples. In the hand penetrometer test, the unconfined compressive strength of a soil sample is estimated by measuring the resistance of a soil sample to penetration of a small, calibrated spring-loaded cylinder.

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

4.0 DESIGN RECOMMENDATIONS

4.1 FOUNDATIONS

4.1.1 Mat Foundations

The foundation analysis was conducted using the information noted in the *Proposed Construction* Section, the boring information, and anticipating that the self-supported tower is supported by a mat foundation bearing at a depth of about 8 feet below the finished grade. Based on our experience with similar projects, ECS anticipates a mat foundation size on the order of 20 feet by 20 feet for the foundation analysis. The following parameters are recommended for proposed self-supported tower mat foundation design:

MAT FOUNDATION DESIGN - SELF SUPPORTED TOWER ⁽¹⁾		
Design Parameter		Value
Maximum Net Allowable Soil Bearing Pressure ⁽²⁾		4,000 psf
Soil Subgrade Modulus (k_v)		11 to 14 psi/in
Acceptable Bearing Soil Material		Stratum II
Competent Soils Designated Adequate for the Allowable Bearing Pressure		$N \geq 15$ bpf or $Q_p \geq 2.25$ tsf
Post-Construction Estimated Settlement	Total	Approximately 1 inch
	Differential ⁽³⁾	Approximately ½ inch

Notes:

1. We recommend a structural engineer provide specific foundation details including footing dimensions, reinforcing, and other details.
2. The applied pressure in excess of the surrounding overburden soils above the base of the foundation and includes a factor of safety of 3.

The modulus of subgrade reaction can be used for design and analysis of a mat foundation. The subgrade modulus, k_v , is not a fundamental soil property and depends on many factors, which include the width, shape, and depth below the ground surface of the loaded area, position under the foundation, and time. The subgrade modulus is the ratio of pressure (p) per unit area of the surface of contact between a loaded mat and the subgrade, and the settlement (δ) produced by this load application. Based on the non-rigid methods of analyzing the deformations within the mat foundation and underlying subgrade soils, a single value of subgrade modulus (k) should not be considered for design, as suggested in the rigid analysis method. In reality, the uniformly loaded mat foundation (underlain by uniform subgrade soils) is expected to settle more at the center as compared to the edges, which will form a dish shape deformation of mat and subgrade soils. Model studies (Pseudo-Coupled) indicate that reasonable results are obtained when “ k_v ” value along the perimeter of the mat are about twice those in the center (ACI, 1993). It should be noted that the project structural engineer would be responsible for the structural design of the concrete mat. The structural stiffness of the mat will determine the distribution of the loading from each temporary/permanent structure added to the mat. Loading the mat from the middle of the mat to the outside edges in a symmetric pattern would produce a more uniform distribution to the overall distortion of the mat during operation. Conversely, loading an extreme corner or edge in an asymmetric pattern would likely produce a larger distortion to the mat during its operation.

Potential Undercuts: The soils at the foundation bearing elevation(s) are anticipated to be competent for support of the proposed tower structure. Where soft/very loose or otherwise inadequate soils are observed at the footing bearing elevations, the poor soils should be undercut and removed, and replaced with the lean concrete. We recommended ECS be retained to observe and test the foundation bearing grade as recommended in the *Foundation and Slab Observations* Section. It is also recommended backfill of foundation undercuts be done as recommended in the *Earthwork Operations* Section of this report.

4.1.2 Deep Foundations (Self-supported Tower)

Alternatively, the proposed self-supported tower could be supported by a system of deep foundations such as drilled shafts. The allowable axial load carrying capacity of a drilled shaft can be computed using the static method of analysis. According to this method, allowable axial capacity, Q_a , at a given penetration is taken as the sum of the skin friction on the side of the shaft, Q_{as} , and the end or point bearing at the shaft tip, Q_{ap} , so that:

$$Q_a = Q_{as} + Q_{ap} = f A_s + q A_p$$

where A_s and A_p represent, respectively, the embedded perimeter surface area and the end area of the shaft; f and q represent, respectively, the allowable unit skin friction and the allowable unit end or point bearing. The total allowable axial capacity in compression will be the summation of the allowable frictional capacity and the allowable end bearing capacity. The total allowable axial capacity in tension (uplift) will be the allowable frictional capacity of the shaft neglecting the end bearing component. Based on the project characteristics, the horizontal (shear) force and overturning moment will govern the design (depth and size) of the shaft. Steel reinforcing steel must be designed by the structural engineer to resist the referenced loads. The Tables below summarize the soil design parameters which should be used for uplift and lateral stability analyses based on the LPILE computer programs. Due to the disturbance during shaft installation, frost depth and wetting/drying cycles, ECS recommends that the upper 66 inches be ignored for the design of the foundation system.

ALLOWABLE BEARING CAPACITIES IN COMPRESSION AND UPLIFT			
Soil Type	Approximate Depth below the Existing Grade (ft)	Allowable Unit End Bearing (psf)	Allowable Unit Skin Friction (psf)
Fill: Very stiff to hard, Sandy Lean Clay	0 to 8½	NA	300
Hard, Lean Clay with Sand (Glacial Till)	8½ to 15	12,000	1,000
Stiff to hard, Lean Clay (Lacustrine)	13 to 30	7,500	675

*Allowable End Bearing and Skin Friction values are estimated based on AASHTO LRFD Bridge Design.

LPILE SOIL PARAMETERS FOR LATERAL LOAD ANALYSIS					
Soil Type	Depth Below the Existing Ground Surface (ft)	"p-y" criteria	Effective Unit Weight (pcf)	Lateral Modulus K (pci)	Strain Factor ϵ_{50}/K_{rm}
Fill: Sandy Lean Clay	0 to 5½	Neglect ¹			
Sandy Lean Clay	5½ to 8	Stiff	120	Ks=840 Kc=340	0.0054
Lean Clay w/Sand (till)	8½ to 15	Stiff	130	Ks=1,340 Kc=540	0.0045
Lean Clay (Lacustrine)	15 to 30	Stiff	125/63 ²	Ks=840 Kc=340	0.0054

Note: ϕ -Friction Angle; Ks/Kc-Static and Cyclic modulus of subgrade reaction (pci), and ϵ_{50}/K_{rm} - strain corresponding 50% of the maximum stress.

¹Neglect upper 5½ feet of soil for lateral load analyses.

²Buoyant Unit Weight of soil. Free ground water is estimated to be at a depth of about 25 feet below the existing grades

4.1.3 Drilled Shaft Excavation/Installation Considerations

Based on the information yielded by the borings, cohesive soils with variable fractions of sand are noted from surface to the termination depths of the borings. The procurement of a highly-qualified specialty contractor experienced in the dewatering of wet granular soils and the installation of drilled shaft foundations for this project is mandatory in order to reduce the potential for construction problems relative to cave-ins and 'running ground' conditions (ACI 304R, Chapter 8, Concrete Placed Under Water). A temporary steel casing is highly recommended to control these adverse ground issues. It is also recommended that the geotechnical engineer who has knowledge of the design, and the geologic and subsurface conditions observe the drilled shaft excavation/construction and backfilling of concrete.

Completed drilled shaft excavations should have a planar bottom for axial bearing considerations. Loose material, disturbed material and water should be removed from the drilled shaft excavation prior to concrete backfilling. Drilled shaft excavations should not be allowed to stand open for a significant length of time because this may allow water to accumulate. Groundwater seepage may be encountered during construction. The maximum depth of water at the bottom of the shaft excavation should not exceed 3 inches prior to concrete pour. Use of drilling mud, downhole dewatering, bentonite or polymer slurry and/or tremie concrete construction methods may be required if groundwater/groundwater seepage is encountered and cannot be managed using temporary casing only. Another alternative may be to use a larger diameter shaft to help reduce drilled shaft embedment depths needed. Sidewalls are recommended to be visually free of cuttings. A clean-out bucket should be provided to permit manual removal of loose or disturbed soils within the drilled shaft excavation.

The potential for significant caving of shaft sidewalls in cohesive soils with frequent sand seams is high and may require temporary steel casing and/or slurry will be required during drilled shaft excavation. Care should be taken while removing liners or temporary casing during concrete placement so the head of concrete inside the casing is greater than the earth pressure and

hydrostatic head outside the casing. The concrete mix for the drilled shaft should be designed and placed to reduce the potential for arching of the concrete during removal of the casing. The temporary steel casing should be extended a minimum 3½ feet above the ground surface for safety and to reduce the potential risk of accidental fall-in of foreign materials and personnel into the excavation hole.

Concrete should consist of a Portland cement mixture properly air-entrained with an appropriate water to cement ratio for proper strength and durability. Tremie method of concrete placement may be required if water bearing soils are present within the anticipated excavation depths. ECS recommends a slump of 5 to 7 inches if tremie placement is required. Care should be exercised so the concrete will not contact the reinforcing cages during placement otherwise segregation of the concrete will occur. If the mixture is too stiff, then reinforcing cages may be pulled up when liners are withdrawn.

The drilled shaft should have a minimum shaft diameter of 30-inches to help reduce arching and the development of possible voids in placement of the in-situ concrete. The shaft should also contain reinforcing steel (designed by the structural engineer) to resist combinations of loadings and to satisfy the applicable building codes.

4.1.4 Spread Footing Foundations (Equipment Building)

Provided subgrades and structural fills are prepared as recommended in this report, the proposed equipment building structure may be supported by conventional spread footings (after removal and replacement of existing fill) or an improved ground system. ECS recommends the spread footing foundation design use the following parameters:

RECOMMENDED FOUNDATION DESIGN PARAMETERS		
Design Parameter		Spread Footing
Net Allowable Bearing Pressure ⁽¹⁾		2,000 psf
Acceptable Bearing Soil Material		Stratum II or Structural Fill
Competent Soils Designated Suitable for the Allowable Bearing Pressure		$N \geq 6$ bpf or $Q_p \geq 1.25$ tsf
Minimum Width		Isolated Columns: 24 inches Continuous Wall: 18 inches
Minimum Exterior Frost Depth (below final exterior grade) ⁽²⁾		66 inches (non-heated structure)
Estimated Settlement	Total ⁽³⁾	Less than 1 inch
	Differential	Less than ¾ inch

Notes:

- (1) Net allowable bearing pressure is the applied pressure exceeding the surrounding overburden soils above the base of the foundation.
- (2) For frost penetration considerations.
- (3) Based on anticipated estimated structural loads. If final loads are different, then ECS must be contacted to update foundation recommendations and settlement calculations.

Potential Undercuts: Based on the completed soil borings and as discussed in section 3.2 Subsurface Characterization of this Report, undocumented fill/possible fill soils were observed in each soil boring, extending to depths ranging from 4 to 8½ feet below the existing grades. ECS

recommends undocumented fill soils be completely removed from below the proposed building footprint and replaced with the compacted low plasticity structural fill. The possible fill soils can remain in place provided observations made during construction indicate the soil is natural and not fill, it contains less than 5 percent organic content, and it meets strength requirements. The *Earthwork Operations* Section in this report provides our subgrade preparation recommendations for the construction of foundations.

Frost Depth: Footings should be placed at a depth to provide adequate frost cover protection. We recommend the perimeter footings be placed at a minimum depth of 5½ feet below finished exterior grade. For mats not placed at a depth to provide adequate frost cover protection there is a risk the foundation will move much more than estimated because of freeze-thaw effects. As an alternative, high strength rigid insulation placed below the foundation and extending 6 feet beyond each foundation edge could be considered to reduce the potential for frost heave.

Foundation Uplift: Resistance to uplift forces will be developed by the dead weight of the structure plus the weight of the soil backfill above the foundation. For uplift resistance, ECS recommends utilizing a backfill unit weight of 125 pounds per cubic foot (pcf) above the water table, and a unit weight of 63 pcf below the water table. It is recommended the backfill be compacted to at least 95 percent of the maximum dry density determined by Modified Proctor test (ASTM D1557). The final design of the foundation for uplift should be based on a minimum factor of safety against uplift of 2.0.

Foundation Lateral Loading: Lateral load resistance will be developed by friction acting at the base of foundations, and the passive earth pressure developed by the footings below-grade. Passive pressure and sliding resistance (friction) may be used in combination, without reduction, in determining the total resistance to lateral loads. The parameters in the following table are recommended for lateral foundation loading:

FOUNDATION LATERAL LOADING RESISTANCE PARAMETERS	
Soil Parameter	Estimated value
Coefficient of Passive Earth Pressure (K_p)	2.4
Soil Moist Unit Weight (γ) - backfill lean clay/sandy lean clay	120 pcf
Interface Friction Angle [<i>Poured concrete on cohesive soil</i>] (ϕ_f)	16°
Sliding Friction Coefficient [<i>Poured concrete on granular soil</i>] (μ)	0.32
Passive Equivalent Fluid Pressure ⁽¹⁾	288H (psf)

Notes:

1. Neglect the passive earth pressure on the low side of the wall within the frost zone because of loss of strength seasonally and strain required to mobilize.

The final design of the foundation for lateral loads should be based on a minimum factor of safety against sliding of 1.5 and overturning of 2. Also, if the resultant force of the maximum vertical force does not act within the middle one-third (kern) of the footing, a smaller effective bearing area is expected to occur and thereby result in a higher effective bearing pressure that should be accounted for in the design.

Where utility trenches or other excavations are located adjacent to foundations, the bottom of the footing should be located below an imaginary 1:1 (horizontal to vertical) plane projected upward from the nearest bottom edge of the utility trench.

4.1.5 Slab/Skid Foundations (Misc. Equipment Pads)

Undocumented fill/possible fill soils were observed in both soil borings below the surficial soil cover. ECS anticipates that fill may be encountered in other unexplored portions of the site that were previously developed areas with building structures. Given the available information, lightly loaded miscellaneous equipment will be supported on slab-on-grade/skid foundations that are bearing at depths ranging from approximately 6 to 12 inches below the final grades. Based on the subsurface exploration, the soils at this site are considered moderately frost susceptible. Slab/skid foundations bearing at a depth of approximately 6 to 12 inches below the final grades on compacted in situ granular soils or compacted structural fill soil (extending through the existing fill) can be designed for maximum net allowable soil bearing pressure of 1,000 psf. An estimated coefficient of subgrade modulus of 7 to 9 pci can be used for preliminary slab foundation design thickness and rigidity. However, if the bearing contact pressure on the supporting soil mass is greater than 1,000 psf or footings are larger than 6 feet by 6 feet, ECS anticipates excessive total and differential settlement to be in excess of 1 inch and ½ inch, respectively.

4.1.6 Helical Pile Foundations (Equipment Building and Misc. Equipment Pads)

As an alternative to removal and replacement of the undocumented existing fill/possible, the proposed equipment building, and miscellaneous equipment pads may be supported by a foundation system consisting of standard helical piles or helical pull-down micropiles which extend through the encountered undocumented fill stratum.

A helical pile consists of circular steel plates welded to a steel shaft. The shafts are "screwed" into the ground at a controlled speed. With the helical pull-down micropile alternative, after the lead section with the helical plates penetrates the soil, a lead displacement plate and extension are bolted onto the shaft. Resuming torque on the assembled shaft advances the helical plates and pulls the displacement plate downward, forcing soil outward to create a cylindrical void around the shaft. From a reservoir at the surface, a flowable grout immediately fills the void, surrounding and encapsulating the shaft. Additional extensions and displacement plates are added until the helical bearing plates achieve the minimum bearing depth and the desired torque.

For both the standard helical pile foundation and the helical pull-down micropile foundation, support for the foundations is achieved by end bearing of the circular plates. However, with the pull-down micropile alternative, additional capacity is achieved through friction between the soil and grouted shaft. Further, the grouted column reduces the risk for buckling of the pile in soft/very loose soil zones.

Since helical piles are proprietary systems, we recommend consulting the selected pile manufacturer for details concerning the design and installation of the piles. Dependent on the selected helix configuration, we estimate an allowable pile capacity of at least 35 kips would be possible at this site.

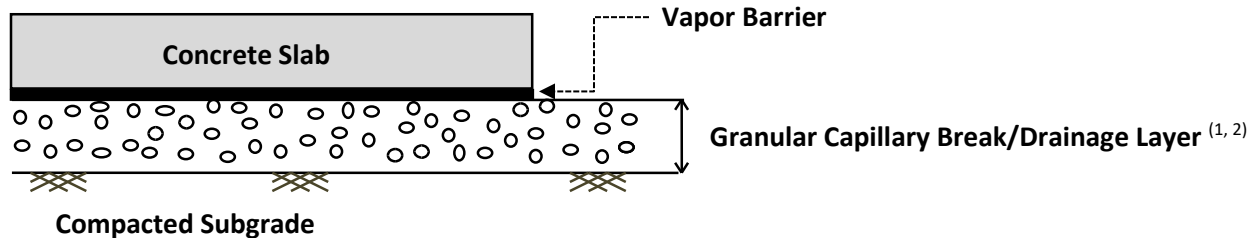
For preliminary design considerations, we recommend utilizing an allowable pile capacity of 20 to 30 kips for a standard helical pile advanced to a tip depth of about 15 feet below the existing grade. The preliminary pile capacity noted above assumes the use of an 8-10-12 inch helix configuration, a minimum 1.75-inch solid steel galvanized square shaft, as well as a minimum steel stress of 80 ksi (kips per square inch), and a minimum 3/8-inch helix plate thickness. We further recommend a minimum pile spacing of five times the largest helix plate diameter.

Our preliminary allowable pile capacity utilizes a minimum factor of safety of 2.0 against bearing failure. The allowable capacities noted above include an estimate based on static soil parameters at the boring locations and the material properties of the helical pile. Using the anticipated loading conditions and the maximum recommended allowable pile capacity, we preliminarily estimate the total settlement should not exceed approximately 1 inch.

It is important to note that the conditions may vary at the exact pile locations and that pile advancement operations may be less than ideal, which could necessitate greater pile depth or helix configuration to reach the capacity recommended above. With this in mind, we recommend a test pile program be implemented at the onset of construction. This program should include loading at least one of the installed piles at each structure to a minimum load equal to 1.5 the design capacity.

4.2 SLABS ON GRADE

Provided subgrades and structural fills are prepared as discussed herein, the proposed floor slab of the equipment building structure can be constructed as Ground Supported Slab (or Slab-On-Grade). For our analysis, we anticipated finished floor elevation will be located within approximately 2 feet of the existing grade, and it appears that slabs on grade will bear on newly compacted structural fill soils. The following graphic depicts our soil-supported slab recommendations:



1. Drainage Layer Thickness: Minimum 6 inches
2. Drainage Layer Material: GRAVEL (GP, GW) or SAND (SP, SW) having a maximum aggregate size of 1 inch and no more than 5 percent passing the No. 200 sieve.

Subgrade Modulus: Provided the subgrade is prepared, and structural fill and the granular drainage layer are placed as recommended in this report, the proposed slabs and pavements can be designed based on the estimated un-factored modulus of subgrade reaction, k_{v1} , of:

- 150 psi/in for Alternative 1 (*Complete removal and replacement*)
- 125 psi/in for Alternative 2 (*Partial removal and replacement*)
- 100 psi/in for Alternative 3 (*Proofroll and Replace as Needed*)

These estimated moduli of subgrade reaction values are based on the recommended minimum drainage base thickness and correlation of index properties and soil type to historical 1 foot by 1

foot plate load tests. The modulus value used in design should be adjusted for areas larger than 1 foot by 1 foot.

Vapor Barrier: Before the placement of concrete, a vapor barrier may be placed on top of the granular drainage layer to provide additional protection against moisture penetration through the floor slab. When a vapor barrier is used, special attention should be given to surface curing of the slab to reduce the potential for uneven drying, curling and/or cracking of the slab. Depending on proposed flooring material types, the structural engineer and/or the architect may choose to eliminate the vapor barrier.

Slab Isolation: Soil-supported slabs should be isolated from the foundations and foundation-supported elements of the structure so that differential movement between the foundations and slab will not induce excessive shear and bending stresses in the floor slab. Where the structural configuration prevents the use of a free-floating slab such as in a drop-down footing/monolithic slab configuration, the slab should be designed with suitable reinforcement and load transfer devices to preclude overstressing of the slab.

Frost Susceptible Areas: Exterior aprons and sidewalks, and portions of the floor slab, such as at doorways, and entrance/exit vestibules may be susceptible to frost heave movement during freezing weather. Additional insulation, installation of subgrade drainage, and/or replacement to the frost depth with non-frost-susceptible backfill should be considered for these areas. Pavement and ground surface grades are recommended to be sloped away from the building and flatwork, to reduce water infiltration and potential frost heave problems.

4.3 SEISMIC DESIGN CONSIDERATIONS

Seismic Site Classification: The International Building Code (IBC) 2018 requires site classification for seismic design based on the upper 100 feet of a soil profile. There are three methods to estimate the Seismic Site Class, namely Standard Penetration Resistance (N-value), undrained shear strength (S_u) and shear wave velocity (v_s) methods.

SEISMIC SITE CLASSIFICATION				
Site Class	Soil Profile Name	Shear Wave Velocity, V_s , (ft./s)	N value (bpf)	Undrained Shear Strength, S_u , (psf)
A	Hard Rock	$V_s > 5,000$ fps	N/A	NA
B	Rock	$2,500 < V_s \leq 5,000$ fps	N/A	NA
C	Very dense soil and soft rock	$1,200 < V_s \leq 2,500$ fps	>50	> 2,000
D	Stiff Soil Profile	$600 \leq V_s \leq 1,200$ fps	15 to 50	1,000 to 2,000
E	Soft Soil Profile	$V_s < 600$ fps	<15	< 1,000

ASCE 7-16 Table 20.3-1 Site Classification

The maximum explored depth in the present subsurface exploration was 30 feet below current site grades. As such, based upon our interpretation of the subsurface conditions and our experience with similar geological settings, the recommended Seismic Site Class is “D” as shown in the preceding Table.

Ground Motion Parameters: In addition to the seismic site classification, ECS has determined the design spectral response acceleration parameters following the IBC methodology (ASCE 7-16). The Mapped Responses were estimated from the 'ATC Hazards by Location' website (<https://hazards.atcouncil.org/>) for the address of the project. The design responses for the short period (0.2 sec, S_{D5}) and 1-second period (S_{D1}) are noted in bold at the far-right end of the following Table.

GROUND MOTION PARAMETERS								
Period (sec)	Mapped Spectral Response Accelerations (g)		Values of Site Coefficient for Site Class		Maximum Spectral Response Acceleration Adjusted for Site Class (g)		Design Spectral Response Acceleration (g)	
	0.2	S_s	0.05	F_a	1.6	$S_{MS}=F_a S_s$	0.080	$S_{D5}=2/3 S_{MS}$
1.0	S_1	0.036	F_v	2.4	$S_{M1}=F_v S_1$	0.086	$S_{D1}=2/3 S_{M1}$	0.057

4.4 UNSURFACED PAVEMENT DESIGN CONSIDERATIONS

Given the available information, ECS understands that unsurfaced (crushed aggregate) access road will be constructed during the construction phase of this project, and later will be utilized for occasional maintenance purposes. Traffic data was not available at the time of this report submittal. However, based on ECS experience with similar facilities, ECS anticipates 6 to 8 (H20-44) trucks per day during construction over a period of 6 months and less than 5 to 7 trucks per month and auto traffic. Based on the estimated traffic data and CBR value of 3, the computed thickness for unpaved crushed aggregate pavement is provided in the following Table.

RECOMMENDED MINIMUM UNSURFACED PAVEMENT SECTION	
Pavement Material	Compacted Material Thickness (inches)
Surface Aggregate (Dense Graded ¾-inch)	3
Crushed Aggregate (Dense Graded 1¼ -inch) without Geogrid	10
Crushed Aggregate with TX5 Geogrid or lime treatment within upper 12 inches	8

Pavement Drainage: An important consideration with the design and construction of pavements is surface and subsurface drainage. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the deterioration of the pavement can be expected. Based on our estimated groundwater level, ECS considers surface water infiltration to be the main source of water to be considered for pavement design on this project.

The final pavement surface is recommended to be shaped or crowned to properly direct surface water to adequate on or off-site stormwater drainage infrastructure. The pavement subgrade should be properly sloped to avoid dips or pockets where water may become trapped. Dips in the subgrade can result in a "bathtub" effect, which may trap water. This trapped water can soften the subgrade and potentially heave the pavement during freezing weather. The subgrade in areas requiring undercut and backfill with granular soils are recommended to be graded to drain toward

a drain tile. The drain tile should be sloped a minimum of ½ to 1 percent to discharge to nearby storm sewers, drainage ditches or other appropriate drainage facilities. Edge drains should be installed where site grades slope toward the pavement edge to reduce the potential for water to enter the base course layer. Edge drains should be sloped to the nearest appropriate drainage facility. Water that ponds on the subgrade surface can lead to deterioration of the subgrade soils, reduction of the base course support characteristics, and result in pavement heave during freezing conditions. Good drainage should help reduce the possibility of the subgrade materials being wet over a long period of time. To reduce the potential for shallow perched water to develop in areas of the site, install “stub” or “finger” drains around catch basins and in other low-lying areas of the parking lot to reduce the accumulation of water above and within the subgrade soils and aggregate base.

Pavement Maintenance: A sound maintenance program should be implemented to help maintain and enhance the performance of pavements and help attain the design service life. A preventative maintenance program should be started early in the pavement life to be effective. The “standard in the industry” supported by research indicates that preventative maintenance should typically begin within 2 to 5 years of the placement of pavement. In addition, routine maintenance should be performed, particularly in turning areas with repeated load applications. At a minimum, these areas will require regrading periodically to maintain effective drainage and to reshape after rutting and shoving. Observe pavements for distresses, such as depressions and poor drainage, typically once in the spring and once in the fall.

4.5 ELECTRICAL RESISTIVITY

The results of the in-situ (Wenner Four-Probe) resistivity testing can be found in the *Soil Resistivity Testing Report* included in Appendix B. The results indicate resistance generally decreases with depth. Based on the test results, we recommend using an average value of 4,000 Ω-cm for grounding installed within 10 feet of the existing grade. However, we recommend testing of the completed grounding system for compliance with required ground specification prior to the startup of the location.

A major factor in the determination of soil corrosivity is electrical resistivity. Electrical resistivity is a measure of resistance to the flow of electrical current. Buried metal corrosion is an electrochemical process in which the amount of metal loss due to corrosion is directly proportional to the flow of electrical current from the metal into the soil. Corrosion currents, following Ohm's Law, are inversely proportional to soil resistivity. Lower electrical resistivities typically occur in soil with higher moisture and higher soluble salt contents, which can be an indication of corrosive soil. A severity rating of corrosivity toward ferrous metals based on resistivity is listed below:

CORROSION SEVERITY RATING BASED ON SOIL RESISTIVITY ⁽¹⁾	
Soil Resistivity (ohm-cm)	Corrosivity Rating
>20,000	Essentially noncorrosive
10,000 – 20,000	Mildly corrosive
5,000 – 10,000	Moderately corrosive
3,000 – 5,000	Corrosive
1,000 – 3,000	Highly corrosive
< 1,000	Extremely corrosive

Notes:

1. Poursae, Rangaraju, and Ding, 2019, Evaluation of H-pile Corrosion Rates for WI Bridges Located in Aggressive Subsurface Environments, Report No. WHRP 0092-16-03.

The results of the electrical resistivity testing suggest the tested soil is corrosive. Note soil resistivity is not the only parameter affecting the risk of corrosion damage and a high soil resistivity does not guarantee the absence of corrosion potential. If corrosion potential is a concern, then we recommend additional testing and analysis be conducted for the soils within the area of the boring. The additional testing should include soil pH, Redox Potential, and sulfide content. We then recommend rating the soil using the American Water Works Association (AWWA) 10-Point system for corrosion potential.

5.0 SITE CONSTRUCTION RECOMMENDATIONS

5.1 SUBGRADE PREPARATION

5.1.1 Stripping and Initial Site Preparation

The subgrade preparation should consist of stripping vegetation, rootmat, topsoil, and other soft/very loose or inadequate materials from the 10-foot expanded foundation limits, 5-foot expanded pavement limits, and 5 feet beyond the toe of structural fills, where feasible. ECS should be retained to observe and document that topsoil and other poor surficial materials have been removed prior to the placement of structural fill or construction of structures.

As discussed in section 2.1 of this report, the site was previously developed with a single-story residential structure. However, it is not reported whether the existing foundations, slabs and below grade structures have been completely removed or left in place. ECS recommends that below grade previously developed structure footings, slabs and utilities should be excavated and backfilled with compacted structural fill within the proposed foundation and building footprint area. Utilities not reused should be capped off and removed or properly abandoned in-place in accordance with local codes and ordinances.

5.1.2 Existing Undocumented Fill

Existing undocumented fill/possible fill was encountered in each soil boring, extending to depths ranging from about 4 to 8½ below the existing site grades. Information regarding the placement and compaction of the existing fill/possible fill is not known. The boring information suggests the undocumented fill/possible fill was likely not placed with engineered control. Also, fill soils may be present in other areas not explored by the soil borings. With undocumented fill there is an inherent

risk for the owner that generally stems from the potential for deleterious material to exist within the fill or to be buried by the fill that was not found by the boring exploration, which could go undetected. This risk of unforeseen conditions cannot be eliminated without complete removal of the existing fill but can be reduced by performing the recommended observation and testing. Using undocumented material for support of foundations would require acceptance of risk by the owner. It is not the geotechnical engineer's responsibility to accept the risk, but rather to inform others of the risk so that they may make a judgment as to what level of cost versus performance risk is acceptable to them.

If available, documentation regarding the existing fill placement and compaction should be provided to ECS for review to help better evaluate potential risks. Test pits at this site may also be prudent to better check the composition of the existing fill/possible fill and to better evaluate its ability for support of the structure and the associated risks.

Fill in Slab and Pavement Areas: Considering the structure slab will be lightly loaded and complete removal and replacement of the existing fill may be cost prohibitive, and the owner may be willing to accept some risk. Below are three alternatives for subgrade preparation in slab and pavement areas with varying anticipated cost and level of risk associated.

- **Alternative 1 (Complete Removal and Replacement):** Completely remove the existing fill materials from slab and pavement areas and replace with structural fill. Note that removal and replacement of the undocumented existing fill material would require excavations of approximately an average depth of 6 feet below existing site grades. However, deeper fill may be present in areas not explored by the borings. This option carries a low risk of poor slab performance but is anticipated to have the greatest construction costs of the alternatives presented.
- **Alternative 2 (Partial Removal and Replacement):** Remove at least 2 feet of the existing Fill below the floor slab and pavement (below the design granular base elevation) and replace the undercuts with new structural fill reinforced with a layer of geogrid (Tensar TX 140 or similar) placed prior to backfilling and compaction of structural fill. After the undercut and prior to placement of geogrid and compacted backfill in pavement areas, the exposed remaining Fill subgrade should be proofrolled as recommended in the *Proofrolling* Section below. Unstable or yielding subgrade materials should be additionally removed and replaced. This alternative carries a low to moderate risk for the proposed floor slab and pavement performance but expected to have moderate construction costs of the alternatives presented.
- **Alternative 3 (Proofroll and Replace as Needed):** After the site has been stripped and the subgrade has been exposed, the subgrade should be proofrolled as recommended in the *Proofrolling* Section below. This alternative will only identify near surface soils that are inadequate for slab or pavement support, and unidentified deeper pockets of inadequate fill could lead to poor performance of the slab. This alternative is expected to have the lowest construction costs of the alternatives presented, but also has a moderate risk of poor slab performance.

5.1.3 Frost Susceptible Soils

The frost susceptible silty and clayey soils encountered in the borings provide a concern for the pavement system. A risk for reduced pavement performance exists with the construction of pavements on frost susceptible soil. The reduced pavement performance may occur because of potential detrimental frost heaving and spring thaw weakening. The risk associated with frost susceptible soils can be reduced by removal of frost susceptible soils from within 3 feet of the finished pavement grade. The risk at this site related to the frost susceptible soils is generally moderate. However, the risk is expected to be high in areas where highly frost susceptible soil such as SILT (ML) or SILTY CLAY (CL-ML) is present within 3 feet of the finished pavement grade.

ECS anticipates the moderately frost susceptible soil will remain in place below pavements provided the soil meets strength requirements and contains less than 5 percent organic content. However, ECS recommends removing highly frost susceptible soils from within 3 feet of the finished pavement grade where it is encountered during construction. The ends of over-excavated areas should be sloped across a minimum length of 10 feet to reduce the potential abrupt changes in the pavement support characteristics that could lead to future pavement distress. The removed material should then be replaced with a properly compacted engineered fill.

5.1.4 Previous Construction Considerations

Possible remnants of the previous construction may be present below the surface in unexplored areas of the site. Site preparation will require complete removal and proper disposal of remnants of previous construction, including pavements, foundations, floor slabs, underground utilities which are not reused, etc. Disposal of debris should be in accordance with local, state, and federal regulations for the material type. As an option, it is possible to leave portions of remaining foundations in-place in the planned parking and landscape areas, provided they are cut off at least 2 feet below the planned subgrade and hollow cores are grouted solid. Construction remnants left in-place may cause excavation difficulties for new utilities or other future construction.

5.1.5 Proofrolling

After the removal of inadequate surface materials, cutting to the proposed subgrade, and prior to the placement of structural fill or other construction materials, the exposed slab and pavement subgrade should be observed by ECS. The exposed subgrade should be proofrolled with construction equipment having a minimum axle load of 10 tons (e.g., fully loaded tandem-axle dump truck in clayey soils or large smooth drum roller in sandy soils). Proofrolling should be traversed with overlapping passes of the vehicle under the observation of ECS. This procedure is intended to assist in identifying localized yielding materials.

Unstable or pumping subgrade areas identified during the proofroll should be repaired prior to the placement of subsequent structural fill or other construction materials. Unstable subgrade repair methods, such as undercutting, or moisture conditioning and recompaction, or chemical stabilization, should be discussed with ECS to determine the appropriate procedures regarding the existing conditions causing the instability. Test pits may be excavated in unstable areas to explore the shallow subsurface materials and to help determine the appropriate remedial action to stabilize the subgrade.

Seasonal reduction of the near surface soil strength can occur during wet times of the year (such as during the spring and fall months, and as evident during drilling operations) or immediately following extended periods of rain. This may result in additional unstable or pumping subgrade areas. Some undercutting or repair of unstable subgrade soils should be anticipated during slab and pavement subgrade preparation. The method of subgrade repair or improvement chosen may be influenced by several factors such as weather and schedule, as well as the area, depth and nature of the unstable subgrade soils. Depending on these and other factors, potential subgrade repair methods are described below, but the actual depth of subgrade undercut and/or stabilization method should be determined at the time of construction. Some common subgrade repair methods include:

Scarification and Compaction: Soils can be scarified, moisture conditioned (i.e., dried or wetted) to within a narrow range of the material's optimum moisture content and compacted. Scarification and compaction is generally most applicable where very shallow unstable conditions are encountered and at times when the soil can be properly dried or wetted to within a narrow range of the materials optimum moisture content.

Undercut and Replacement: ECS recommends soft or yielding soils be evaluated in approximately 6 to 12-inch intervals to help limit the volume of undercuts. If soft or yielding soils are identified, the contractor should remove only 6 to 12 inches of material at a time in the subject area and then proofroll/evaluate the undercut subgrade to determine if additional undercut is needed. This may take more time but could potentially reduce the removal of more soil than necessary. Use of a geogrid could also be considered to locally reduce undercut depths. A geogrid, if used, should be placed after underground work, such as utility construction, is complete. Do not operate equipment on the geogrid until after 1 foot of structural fill is placed above it. Depending on the conditions at the time of repair, use of an aggregate structural fill, such as crushed stone, crushed concrete or gravel, may be needed.

Chemical Modification: Alternatively, if these soils cannot be stabilized by conventional methods, chemical modification of the subgrade soils, such as with lime, lime kiln dust, cement, cement kiln dust, or other materials, may be utilized to reduce the moisture content and/or provide additional stabilization. An experienced pre-qualified contractor that has successfully chemically modified similar-sized projects with similar soil conditions is recommended to be used. The soil modification procedure, such as determination of the type and quantity of additive, and mixing and curing procedures, should be evaluated before implementation. This evaluation may include testing the soil to check if an adverse chemical reaction could occur. Chemical modification agents can have caustic effects to humans and property. The contractor should be required to minimize dusting or implement dust control measures. For preliminary estimating purposes, the approximate incorporation rate (based on dry weight of soil) is typically in the range of 6 to 7 percent, by dry weight, for hydrated lime or lime by-products, and 5 to 7 percent, by dry weight, for Portland cement. Typically, the percentage needed is less for hydrated lime than other lime by-products because the available calcium oxide content of lime by-products tends to be lower. Note insufficient mellowing of modified soils could lead to heaving after placement. Subgrade modification can result in the creation of an 'aquiclude' layer which will allow water to pond above the stabilized surface within the base course. Such water, if not

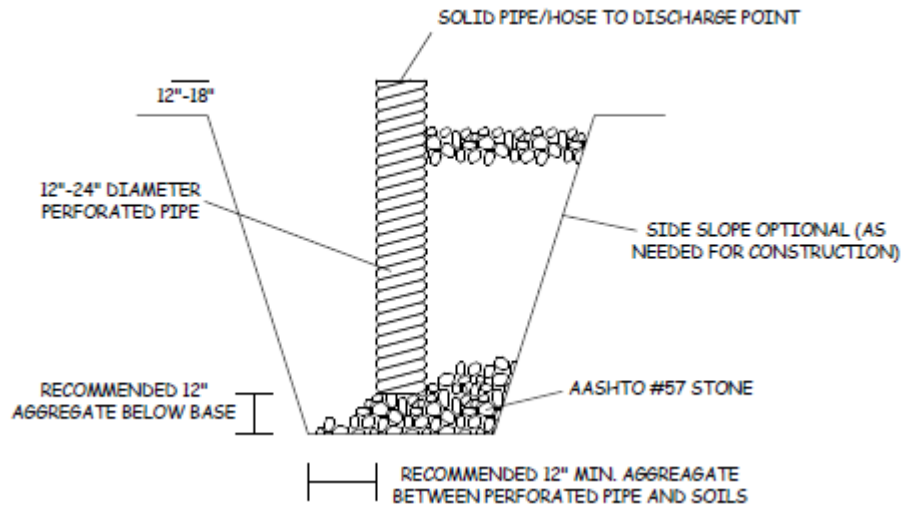
drained properly, can freeze in cold weather potentially resulting in significant heave of the pavement. Alterations to the pavement sections to include additional drainage, such as an open-graded drainage aggregate layer, may be needed if a chemically modified subgrade is used.

5.1.6 Site Temporary Dewatering

The contractor shall make their own assessment of temporary dewatering needs based upon the limited subsurface groundwater information presented in this report. Soil sampling is not continuous, and thus soil and groundwater conditions may vary between sampling intervals (typically 5 feet). If the contractor believes additional subsurface information is needed to assess dewatering needs, they should obtain such information at their own expense. ECS makes no warranties or guarantees regarding the adequacy of the provided information to determine dewatering requirements; such recommendations are beyond our scope of services.

Dewatering systems are a critical component of many construction projects. Dewatering systems should be selected, designed, and maintained by a qualified and experienced (specialty or other) contractor familiar with the geotechnical and other aspects of the project. The failure to properly design and maintain a dewatering system for a given project can result in delayed construction, unnecessary foundation subgrade undercuts, detrimental phenomena such as ‘running sand’ conditions, internal erosion (i.e., ‘piping’), the migration of ‘fines’ down-gradient towards the dewatering system, localized settlement of nearby infrastructure, foundations, slabs-on-grade and pavements, etc. Water discharged from a site dewatering system shall be discharged in accordance with local, state, and federal requirements.

Strategies for Addressing Perched Groundwater: The typical primary strategy for addressing perched groundwater seeping into excavations is pumping from a trench (or French drain) and sump pits with sump pumps. The inlet of the sump pump is placed at the bottom of the corrugated pipe and the discharge end of the sump is directed to an appropriate stormwater drain. A typical sump pump drain (found in a sump pit or along a French drain) is depicted below:



Sump Pit/Pump Diagram

A typical French drain consists of an 18 to 24-inches wide by 18 to 24-inches deep bed of AASHTO No. 57 (or similar open graded aggregate) aggregate wrapped in a medium duty, non-woven geotextile and (sometimes) containing a 6-inch diameter, Schedule 40 PVC perforated or slotted pipe. Actual dimensions should be as determined necessary by ECS during construction. After the installation has been completed, the geotextile should be wrapped over the top of the aggregate and pipe followed by placement of backfill. The top of the drain should be positioned at least 18 inches below the design subgrade elevations. Drains should not be routed within the expanded building limits.

Pumping wells or a vacuum system could also be used to address perched groundwater. These techniques often are only effective during the initial depletion of the perched water quantity and may quickly be ineffective at addressing accumulation of water from rain, snow, etc.

Surface Drainage: The surface soils may be erodible. Therefore, the contractor should provide and maintain good site surface drainage during earthwork operations to maintain the integrity of the surface soils. Erosion and sedimentation controls should be in accordance with sound engineering practices and local requirements. Surface water should be directed away from the construction area, and the work area should be sloped away from the construction area at a gradient of 1 percent or steeper to reduce the potential of ponding water and the subsequent saturation of the surface soils. At the end of each workday, the subgrade soils should be sealed by rolling the surface with a smooth drum roller to reduce infiltration of surface water.

5.2 EARTHWORK OPERATIONS

5.2.1 Structural Fill

Prior to placement of structural fill, representative bulk samples (about 50 pounds) of on-site and off-site borrow should be submitted to ECS for laboratory testing, which will typically include natural moisture content, Atterberg limits, grain-size distribution, and moisture-density relationships (i.e., Proctors) for compaction. Import materials should be tested prior to being hauled to the site to determine if they meet project specifications. Alternatively, Proctor data from other accredited laboratories can be submitted if the test results are within the last 90 days.

Satisfactory Structural Fill Materials: Structural fill is defined as inorganic soils with the following engineering properties and compaction requirements:

STRUCTURAL FILL INDEX PROPERTIES	
Subject	Property
Liquid Limit (LL) and Plasticity Index (PI)	LL < 40, PI < 20
Maximum Particle Size	3 inches
Maximum Fines Content Passing #200 Sieve	25% by dry weight
Maximum Organic Content	5% by dry weight

STRUCTURAL FILL COMPACTION REQUIREMENTS	
Subject	Requirement
Compaction Standard	Modified Proctor, ASTM D1557
Minimum Required Compaction	95% of Max. Dry Density
Moisture Content	-2 to +3% points of the soil's optimum value
Maximum Loose Lift Thickness	8 inches prior to compaction

On-Site Borrow: None of the encountered soils would likely meet our recommendations for use as structural fill but should be further evaluated and tested by ECS prior to use. On-site soil used as structural fill should be free of frozen matter, deleterious materials, or chemicals that may result in the material being classified as “contaminated.” Some conditions at the time of construction, such as wet or freezing weather, may preclude the use of on-site soil, and it may be necessary to use an imported less moisture sensitive or less frost susceptible granular material. Some of the soil samples appeared to have a relatively high moisture content, so the contractor should expect some drying of on-site soil prior to reuse as structural fill.

Fill Placement: Fill materials should not be placed on frozen soils, on frost-heaved soils, and/or on excessively wet soils. Borrow fill materials should not contain frozen materials at the time of placement, and frozen or frost-heaved soils should be removed prior to placement of structural fill or other fill soils and aggregates. Excessively wet soils or aggregates should be scarified, aerated, and moisture conditioned.

Structural fill placed below foundations and within the foundation influence zone should extend 1 foot beyond the outside edges of the footings and from that point, outward laterally 1 foot for every 2 feet of fill thickness below the footing. Use of lean mix concrete to limit lateral over-excavation may not be effective at this site because of caving of excavation sidewalls within the granular soils. In addition, we **strongly** recommend ECS document the material exposed in the excavations does not exhibit obvious characteristics that would adversely affect the performance of the foundation system.

Compaction Equipment: Compaction equipment appropriate to the soil type being compacted should be used to compact the subgrades and fill materials. Sheepsfoot compaction equipment should be used for the compaction of fine-grained soils (Clays and Silts). A vibratory steel drum roller should be used for compaction of coarse-grained soils (Sands and Gravels) as well as to help seal compacted surfaces.

5.3 FOUNDATION AND SLAB OBSERVATIONS

Protection of Foundation Excavations: Exposure to the environment may weaken the soils at the footing bearing level if the foundation excavations remain open for too long a time. Foundation concrete should be placed the same day that excavations are made. If the bearing soils are softened by surface water intrusion or exposure, then the softened soils should be removed from the foundation excavation bottom immediately prior to placement of concrete. If the excavation must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, then a

1 to 3-inch thick “mud mat” of “lean” concrete should be placed on the bearing soils before the placement of reinforcing steel.

Footing Subgrade Observations: Because the boring encountered undocumented fill/possible fill soils, it will be important to have ECS observe the foundation subgrade prior to placing foundation concrete, to confirm and document the anticipated bearing soils. Where undocumented fill, organic soils, soft/very loose soil, or inadequate soils are observed in the foundation influence zone, we recommend the removal of the poor soils. Undercuts should be backfilled with structural fill up to the original design bottom of footing elevation. The original footing is then recommended to be constructed on top of the structural fill.

Slab Subgrade Verification: Prior to placement of a drainage layer, the subgrade should be prepared in accordance with the recommendations found in the *Proof-rolling* Section of this report. Slab areas should be proofrolled with construction equipment having a minimum axle load of 10 tons (e.g., fully loaded tandem-axle dump truck in clayey soils or large smooth drum roller in sandy soils) or evaluated with hand-operated testing equipment to check the subgrade support characteristics.

5.4 UTILITY INSTALLATIONS

Utility construction should be in accordance with *The Standard Specifications for Sewer and Water Line Construction in Wisconsin*.

Utility Subgrades: ECS expects the soils encountered in our exploration to be generally adequate for support of utility pipes at typical utility depths except for the existing fill and soft/very loose soil mentioned above. The pipe subgrade should be observed and probed for stability by ECS to confirm the encountered materials meet our recommendations. Existing fill, soft/very loose, organic, or otherwise substandard materials encountered at the utility pipe subgrade elevation should be removed and replaced with properly compacted structural fill or pipe bedding material.

Utility Backfilling: The granular bedding material should be at least 4 inches thick, but not less than that specified by the project drawings and specifications. ECS recommends granular bedding consist of crushed stone chips in accordance with Table 32 and Chapter 8.43.0 of *The Standard Specifications for Sewer and Water Line Construction in Wisconsin*. Fill placed for support of the utilities, as well as backfill over the utilities, should satisfy the recommendations for engineered fill given in this report. We recommend cover material consist of material in accordance with Table 36 and Chapter 8.43.3 of *The Standard Specifications for Sewer and Water Line Construction in Wisconsin*. Granular backfill material should consist of material in accordance with Table 37 and Chapter 8.43.4 of *The Standard Specifications for Sewer and Water Line Construction in Wisconsin*. Excavated material in accordance with Chapter 8.43.5 of *The Standard Specifications for Sewer and Water Line Construction in Wisconsin*, and as recommended in the *Earthwork Operations* Section of this report could also be used as backfill.

We do not recommend flood compaction of the backfill, especially within a cohesive soil excavation, where cohesive soils are used as backfill, and/or where a shallow water table exists. Mechanical compaction is recommended and preferred since it generally provides more uniform compaction than flood compaction.

Excavation Safety: The contractor should make and maintain excavations and slopes in accordance with OSHA excavation safety standards. The contractor is solely responsible for designing and constructing stable, excavations and slopes and should shore, slope, or bench the sides of the excavations and slopes as required to maintain stability of both the excavation sides and bottom. The contractor's responsible person, as defined in OSHA 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. ECS is providing this information solely as a service to our client. ECS is not assuming responsibility for construction site safety or the contractor's activities; ECS does not imply such responsibility, and the contractor, design team and owner should not infer it.

6.0 CLOSING

ECS has prepared this report to guide the geotechnical-related design and construction aspects of the project. We performed these services in accordance with the standard of care expected of professionals in the industry performing similar services on projects of like size and complexity at this time in the region. No other representation expressed or implied, and no warranty or guarantee is included or intended in this report.

The description of the proposed project is based on information provided to ECS by Mission Support Services, LLC. If this information is inaccurate or changes, either because of our interpretation of the documents provided or site or design changes that may occur later, then ECS should be contacted so we can review our recommendations and provide additional or alternate recommendations that reflect the proposed construction.

We recommend that ECS review the project plans and specifications so we can confirm that those plans/specifications are in accordance with the recommendations of this geotechnical report.

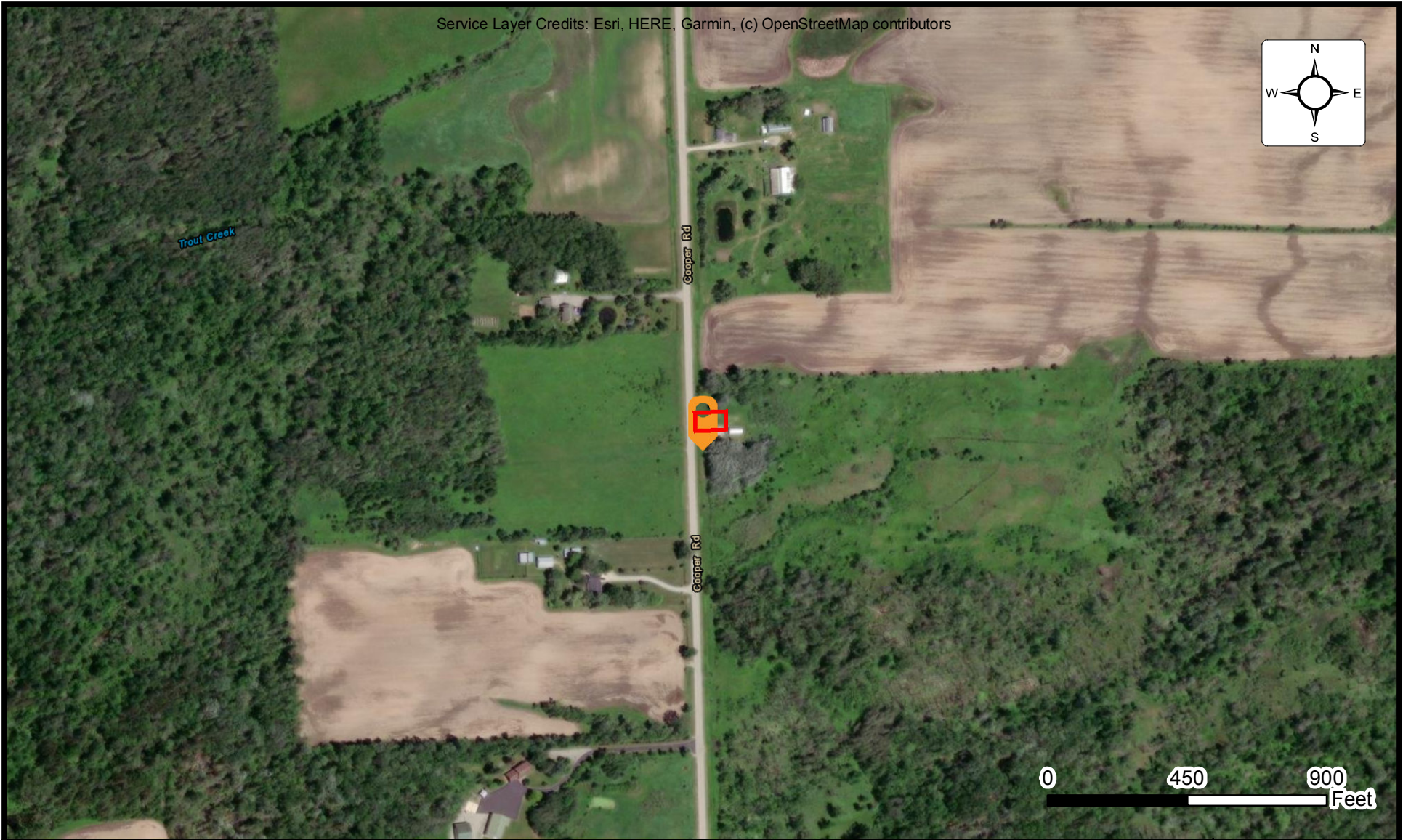
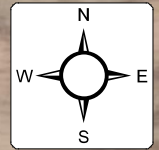
Field observations, and quality assurance testing during earthwork and foundation installation are an extension of, and integral to, the geotechnical design. We recommend that ECS be retained to apply our expertise throughout the geotechnical phases of construction, and to provide consultation and recommendation should issues arise.

ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

APPENDIX A – Diagrams & Reports

Site Location Diagram
Boring Location Diagram
Soil Survey Map

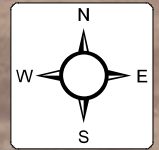
Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors



SITE LOCATION DIAGRAM PROPOSED SELF-SUPPORTED TOWER (NW TOWER)

COOPER ROAD, ONEIDA, WISCONSIN
MISSION SUPPORT SERVICES

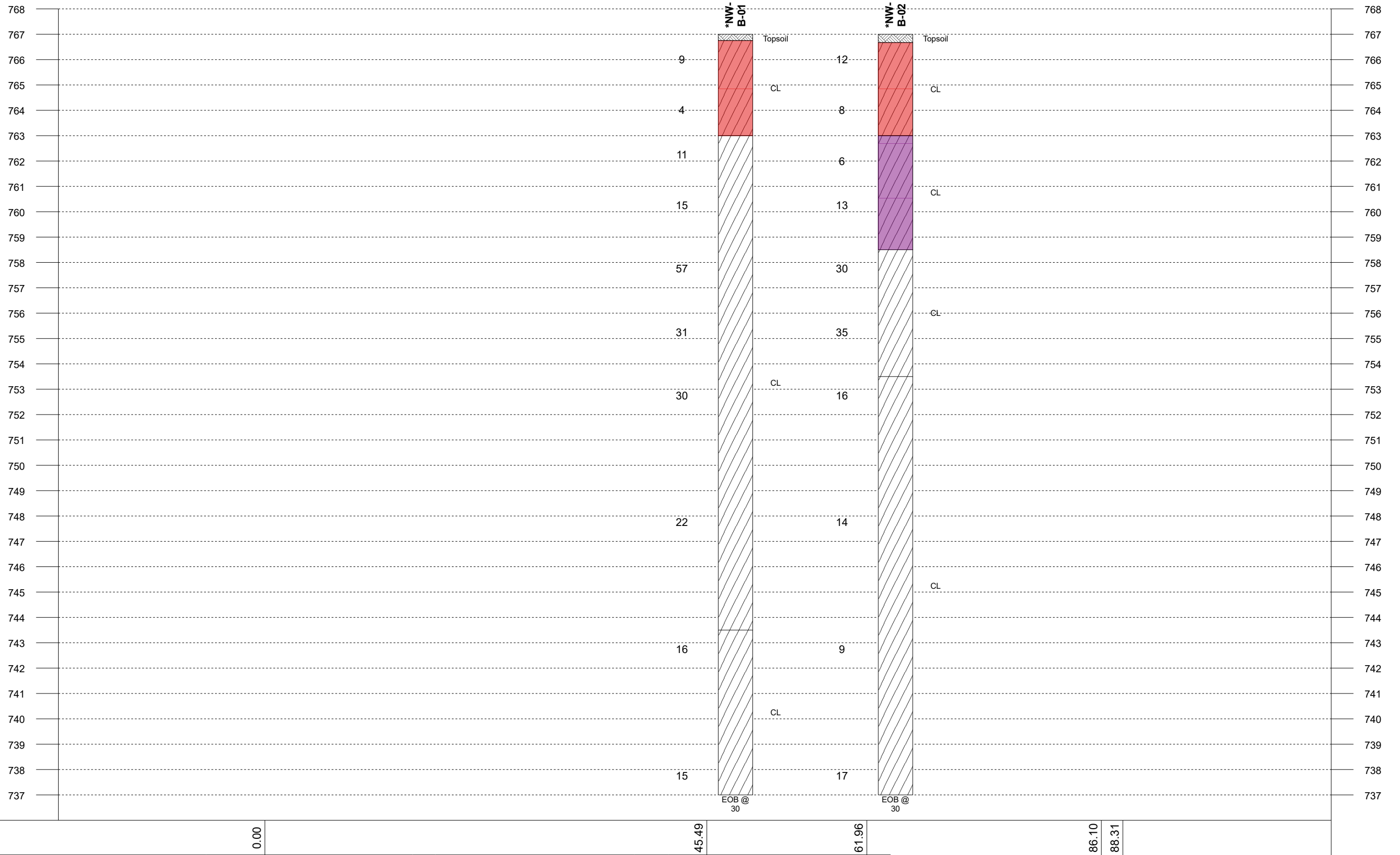
ENGINEER MEK1
SCALE AS NOTED
PROJECT NO. 59:3565
FIGURE 1 OF 1
DATE 8/8/2023



BORING LOCATION DIAGRAM PROPOSED SELF-SUPPORTED TOWER (NW TOWER)

COOPER ROAD, ONEIDA, WISCONSIN
MISSION SUPPORT SERVICES

ENGINEER MEK1
SCALE AS NOTED
PROJECT NO. 59:3565
FIGURE 1 OF 1
DATE 8/8/2023



Legend Key

- Topsoil
- Lean CLAY

Notes:
 1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
 2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
 3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
 4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit	Water Content	Liquid Limit	▽	WL (First Encountered)		Fill
X	●	△	▼	WL (Completion)		Possible Fill
[FINES CONTENT %]			▽	WL (Estimated Seasonal High Water)		Probable Fill
	BOTTOM OF CASING		▽	WL (Stabilized)		Rock
	LOSS OF CIRCULATION					
○	CALIBRATED PENETROMETER					

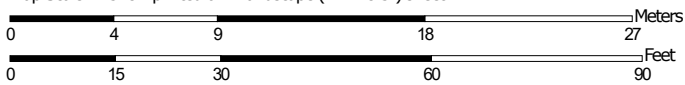


GENERALIZED SUBSURFACE SOIL PROFILE	
Section line 1	
Proposed Self-supported Tower (NW Tower)	
Mission Support Services	
Cooper Road, Oneida, Wisconsin, 54165	
Project No: 59:3565	Date: 08/09/2023

Custom Soil Resource Report Soil Map



Map Scale: 1:328 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84



APPENDIX B – Field Operations

Subsurface Exploration Procedure: Standard Penetration Testing (SPT)

Reference Notes for Boring Logs

Boring Logs B-01 and B-02

In-Situ Electrical Resistivity Test Results



SUBSURFACE EXPLORATION PROCEDURE: STANDARD PENETRATION TESTING (SPT)

ASTM D 1586

Split-Barrel (Split-Spoon) Sampling

Standard Penetration Testing, or **SPT**, is the most frequently used subsurface exploration test performed worldwide. This test provides samples for identification purposes as well as a measure of penetration resistance, or N-Value. The N-Value, or blow counts, when corrected and correlated, can approximate engineering properties of soils used for geotechnical design and engineering purposes.

SPT Procedure:

- Involves driving a 2-inch outside diameter hollow tube (split-spoon) into the ground by dropping a 140-lb hammer a height of 30 inches at desired depth
- Recording the number of hammer blows required to drive the split-spoon a distance of 12 inches (in 3 or 4 Increments of 6 inches each)
- Auger is advanced* and an additional SPT is performed
- One SPT test is typically performed every 2½ to 5 feet.
- Obtain a 1⅜-inch diameter soil sample



**Drilling Methods May Vary – The predominate drilling methods used for SPT are open hole fluid rotary drilling and hollow-stem auger drilling.*

REFERENCE NOTES FOR BORING LOGS

MATERIAL ^{1,2}	
	ASPHALT
	CONCRETE
	GRAVEL
	TOPSOIL
	VOID
	BRICK
	AGGREGATE BASE COURSE
	GW WELL-GRADED GRAVEL gravel-sand mixtures, little or no fines
	GP POORLY-GRADED GRAVEL gravel-sand mixtures, little or no fines
	GM SILTY GRAVEL gravel-sand-silt mixtures
	GC CLAYEY GRAVEL gravel-sand-clay mixtures
	SW WELL-GRADED SAND gravelly sand, little or no fines
	SP POORLY-GRADED SAND gravelly sand, little or no fines
	SM SILTY SAND sand-silt mixtures
	SC CLAYEY SAND sand-clay mixtures
	ML SILT non-plastic to medium plasticity
	MH ELASTIC SILT high plasticity
	CL LEAN CLAY low to medium plasticity
	CH FAT CLAY high plasticity
	OL ORGANIC SILT or CLAY non-plastic to low plasticity
	OH ORGANIC SILT or CLAY high plasticity
	PT PEAT highly organic soils

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

PARTICLE SIZE IDENTIFICATION	
DESIGNATION	PARTICLE SIZES
Boulders	12 inches (300 mm) or larger
Cobbles	3 inches to 12 inches (75 mm to 300 mm)
Gravel: Coarse	¾ inch to 3 inches (19 mm to 75 mm)
Gravel: Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand: Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
Sand: Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
Sand: Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")	<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS		
UNCONFINED COMPRESSIVE STRENGTH, QP ⁴	SPT ⁵ (BPF)	CONSISTENCY ⁷ (COHESIVE)
<0.25	<2	Very Soft
0.25 - <0.50	2 - 4	Soft
0.50 - <1.00	5 - 8	Medium Stiff
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

RELATIVE AMOUNT ⁷	COARSE GRAINED (%) ⁸	FINE GRAINED (%) ⁸
Trace	≤5	≤5
With	10 - 20	10 - 25
Adjective (ex: "Silty")	25 - 45	30 - 45

GRAVELS, SANDS & NON-COHESIVE SILTS	
SPT ⁵	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

WATER LEVELS ⁶	
	WL (First Encountered)
	WL (Completion)
	WL (Seasonal High Water)
	WL (Stabilized)

FILL AND ROCK			
FILL	POSSIBLE FILL	PROBABLE FILL	ROCK

¹Classifications and symbols per ASTM D 2488-17 (Visual-Manual Procedure) unless noted otherwise.

²To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.

³Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-FILL)].

⁴Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).

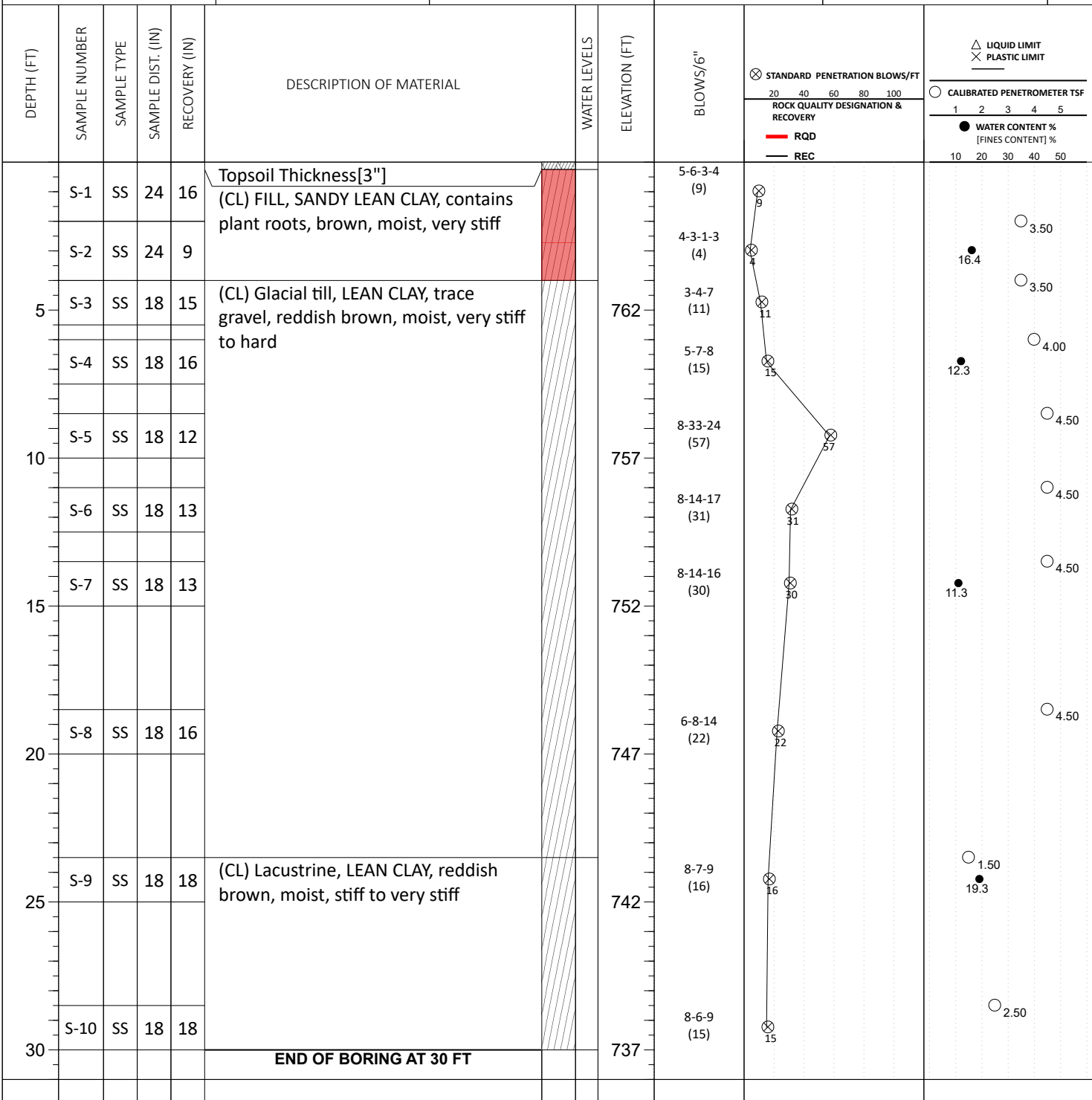
⁵Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf). SPT correlations per 7.4.2 Method B and need to be corrected if using an auto hammer.

⁶The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.

⁷Minor deviation from ASTM D 2488-17 Note 14.

⁸Percentages are estimated to the nearest 5% per ASTM D 2488-17.

SITE LOCATION: Cooper Road, Oneida, Wisconsin, 54165			LOSS OF CIRCULATION 	
NORTHING: 924713.5	EASTING: 2430011.9	STATION:	SURFACE ELEVATION: 767	BOTTOM OF CASING



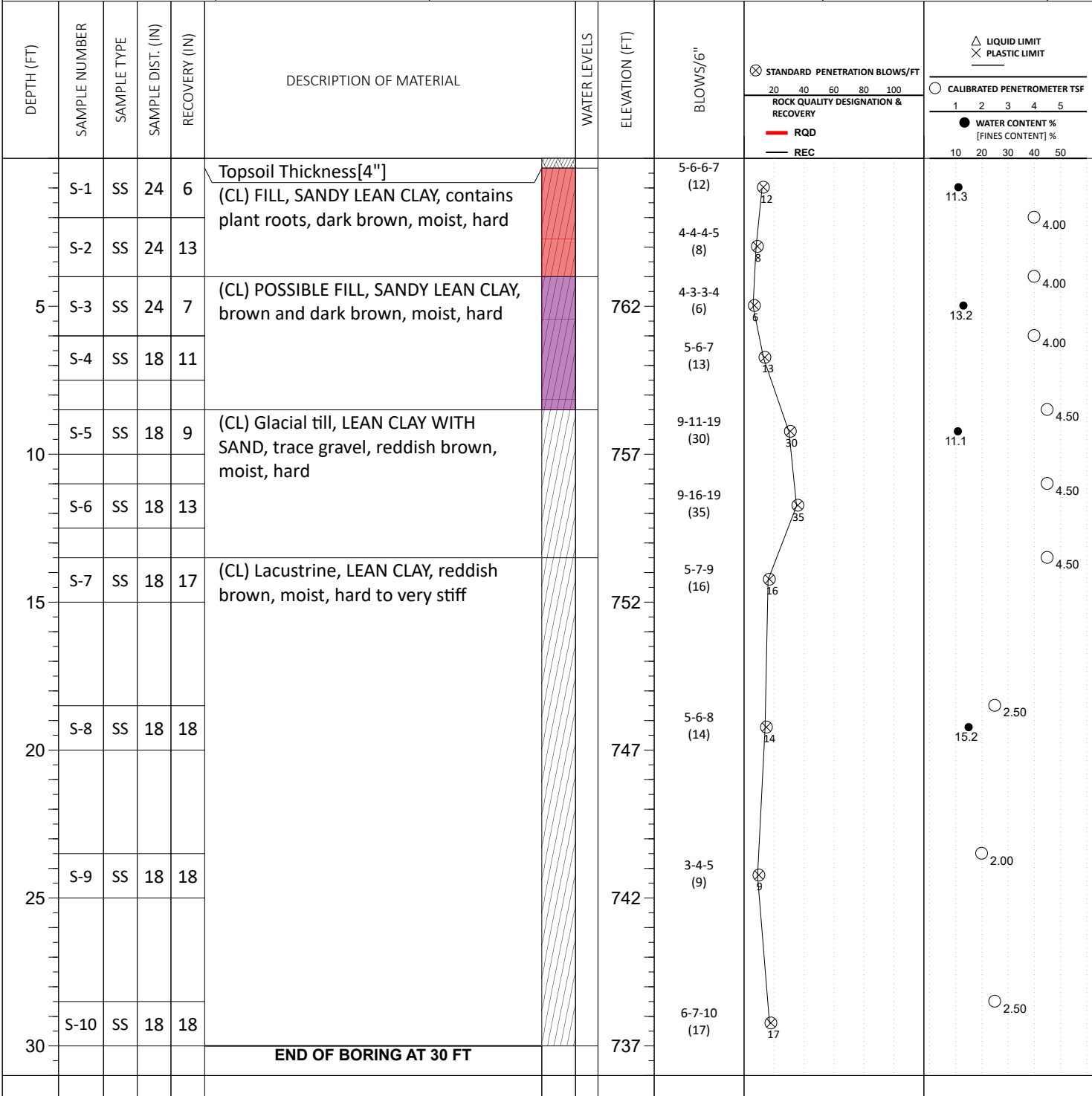
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

<input type="checkbox"/> WL (First Encountered)	None	BORING STARTED: Jul 07 2023	CAVE IN DEPTH:
<input type="checkbox"/> WL (Completion)	None	BORING COMPLETED: Jul 07 2023	HAMMER TYPE: Auto
<input type="checkbox"/> WL (Seasonal High Water)		EQUIPMENT: Truck	DRILLING METHOD: 3-1/4" Hollow stem auger
<input type="checkbox"/> WL (Stabilized)		LOGGED BY: YP	

GEOTECHNICAL BOREHOLE LOG

SITE LOCATION:
Cooper Road, Oneida, Wisconsin, 54165

NORTHING: 924712.4	EASTING: 2430028.4	STATION:	SURFACE ELEVATION: 767	LOSS OF CIRCULATION 
				BOTTOM OF CASING 



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

<input type="checkbox"/> WL (First Encountered)	None	BORING STARTED: Jul 06 2023	CAVE IN DEPTH:
<input checked="" type="checkbox"/> WL (Completion)	None	BORING COMPLETED: Jul 06 2023	HAMMER TYPE: Auto
<input checked="" type="checkbox"/> WL (Seasonal High Water)		EQUIPMENT: Truck	DRILLING METHOD: 3-1/4" Hollow stem auger
<input checked="" type="checkbox"/> WL (Stabilized)		LOGGED BY: YP	

GEOTECHNICAL BOREHOLE LOG

ELECTRICAL RESISTIVITY SOUNDING DATASHEET

Project Name:	Oneida Broadband NW Tower Site
ECS Project No.	59:3565
Project Location:	N7890 Cooper Road, T. Oneida, Outagamie County, WI
Prepared for:	Mission Support Services
Instrument Used:	Fluke 1625 GEO Earth Ground Tester
Array Type:	Wenner 4-Electrode (ASTM G-57)



Test Location	Spacing (feet) A	Resistance (ohms) R	Apparent Resistivity (ohm-cm)
NW-B-01 Line Bearing: N/S Tested 6-28-2023	2.5	19.39	9,283
	5	6.45	6,176
	10	2.14	4,098
	20	1.23	4,711
NW-B-01 Line Bearing: E/W Tested 6-28-2023	2.5	20.97	10,039
	5	6.10	5,841
	10	2.19	4,194
	20	1.29	4,941

APPENDIX C – Laboratory Test Results

Laboratory Procedures



LABORATORY PROCEDURES:

Moisture content determination was performed on select fine-grained soil samples in accordance with ASTM D 2216.

Calibrated hand penetrometer tests (Qp) were performed on select cohesive soil samples. In the hand penetrometer test, the unconfined compressive strength of a soil sample is estimated, to a maximum of 4.5 or 6 tons per square foot (tsf), depending on the penetrometer model, by measuring the resistance of a soil sample to penetration by a small, calibrated, spring-loaded cylinder.

APPENDIX D – Supplemental Report Documents

Important Information about This Geotechnical-Engineering Report

Important Information about This

Geotechnical-Engineering Report

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

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

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

Understand the Geotechnical-Engineering Services Provided for this Report

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

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

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

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer

will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

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

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

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

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

Read this Report in Full

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

You Need to Inform Your Geotechnical Engineer About Change

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

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

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

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

Most of the “Findings” Related in This Report Are Professional Opinions

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

This Report’s Recommendations Are Confirmation-Dependent

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

This Report Could Be Misinterpreted

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

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

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

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note*

conspicuously that you’ve included the material for information purposes only. To avoid misunderstanding, you may also want to note that “informational purposes” means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

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

Geoenvironmental Concerns Are Not Covered

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

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

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



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