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November 12, 2018

Ms. Bria Boos
Project Manager – Land & Water Unit
Hennepin County Environment & Energy Dept.
701 4th Ave. South, Suite 700
Minneapolis, MN 55415

Mr. Tim Bruers
Project Manager - Design
Hennepin County Transporation Dept.
1600 Prairie Dr
Medina, MN 55340

GTE Project No. 95423-E

RE: Geotechnical Engineering Report - Hennepin County CSAH 112 Phase 3 – Subgrade Soil Conditions/Improvements, Construction Considerations and Roadway Embankment Soft Ground Encroachment Areas in Orono, MN

Dear Ms. Boos/Mr. Bruer:

We have completed the laboratory testing and geotechnical analysis for the above referenced project. Our report includes a geotechnical review and recommendations associated with roadway reconstruction, pond infiltration rates, construction considerations including groundwater control and vibrations, and roadway embankment encroachment into wetland areas along the proposed CSAH 112 Phase 3 roadway alignment. If you have any questions concerning this report, please do not hesitate to contact us.

Respectfully,

GALE-TEC ENGINEERING, INC.

Nathan M. Lichty, P.E.
Project Engineer

Stephan M. Gale, P.E.
Principal Engineer

CC: Ms. Sherry VanDuyn, P.E.
Landmark Environmental, LLC.
2042 W. 98th St.
Bloomington, MN 55431

I hearby certify that this plan, specification, calculation or report was prepared by me or under my direct supervision and that I am a Registered Professional Engineer under Minnesota Statute, Sections 326.02 to 326.15

Nathan M. Lichty

Date: 11/12/2018 Reg. No. 51331

NML/SMG REPORT/ Landmark, Hennepin County CSAH 112, Phase 3, Orono, MN

GEOTECHNICAL ENGINEERING REPORT FOR CSAH 112 – PHASE 3 SUBGRADE SOIL CONDITIONS/IMPROVEMENTS, CONSTRUCTION CONSIDERATIONS AND ROADWAY EMBANKMENT WETLAND ENCROACHMENT AREAS IN LONG LAKE & ORONO, MN

1.0 INTRODUCTION

The Phase 3 portion of the Hennpein County CSAH 112 project is proposed to extend from Willow Dr. to CSAH 6. The project is currently in the prelimary design phase with construction planned for the 2020 construction season. The County has indicated that reconstruction plans will include: pavement reconstruction, utility replacement, stormwater pond expansion, Willow Dr. and Old Crystal Bay Road intersection reconstruction and inclusion of a new bike trail along the alignment. We understand that the County is not proposing a change in the pavement grade or in roadway alignment. Inclusion of a new bike trail will require roadway embankment widening of approximately 15ft.

Roadway embankment widening will encroach into two (2) wetland areas approximately between Stations 806+00 – 810+00 and 784+00 – 792+00. Preliminary Design borings performed in 2012 identified buried deep peat soils beneath the existing roadway embankment in these wetland areas.

We have been requested to 1) perform a subsurface exploration consisting of 14 borings and laboratory testing on pavement subgrade soils and roadway embankment foundation soils, 2) comment on existing pavement and existing uitility trench conditions, 3) provide recommendations for pavement R-value and discuss potential subcuts for subgrade correction, 4) provide an estimate of storm water pond infiltration rate, 5) provide an evaluation of potential ground improvement measures in embankment wetland encroachment areas and 6) comment on construction considerations with respect to groundwater control and vibrations. Our services were performed in substantial conformance with our sub-consultant agreement dated June 19, 2018.

2.0 SUBSURFACE EXPLORATION AND LABORATORY TESTING

The subsurface exploration, performed by Glacial Ridge Drilling under a separate agreement with Landmark, consisted of a series of 14 soil borings performed along the roadway alignment to assess pavement subgrade and roadway embankment foundation conditions. These soil borings were performed to supplement borings that were drilled by GTE as part of a preliminary evaluation along the entirety of the CSAH 112 roadway in 2012. The locations and surface elevations of the 2012 soil borings are given in Table No. 1. The 2012 soil boring logs associated with the Phase 3 project are included in the Appendix.

Table No. 1: Boring Locations from 2012 Subsurface Exploration

Soil Boring	Northing	Easting	Surface Elevation (ft)
B-1	172544.8	440877.4	984.6
B-2	172429	441711.9	983.3
B-3	172432.8	441969.7	990.4
B-4	172389	442470.6	997.7
B-5	172428.6	442673.9	996
B-6	172409.1	443147.5	985.9
B-7	172380.2	443511.8	984.8
B-8	172406.8	444169.4	1005.2
B-9	172347.4	444833.9	1026.1
B-10	172372.9	445071.8	1028
B-11	172328.4	445325.7	1026.6
B-12	172330.8	445662.1	1026.4
B-13	172389.2	446157.8	1025.2
B-14	172353.6	446486.1	1023.2
B-15	172306.4	447002	1015.8
B-16	172370.2	447442.1	1016.2

2.1 Drilling

Drilling along the roadway alignment occurred on August 28 and 29, 2018. A piezometer was installed along Kelley Parkway, adjacent to an existing stormwater pond. The 2018 borings were drilled to supplement the soil borings drilled during the 2012 preliminary design phase. Boring locations were selected by Landmark and Hennepin County to also support the Phase 2 environmental site assessment. Borings were staked in the field by Gale-Tec Engineering, Inc. (GTE). Prior to drilling, Gopher State One Call was contacted to check for underground utilities. Borings were drilled with a truck mounted CME 75 rig. All borings were drilled through the pavement section with ten (10) borings drilled to depths of 12ft and the three (3) borings adjacent to wetlands drilled to a depth of 40ft. The boring in which the piezometer was installed was drilled to a depth of 30ft.

Boring locations and surface elevations have not been obtained at this time, the approximate location of each borings is shown on the boring location diagram, which is included in the Appendix.

Soil samples were collected using the split-spoon (SS) sampling procedure at continuous intervals to a depth of 12ft to facilitate environmental sampling. Samples were collected at 5ft intervals when borings extended beyond a depth of 12ft. In the SS method, the number of blows required to drive the split-spoon sampler into the ground in 6-inch increments is recorded. The sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. SS soil samples were placed in glass jars and returned to us for further classification. The depths at which water was encountered was recorded during drilling operations and the borings were then backfilled. The boreholes drilled to a depth of 12ft were backfilled with soil, while borings that extended to a depth

of 30-40ft were backfilled with grout, according to Minnesota Department of Health standards.

2.2 Laboratory Testing

Calibrated penetrometer (Q_p) tests were performed on clay and peat samples. The calibrated penetrometer is a spring calibrated probe that is used to estimate the unconfined compressive strength of clay-type soil and is reported in tons per square foot (tsf). Moisture content (w/c), density, organic content (o/c) and percent passing the U.S. No. 200 Sieve (P200) testing was also performed. Environmental laboratory testing, performed by Landmark, included using a photoionization detector (PID) to detect Volitale Organic Compounds (VOCs). All geotechnical laboratory test results and PID results are shown on the boring logs, which are included in the Appendix.

Additionally, a single-load laboratory consolidation test was performed on a sample of peat taken from Shelby Tube Sample TW#3 taken at a depth of 32 – 34ft. In a single load laboratory consolidation test, a constant load is applied to the soil specimen for an extended period of time and the specimen deformation is periodically recorded in an effort to obtain the secondary consolidation properties of the peat soil. The load applied is approximately equal vertical effective stress acting on the soil from the depth at which the sample was recovered (32ft). The results of the consolidation test indicate the peat soil sampled contained an coefficient of secondary compression (C'_α) of approximately 0.025. This value was used in the settlement analysis, with the results presented in Section 5.0. The results of the single load laboratory consolidation test are included in the Appendix.

3.0 SITE, SOIL, GROUNDWATER CONDITIONS ALONG ROADWAY ALIGNMENT

3.1 Site Conditions

From Willow Dr. to CSAH 6, the limits of the CSAH 112 – Phase 3 reconstruction project, the roadway embankment encroaches into two (2) wetland areas adjacent to Classsen Lake. The wetlands are located approximately between stations 806+00 – 810+00 and 784+00 – 792+00. Between stations 806+00 – 810+00 the existing roadway embankment is approximately 15ft in height and has approximately 2H:1V embankment side slopes. Between stations 784+00 – 792+00, the existing roadway embankment is approximately 6-8ft in height and has 2H:1V side slopes on the south side of the embankment and 4H:1V side slopes on the north side of the embankment.

A storm water pond is present on the north side of the existing roadway embankment approximately between stations 841+00 – 849+00. We understand that the County is proposing to increase the size of this wet pond as part of this project.

Outside of the wetland areas the existing Phase 3 roadway embankment is approximately 2-3ft above the surrounding grade.

3.2 Soil Conditions

Existing Pavement Section – All 2018 soil borings (B-72 to B-85), with the exception of boring B-83, were drilled through the existing CSAH 112 pavement section. The borings were drilled through the shoulder of the existing roadway. At the boring locations, approximately 5-6 inches of bituminous pavement was encountered and was underlain by an aggregate base layer that consisted of a well graded silty sand with gravel possibly meeting the requirements of a MnDOT Class 5. At boring locations along the western portion of the roadway alignment (B-72 to B-75) and eastern portion of the alignment (B-82 to B-85) a granular subbase layer, which could possibly meet the requirements of a Select Granular Borrow material was encountered. The pavement section at each boring location is identified in Table No. 3.

Table No. 3: Pavement Shoulder Section Thickness at Boring Locations

Soil Boring	Bituminous Wearing Course Thickness*(in)	Aggregate Base Coarse Thickness*(in)	Granular Subbase Course Thickness*(ft)	Approx. Station
B-72	5 inches	7 inches	2½ ft	-
B-73	5 inches	6 inches	2½ ft	-
B-74	5 inches	7 inches	2 ft	786+00
B-75	5 inches	9 inches	3 ft	788+00
B-76	5 inches	9 inches	none	791+00
B-77	3 inches	1 inch	none	794+00
B-78	4 inches	9 inches	none	808+00
B-79	4 inches	9 inches	none	819+00
B-80	5 inches	14 inches	none	829+00
B-81	5 inches	14 inches	none	833+00
B-82	15 inches	4 inches	½ ft	838+00
B-83**	N/A	N/A	N/A	-
B-84	6 inches	2 inches	1½ ft	848+50
B-85	10 inches	9 inches	2 ft	855+00

*As measured by the Glacial Ridge Driller
**Pond boring

At several 2012 soil boring locations, (B-2, B-10 and B-14), an 8-10 inch concrete pavement section was encountered beneath the bituminous wearing course. These borings were drilled through the driving lane or near the centerline of existing CSAH 112 – Phase 3 within the Classen Lake wetland area, west of the Old Crystal Bay Road intersection and just west of the Industrial Blvd intersection, respectively. Concrete pavement was not encountered at any boring locations drilled as part of the 2018 investigation; though these borings were drilled through the road shoulder.

Roadway Embankment Fill – All soil borings, with the exception of B-83, were drilled through the existing CSAH 112 – Phase 3 roadway embankment. Beneath the pavement

section, embankment fill soils generally consists of a soft to stiff silty clay to sandy clay soil.

Where the existing roadway embankment was constructed through the wetland area approximately between stations 784+00 – 792+00, the borings identify that the 5-8ft tall roadway embankment consists of soft to medium stiff silty to sandy clay soil. These soils had a moisture content of 18.4% at B-76 and a penetrometer estimated unconfined compressive strength ranging from 0.1 to 0.5 tsf.

Where the existing roadway embankment extends through the wetland area approximately between stations 806+00 – 810+00, the approximately 15ft tall roadway embankment consists of a stiff to very stiff silty clay soil. These soils had a moisture content of 20.8%, and a penetrometer estimated unconfined compressive strength of 0.5 to 3.0 tsf.

Native Soils – The borings identify that the native soils along the CSAH 112 – Phase 3 alignment, outside of the Classen Lake wetland areas, generally consists of a very soft to medium stiff clayey silt to silty clay on the eastern portion of the CSAH 112 – Phase 3 roadway alignment and a stiff to very stiff silty clay on the western portion of the CSAH 112 – Phase 3 roadway alignment. The clayey silt soil along the eastern portion of the CSAH 112 – Phase 3 roadway alignment, specifically at soil boring locations B-79, B-80, B-81, B-82, B-84 and B-85, had moisture contents ranging from 17.2 – 23.6%. The stiff silty clay soils were encountered along the western portion of the CSAH 112 roadway alignment, specifically at soil boring locations B-72, B-73, B-77 and B-78. At B-77 the stiff silty clay had a moisture content of 20.8%.

At some locations along the central portion of the alignment, specifically soil borings B-79 to B-81, a layer of loose, saturated silty sand was encountered at a depth of 5-7ft below the ground surface.

Swamp Deposited Soils – Soil borings B-74, B-75 and B-76 were drilled through the existing roadway embankment through the wetland area approximately between stations 784+00 – 792+00. As part of the preliminary CSAH 112 subsurface investigation, 2012 soil boring B-2 was also drilled through this wetland area. The results of the these borings indicate that swamp-deposited amorphous (decomposed) peat soils extend to a depth of 16 – 37ft beneath the crest of the existing roadway embankment. The peat layer thickness varies from between 5-7ft at B-76 and B-77 to 16ft at B-2. At all boring locations, the peat soils appear to have been "trapped" beneath replacement fill soils that had been placed as part of a partial muck out when the original roadway embankment was constructed. The peat soil samples recovered beneath the roadway embankment fill had been consolidated under the weight of the embankment. The consolidated amorpous peat soils had a moisture content of 93.7 to 141.5% and an organic content of 14.6 – 22.6% and a penetrometer estimated unconfined compressive strength of 0.5 – 1.0 tsf. We did not drill at locations outside of the embankment in the wetland areas, but we estimate that unconsolidated peat soils extend to a depth of 30 – 35ft below swamp grade.

The borings indicate that the replacement embankment soils, placed during the roadway embankment construction within the wetland area approximately between stations 784+00 – 792+00, consist of a soft to medium stiff silty clay soil. This soft clay fill material extended to a depth ranging from 13ft to 32ft beneath embankment grade, at the soil boring locations. This soft material contained a moisture content ranging from 18.4 – 24.5%, a dry density fo 100.4 pcf and an estimate dunconfined compressive strength of 0.3 – 1.3 tsf.

3.3 Groundwater Conditions

Groundwater was encountered at several soil borings at various locations along the CSAH 112, Phase 3 alignment. At soil borings B-73 and B-74 drilled along the western portion of the alignment, groundwater was encountered in granular soil layers at depths ranging from 7-11ft below the ground surface.

At soil borings B-75 and B-76, drilled within the 784+00 to 792+00 wetland area, groundwater was not encountered during and post drilling operations.

At soil borings B-79, B-80 and B-81, drilled along the central portion of the alignment, groundwater was encountered in relatively thin granular soil layer present at depths of 7-9ft below the existing roadway grade.

At soil borings B-85, drilled along the western portion of the alignment, groundwater was encountered in relatively thin granular soil layer present at a depth of 8ft below the ground surface.

At soil boring B-83, drilled through Kelley Parkway, located on the north side of the existing stormwater pond between stations 841+00 – 849+00, a piezometer was installed at a depth of 30ft to measure long term groundwater levels in this area.

In general, soil borings drilled along the alignment indicated that groundwater was encountered within relatively thin granular soil layers located above and below cohesive soil layers. Based on these observations, we estimate that this groundwater represents perched groundwater seams. In the clay and organic type soils that exist on this site, a relatively long period of time is required for the groundwater table to attain an equilibrium position within the borehole. In order to obtain a depiction of the water table in clay and peat soils, open-pipe piezometers should be installed and monitored over a period of months. In any event, the water table in the area of the borings should be expected to fluctuate depending on precipitation, runoff and various other reasons.

4.0 GEOTECHNICAL RECOMMENDATIONS FOR ROADWAY ALIGNMENT NOT INCLUDING WETLAND ENCROACHMENT AREAS

4.1 Existing Pavement Section

Concrete pavement was encountered beneath the bituminous wearing course at 2012 boring locations drilled within the driving lanes/centerline of the roadway. Soil borings

drilled as part of the 2018 investigation were drilled through the pavement shoulders and did not encounter concrete pavement. Further coring/borings through the roadway driving lanes could be performed further to define the limits of the underlying concrete pavement.

Pavement reconstruction will likely include removing/recycling the existing bituminous and concrete pavement and aggregate base section. If the roadway is widened without removing the existing pavement and aggregate base and a differential pavement section is created, then cracking and uneven pavement can result due to differential frost heave. The granular subbase layer, generally encountered along the western and eastern portions of the alignment (see Table No. 2), would not need to be removed and replaced.

4.2 Subgrade Improvement and R-value

Along the eastern portion of the Phase 3 roadway alignment, the borings identified the native soils beneath the aggregate base/granular base consist of a soft to medium firm clay (represented by an unconfined compressive strength of 0.3 to 1.0 tsf) while the native soils beneath the aggregate base/granular base for the westerm portion of the alignment consists of a stiff to very stiff clay (represented by an unconfined compressive strength of 1.0 to 2.0 tsf).

According to MnDOT Materials and Road Research frost depth testing, frost penetration depths are generally in the range of 4ft in Southern Minnesota and silty clay soils are frost susceptible and susceptible to thaw settlement. The silty clay soils are also susceptible to loss of strength with the introduction of water and/or traffic from construction equipment. Disturbance of the clays from either of these two (2) events or other influences could cause them to loose strength and provide poor support for backfill.

In general, the same subcut depth, geotextile, granular base and drainage used for the Phase 1 and Phase 2 portions of the CSAH 112 project are recommended. This includes subcutting pavement areas a minimum of 2 ft where soft clays occur, placing a MnDOT Specification 3733 – Type VI geotextile and backfilling with a MnDOT 3149 Select Granular material before placing the pavement aggregate section. Based on the silty clay soils encountered, we recommend that the pavement be designed for a Hveem Stabilometer Value (R-Value) of 10. An R-Value of 40 can be used where a granular subbase layer of at least 2 ft already exists such as along the western portion of the alignment or at least 2ft of new granular subbase is placed.

A Select Granular Borrow section beneath the pavement should be provided with a means of subsurface drainage to prevent water buildup in the pavement section and subgrade. This can be in the form of drains which drain into storm water systems, or outlet into ditches. Where sand base course layers include sufficient sloping, and water can migrate to lower areas, drains can be limited to finger drains at the catch basins. Perimeter edge drains can also aid in intercepting water which may infiltrate below the pavement.

We recommend using a MnDOT Specification 3733 Type VI geotextile to help provide separation and potentially reinforcement between the Select Granular Borrow and the subgrade. We suggest this be considered for the entire alignment because of the variability of the clay soil subgrade. The Type VI, as opposed to a Type V, is recommended for it's higher strength and so that drainage through the geotextile (or permittivity) can occur. The Type VI geotextile should have the following properties.

Test Description (units)	Test Method	Minimum Test Value[1]
Wide-Width Tensile Strength (pounds/inch) Machine direction	ASTM D-4595	100 minimum at 5% elongation
Wide-width Tensile Strength (pounds/inch) Machine Direction	ASTM D-4595	300 minimum at ultimate
Wide-Width Tensile Strength (pounds/inch) Cross direction	ASTM D-4595	300 minimum at ultimate
Permittivity (gallons/minutes/foot^2)	ASTM D-4491 8 CM TO 2 CM Falling Head Test Method	40 minimum

[1]Minimum Average Roll Value

The geotextile should be installed full-width beneath the new pavement section. Although MnDOT Specification 3733 requires that geotextile panels be sewn together, adjacent panels could be overlapped a minimum of 1 foot to provide full coverage or attached with a MnDOT approved adhesive such as 3M Holdfast 70.

4.3 Stormwater Infiltration Rate at Station 840+00 to 849+00 Stormwater Pond

We understand that the County has proposed enlarging the existing stormwater pond that is present on the north side of the alignment approximately between stations 841+00 – 849+00. Soil conditions along this portion of the CSAH 112 Phase 3 alignment generally consist of silty clay to sandy clay soils. The Minnesota Pollution Control Agency Stormwater Manual identifies that clay soils with the Unified Soil Classification sympol of CL fall within the hydrologic soil group "D". This soil is reported in the manual to have an infiltration rate of approximately 0.06 inches per hour. Our review of the soil samples recovered from the soil borings indicate that the CL clay likely underlies the stormwater pond. We estimate that the soil infiltration rate will likely be in the range of 0.03 – 0.06 inches per hour.

Along the western and eastern portions of the CSAH 112 Phase 3 alignment, specifically at soil boring locations B-73, B-79, B-80, B-81 and B-85, a 2-3ft thick layer of silty sand soils were encountered within 5-10ft of the ground surface. These soil layers contained perched groundwater, however, the layers do not appear to be continuous, and so infiltration should be assumed to be represented by the clay soils.

4.4 General Construction Considerations

Groundwater Management during Construction – The results of the 2012 and 2018 subsurface explorations indicate that at various locations along the CSAH 112 – Phase 3 alignment perched groundwater is located within granular soil seams within 5-9ft of the ground surface. Excavations to replace existing utilities or culvert installation could encounter these perched groundwater seams. Surface runoff is also likely to pond in excavated areas due to the relatively impermeable nature of the native clay soils.

The base of all excavations should be free of water and loose soil prior to backfilling. If perched groundwater or runoff water is encountered during construction, this water should be removed, likely using sump pumps. Any resulting loose or softened soils should also be removed and replaced.

Precondition Surveys & Vibration Monitoring – A portion of the CSAH 112 – Phase 3 roadway alignment, specifically from Willow Dr. to Old Crystal Bay Rd, extends through an urban area which includes commercial and industrial structures located near the roadway. The on-site soils may transmit vibrations emitted from vibratory rollers and other construction equipment and there may be occurrences where vibrations can cause structural or cosmetic damage. Precondition surveys of these structures prior to construction and vibration monitoring near these structures is recommended. We recommend a peak particle velocity of 0.2 inches/sec be considered a maximum threshold for vibrations. If this threshold is being exceeded, then alternate construction processes may need to be implemented, such as using compaction equipment without vibratory effects.

5.0 GEOTECHNICAL RECOMMENDATIONS FOR WETLAND ENCROACHMENT AREAS

Station 784+00 to 792+00 – Soil borings (B-2 and B-74, B-75 and B-76) performed through the existing CSAH 112 – Phase 3 roadway embankment through the wetland area at approximately stations 784+00 to 792+00 indicate that a muck out or other similar ground improvement methods were likely attempted during the initial construction of CSAH 112 (formally T.H. 12). The soil borings indicate that the original extent of the peat soils was likely approximately 10-32ft below the original swamp grade. We estimate peat soils extend to this depth outside of the existing roadway embankment footprint. Broings identify that backfill soils placed within the embankment footprint during the original muck out generally consisted of a soft to medium stiff silty clay soil, implying that the soil was placed with a relatively high moisture content and with little compactive effort. At three of the four boring locations (B-2, B-75, B-76) within this wetland area there was approximately 3-15ft of amorphous peat soils remaining beneath the replacement fill soil. This indicates that either the total muck out was not successful or that only a partial muck out was planned and then implemented. These peat soils beneath the embankment have been consolidated due to the additional weight of the replacement fill soils and the roadway embankment. Though consolidated, these organic soils would

be susceptible to additional compression/settlement with increased loading. The peat outside the embankment remains unconsolidated and is likely very soft.

Station 806+00 to 810+00 – Soil borings (B-6 and B-77) performed through the existing CSAH 112 roadway embankment through the eastern Classen Lake wetland area at approximately stations 806+00 – 810+00 indicate approximately 5ft of peat and swamp deposited clay soils exist beneath the existing roadway embankment, extends approximately 8-15ft above the surrounding swamp grade.

Summary – Ground improvement measures could be employed to facilitate widening the roadway embankment out into the wetland areas between Stations 784+00 – 792+00 and between Stations 806+00 – 810+00 including: 1) removing and replacing the peat soils outside the existing embankment while leaving the peat in place beneath the existing embankment and 2) widening the embankment over the peat with a high strength geotextile, stage loading and surcharging.

A third alternative could be to construct a the widened roadway embankment sideslope as a Reinforced Soil Slope (RSS), with a slope face angle of 45 to 70 degrees, to maintain the new embankment slope toe within the footprint of the existing embankment, so as not to build over the soft, unconsolidated peat outside the existing embankment.

Considering the existing roadway embankment geometry, fill placement over the undisturbed swamp deposited soils in the wetland area could be avoided by keeping the widened roadway embankment within the existing embankment footprint. A portion of the soft peat and clay soils beneath the existing roadway embankment within the wetland area between stations 784+00 – 792+00 appear to have been removed during initial embankment construction. Placement of a height of 5-8ft of additional fill on the existing embankment side slope may be feasible. This could be accomplished by constructing a geogrid reinforced soil slope (RSS) with a slope face of 45 to 70 degrees at the shoulder PI of the widened roadway embankment.

5.1 Trail Widening to Include RSS within Existing Embankment Footprint - Approximate Stations 784+00 – 792+00

Within this area, the existing roadway embankment is approximately 5-8ft in height and contains an approximately 4H:1V side slope to the north, where the bike trail is likely to be placed. We estimate the peat depth to be between 15-35ft in the undisturbed wetland area adjacent to the existing roadway embankment. We estimate that the new trail section will require the roadway embankment crest to be widened approximately 10-15ft out toward the wetland. A conventional removal and replacement of the up to 35ft of soft swamp deposited soils within the wetland area would affect a significant portion of the wetland and would not likely be feasible. The likely result of a removal and replacement attempt would result in some trapped peat soils remaining beneath the replacement fill, similar to what exists beneath the existing roadway embankment. The trapped peat soils would then compress under the increased weight of the replacement fill, likely resulting in embankment settlement and poor roadway embankment performance. Dewatering of

the existing wetland and a sheetpile wall along Classen Lake, similar to what was done for the CSAH 112 – Phase 1 widening into Long Lake, could be required.

Given the existing embankment geometry and relatively small roadway embankment crest widening required to facilitate bike trail installation, a reinforced soil slope (RSS) could be constructed to keep the widened roadway embankment crest within the footprint of the existing embankment and thus reduce wetland disturbance in this area. We estimate a 5-8ft tall RSS would be required along approximately 800ft of roadway between stations 784+00 – 792+00. A CIP Concrete cantilever retaining wall, a panel faced MSE wall or a gravity precast modular block wall could also be considered, though these structures would need to be supported on piles, due to the presence of the buried peat soils beneath the existing roadway embankment and their settlement potential. As opposed to a concrete faced grade separation structure, an RSS could likely tolerate this settlement, if designed appropriately. The results of a settlement analysis, presented in the following section, indicate that 1-3 inches of settlement could occur. An RSS is a flexible structure that would be able to tolerate these amounts of settlement without adverse effects.

Based on the existing geometry and soil conditions within this wetland area, we believe that a cost effective grade separation structure could be a 1H:2.75V (70°) geogrid RSS. MnDOT has a standard template for a 70° (1H:2.75V) RSS, however, this Template can not be used for this project due to the underlying soft soils that would be present beneath the RSS and the potential for a "sloping toe" at the RSS base. An actual design prepared by us, similar to that used for CSAH 112 – Phase 1 adjacent to Long Lake would be required. RSSs consist of Select Granular backfill and multiple layers of geogrid reinforcement, typically installed at 2-3ft vertical increments at horizontal lengths typically equal to 80 – 120% of the RSS height. Depending on the proposed trail width, this horizontal geogrid length could likely be installed without disrupting the existing roadway embankment. The face of a 1H:2.75V RSS is formed using a tiered face, which typically consists of a series of vertical elements, successively stacked at a given horizontal offset to form tiers. The vertical elements typically consist of geocells or geotextile mesh/turf reinforcement mat wrap within galvanized metal wire basket forms. Vegetation establishment along the horizontal tiers is important to reduce slope face erosion potential over the long term. Photos of several 1H:2.75V RSS used for Minnesota County highway projects are shown in Figures Nos. 1 and 2.

Figure No. 1: 1H:2.75V RSS, Facing Constructed using
Geotextile Wrap and Wire Baskets



Figure No. 2: 1H:2.75V RSS,
Facing Constructed using Geocells



To assess the feasibility of an RSS within the wetland area between stations 784+00 – 792+00, a slope stability and settlement analysis was performed. For this analysis we developed a preliminary cross section with an existing embankment and RSS height of approximately 7ft and a proposed trail width of 12ft. The existing embankment side slope is approximately 4H:1V.

The soil profile used for these analyses was developed based on the results of the subsurface exploration, specifically soil boring B-76. The soil profile at B-76 consists of approximately 27ft of clay replacement fill placed for the existing roadway embankment. Beneath the clay replacement fill an approximately 7ft thick layer of consolidated amorphous peat was present. Outside of the existing roadway embankment footprint the soil profile was assumed to consist of a 35ft thick layer of unconsolidated peat soil layer.

Stability Analysis – The stability analysis was performed using the computer program Slope-W by Geostudios, Inc. The procedure selected employs Spencer's method of slices to evaluate slope stability using limit equilibrium. A minimum acceptable short-term (undrained condition) factor of safety of 1.3 and long-term (drained condition) factor of safety of 1.5 is considered acceptable, per FHWA NHI-10-024, the Federal Highway Administration's RSS design manuals.

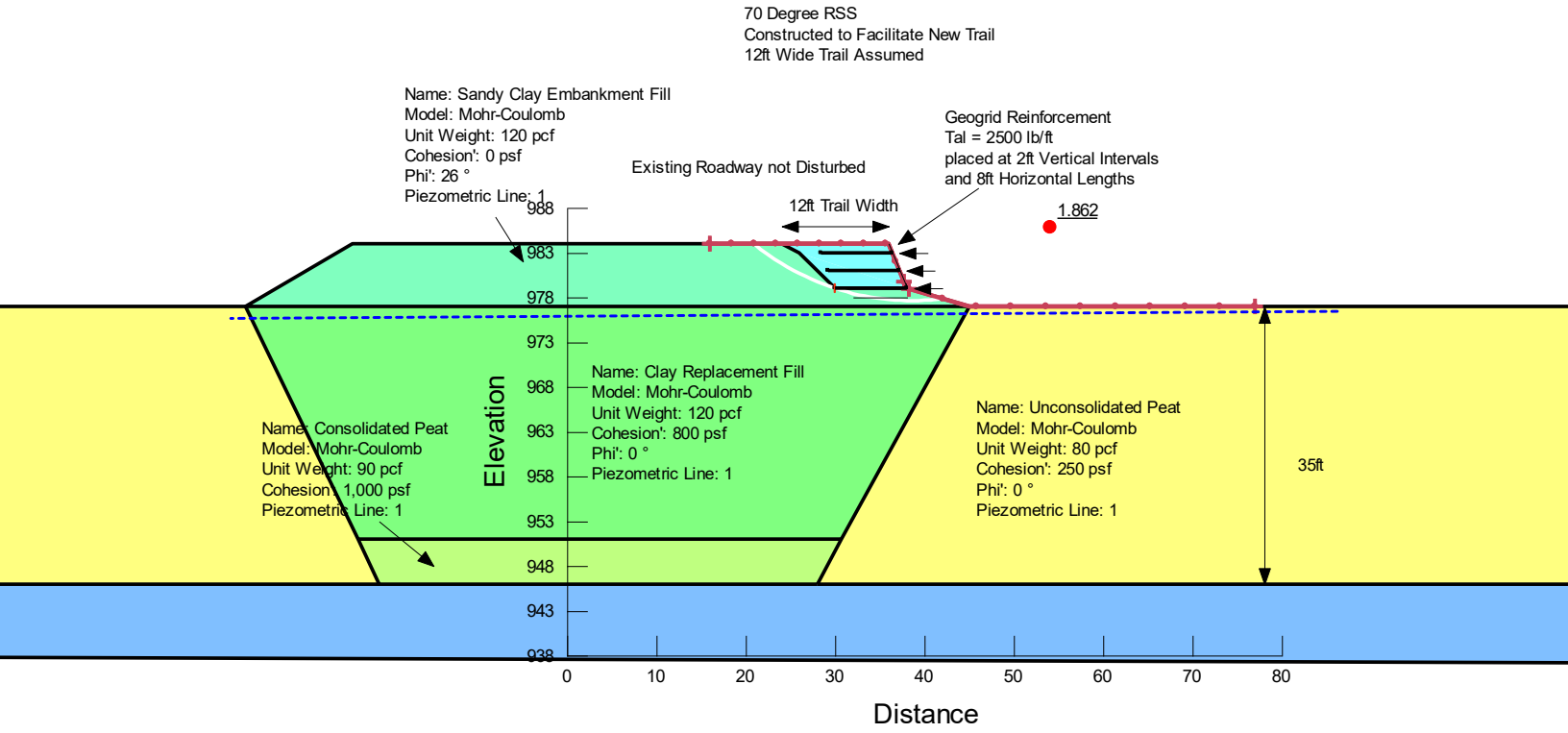
The soil strength parameters used in the settlement analysis are given in Table No. 4. The soil strength parameters are based on the results of the subsurface exploration, as well as our experience.

Table No. 4: Preliminary Design Parameters

Material	Soil Density (pcf)	Undrained Cohesion (psf)	Undrained Friction Angle (deg)	Drained Friction Angle (deg)
Embankment Fill	120	0	26	26
RSS Reinforced Fill	125	-	35	35
Consolidated Peat	90	800	-	16
Unconsolidated Peat	80	250	-	10
Soft Clay Replacement Fill	120	800	-	26

The results of the stability analysis for the 1H:2.75V RSS are shown in Figure No. 3.

Figure No. 3: Global Stability Analysis of Preliminary Cross Section considering a 1H:2.75V RSS within the wetland area between stations 784+00 – 792+00



The results of the analysis indicate that an adequate factor of safety against embankment side slope instability can be obtained assuming the following:

- The RSS is kept within the footprint of the existing roadway embankment
- The RSS is embedded at least 2ft into the existing embankment side slope
- Geogrid reinforcement with a Tal = 2500 lb/ft, placed at a horizonztal length of at least 1.0H (including embedment depth) with a minimum of 8ft and is placed at 2ft vertical intervals

Settlement Analysis – The computer program Sigma-W by Geostudios, Inc. was used to model the magnitude and time rate of settlement of a typical embankment section within the wetland area between stations 784+00 – 792+00. In the Sigma-W computer program, a soil profile is developed and then individual soil layers are split into discrete elements that interact with each other as an external stress is applied. This method of analysis, often refered to as "finite element" analysis, determines the physical changes such as horizontal and vertical displacement, strain, and excess pore water presure development in each individual element and then totals the changes in the elements to estimate an entire soil layer's response to an externally applied stress. The results of this analysis allow for the soil layers physical changes, i.e. settlement, excess pore water pressure development/dissipation, stress increase, to be determined for the entire cross section used for the model.

Sigma-W allows different soil types to be represented by different compressibility models. Granular soils, such as the existing roadway embankment fill, were represented with a linear-elastic model, while cohesive soils, such as the peat and clay replacement fill, were represented using the Modified Cam Clay (MCC) model.

In the linear elastic model, the compressibility of the soil layer is represented by its elastic modulus (E) and by its Poisson's ratio (μ.) The amount of settlement that occurs in the soil layer is determined by elasticity theory. An elastic modulus of 125,000 lbs/ft^2 (psf) and a Poisson's ratio of 0.33 were used to represent the stiffness of the existing clayey sand embankment fill. An elastic modulus of 800,000 psf and a Poisson's ratio of 0.33 were used to represent the stiffness of the RSS granular reinforced fill.

In the Modified Cam Clay model, the consolidation settlement that occurs in a soft cohesive soil is modeled similar to conventional consolidation theory, but using critical state soil mechanics. The consolidation settlement curve is represented on a natural log scale instead of log base 10 scale. Thus, the conventional consolidation settlement parameters calculated from a laboratory consolidation test, the compression index (Cc) and the recompression index (Cr), have to be revised to obtain values that represent consolidation settlement on a natural log scale. These values are refered to as lamda (λ), which correlates to compression index Cc and kappa (κ) which correlates to the recompression index Cr.

For this analysis, the settlement parameters associated with the peat and clay soil were estimated based on the laboratory indexing testing results and our experience with similar amorphous peat and clay soils on past projects.

Similar to the granular soils, a single value was used to represent the peat and clay soil layers. Table No. 5 includes the consolidation settlement values used to represent each soil layer.

Table No. 5 – Consolidation Settlement Values

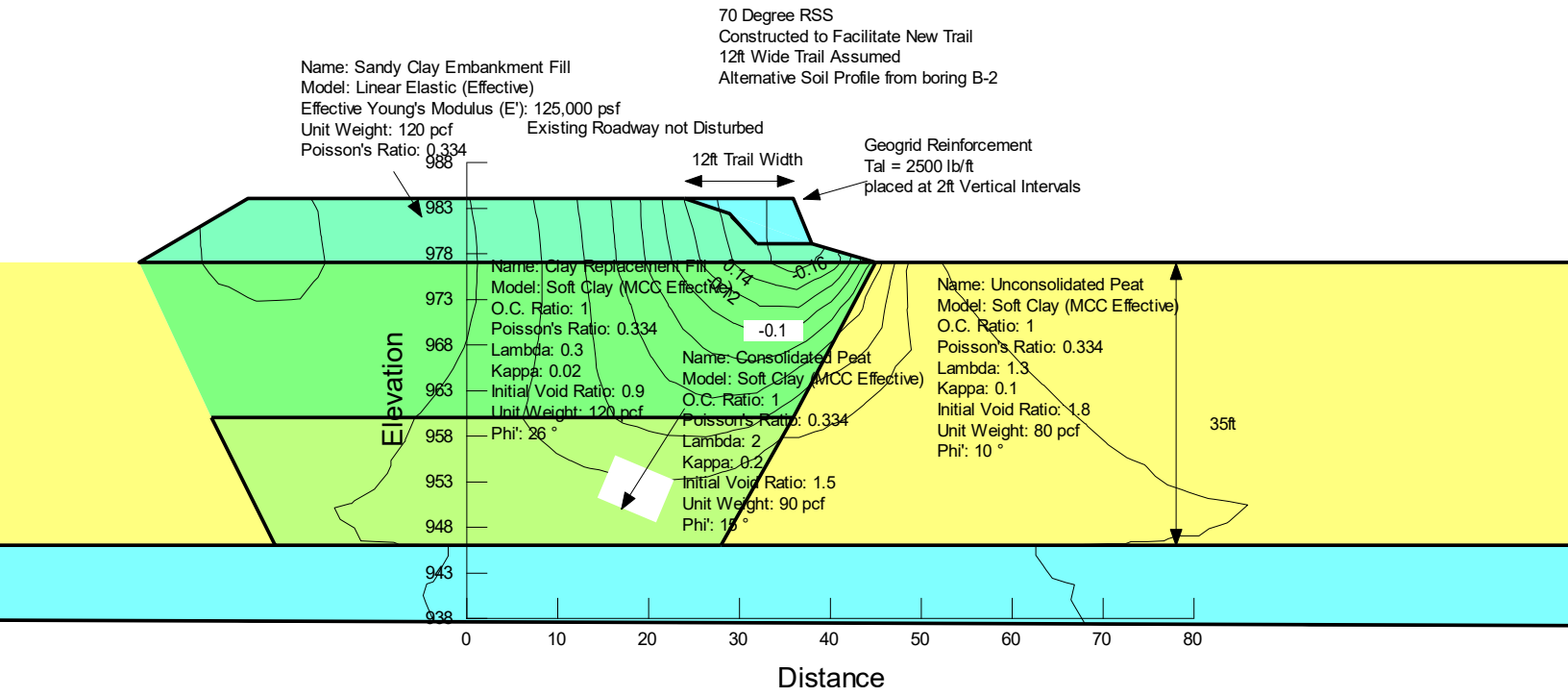
Soil Layer	Density (pcf)	Initial Void Ratio	Recompression Line Slope (κ)	Compression Line Slope (λ)
Unconsolidated Peat	130	1.8	0.02	2.0
Consolidated Peat	90	1.5	0.02	2.0
Clay Replacement Fill	120	0.90	0.02	0.3

The peat and clay replacement fill soils were assumed to be in a normally consolidated state, thus any additional stress placed on the soils was assumed to induce consolidation settlement along the compression line slope. This would be a conservative assumption for the clay replacement fill soil.

Secondary compression settlement can occur in peat and organic soils as organic soil particles decompose and reorganize themselves over an extended period of time. In certain types of peat soils, significant (e.g. several inches to feet) of secondary compression settlement can occur over the long term.

The results of the primary consolidation settlement analysis indicate that approximately 2 inches (0.16 ft) of settlement could be expected to occur beneath the RSS embankment toe during or shortly after construction. The results of this analysis are illustrated in Figure No. 4.

Figure No. 4: Results of Settlement Analysis performed at Preliminary Cross Section within Wetland Area between Station 784+00 – 792+00



For the secondary compression settlement analysis, we assumed a coefficient of secondary settlement (C'_α) of 0.025, based on the results of the single-load laboratory consolidation test performed on the peat sample recovered at soil boring B-76A. The results of this analysis indicate that the edge of the existing roadway embankment as well as the proposed widened embankment could be subjected to an additional 1-2 inches of settlement over the long term.

The time rate of primary consolidation of the underlying clay replacement fill and peat was estimated using a representative coefficient of consolidation (Cv) value for the peat and clay replacement fill layer. The estimated coefficient of secondary settlement (C'_α) of the peat soils was used to estimate the secondary settlement that has occurred after primary consolidation settlement completion.

The results of the time rate of settlement analysis indicate that the majority of the primary consolidation settlement in the clay and peat soils is likely to occur within the first 3-6 months post-construction. The remaining settlement is likely to occur over the course of

several years after construction completion. The secondary compression settlement is likely to continue over the long term, with the potential for several inches of differential settlement to occur.

If the RSS within the existing embankment footprint concept is selected as the preferred method of construction, than the following actions are recommended.

- Additional borings and lab testing be performed this winter when the ground is frozen.
- Monitoring of pore pressures and settlement occur with regular review of results by us.
- County accepts the increase risk of settlement and differential settlement over the long term.

5.2 Trail Widening over Virgin Wetland Areas – Stations 784+00 to 792+00 & 806+00 to 810+00

As an alternative to Section 5.1, the trail/roadway widening can be extended out over the virgin soft ground within either or both wetlands areas. From stations 806+00 – 810+00 the existing roadway embankment geometry may not facilitate installation of an RSS within the existing embankment footprint and as such, embankment construction will be required over the soft soil areas. Assuming a 12ft wide trail embankment widening and 3H:1V side slopes, we estimate approximately 15ft-20ft of wetland encroachment between station 784+00 – 792+00 and approximately 50- 60ft of wetland encroachment between stations 806+00 – 810+00.

Where roadway embankments are constructed over peat and soft clay soils, embankment side slope instability during and post construction can be expected but primary consolidation settlement and long term secondary settlement can be expected to occur. Primary consolidation settlement occurs as excess pore water pressure is dissipated from the void spaces present in the peat/soft clay soils when fill is placed over these deposits. In peat type soils, which have a void ratio larger than conventional clay soils, several feet of primary consolidation settlement can occur, depending on the height of the roadway embankment and stress increase induced on the peat soils. In amorphous or decomposed peat and in clay type soils, this type of settlement can take years to occur after embankment construction is completed.

Long term secondary settlement, a phenomenon common in peat and soft organic soils, occurs due the reorganization of soil particles under a constant stress and occurs in addition to primary consolidation settlement. This type of settlement begins toward the end of primary consolidation settlement and continues at a decreasing magnitude over the long term. In some cases, several inches to feet of secondary settlement have been observed in peat and organic soils over the course of many years.

Embankments constructed over soft peat and soft clay soils can be subjected to slope instability, which typically occurs either during embankment construction or shortly after construction completion, but can also occur over the long-term. Embankment instability occurs in the form of either a mudwave extending out into the undisturbed wetland, or a

deep-seated, rotational failure plane extending through the roadway embankment and through the underlying soft soils. Deep seated failure plane development can occur either quickly with the formation of a large head scarp and heaving of the wetland soils near the toe of the slope, or very slowly in a creeping type failure, where the failure plane may move only a small amount over a long period of time.

When widening embankments out over soft ground, several mitigation options exist to reduce the potential for slope instability and reduce the potential for excessive settlement. These options are discussed below:

Option 1 - Removal/Replacement – This option bears a higher degree of reliability and a lower amount of risk with respect to long-term settlement than other options, if constructed properly. The underlying peat and soft clay soils could be excavated from beneath the future embankment footprint and beyond the future embankment toe 1ft for each 1ft of excavation depth and replaced with compacted MnDOT Select Granular Borrow-Modified to 7% passing the U.S. No. 200 sieve, due to the high groundwater table. The excavation should remove the peat and soft clay soils down to a stiff clay base; based on the borings, this depth may be approximately 15ft -35ft from the existing swamp grade at the toe of the existing embankment in wetland areas between Station 784+00 – 792+00 and a depth of approximately 5 – 10ft between 806+00 – 810+00. The width of the excavation and disturbance into the wetlands could be significant as a result of the excavation and would likely require reconstruction of the existing roadway embankment. Dewatering during excavation and fill placement is recommended.

After excavation and replacement is completed it is recommended that a subsurface exploration, consisting of a series of Cone Penetration Tests (CPTs) be performed in the replacement area to confirm that all soft soils were removed during the excavation process. If several feet of soft soil is "trapped" beneath the replaced granular fill, this trapped peat or soft clay would be subjected to primary and secondary consolidation settlement, which could lead to differential settlement and poor roadway embankment and pavement performance; and a contingency option would be to design a surcharge at that time.

Option 2 – Placement of High Strength-High Modulus Geotextile Special, Embankment Construction using Stage Loading and Final Surcharge – Peat and soft clay soils that are filled over in a controlled and stable manner can be expected to gain strength over time as they consolidate. Placement of a high strength geotextile at the base of the embankment can help maintain a desired factor of safety with regard to embankment stability during staged construction, as peat settlement and subsequent strength gain occurs. A reinforcement geotextile used in embankment construction over soft ground typically has a high tensile strength in the machine (roll) direction. It is deployed in panels with its high strength direction placed perpendicular to the centerline of the roadway embankment. Adjacent geotextile panels are sewn together to help maintain a stable separation of the embankment fill and the underlying soils. The high geotextile tensile strength acts to resist the forces that can cause a rotational shear failure of the peat or soft clay. As the embankment settles and the peat/soft clay consolidates, the geotextile stretches, mobilizing its' resisting tensile force. The geosynthetic must also be permeable

in order to allow the transfer of water from the underlying soft soils as the excess pore pressure dissipates with consolidation.

The embankment would need to be constructed using a stage loading technique to avoid over stressing and failing the underlying peat and soft clay layer. Stage loading refers to only placing several feet of embankment fill over the course of several weeks to allow excess pore water pressure dissipation, settlement and strength gain to occur in the underlying soft soils.

For embankments built over peat/soft organic soils, a surcharge would need to be placed over the widened embankment area to decrease long-term potential settlement. We recommend a surcharge of 5ft above final grade. The surcharge would need to be in place for an estimated period of 9 to 12 months. A temporary grade separation structure, such as stacked Jersey barriers or a geotextile burrito wrapped soil slope (RSS) could be installed on the embankment crest to retain the surcharge fill such that the existing CSAH 112 roadway would remain open during the surcharge period.

Option 3 – Wick Drain Placement, Reinforcement Geosynthetic Placement, Staged Fill Placement with Final Surcharge – This option is similar to Option No. 2 with the addition of wick drains installed through the peat/soft clay soils prior to embankment construction. A wick drain, or prefabricated vertical drain, consists of a non-woven geotextile fabric wrapped around a plastic core. The plastic core is ladder-shaped, containing multiple drainage channels for water to exit. The rectangular wick drain is approximately 6 inches wide by about ½ inch thick, and is installed in a continuous ribbon through the entirety of peat/soft clay layer and anchored into firm soils below. We estimate wicks with lengths of approximately 10 – 35ft for the two wetland areas. The wick drains are installed using an excavator with a special mandrel attachment, at predetermined horizontal offsets. Once installed, the wick drains provide a shorter drainage path for water to exit the low-permeability peat or soft clay. This shorter drainage path decreases the time required for settlement to take place.

Our preliminary analysis and experience indicate that if wick drains are installed, in a 4ft triangular pattern to a depth of approximately 35ft through the entire peat layer in the wetland area between stations 784+00 – 792+00 and a depth of 10-15ft through the entire peat and soft clay layer within the wetland area between stations 806+00 – 810+00, then the surcharge period could be reduced to approximately 3 – 4 months, likely making it possible to complete embankment construction in one construction season.

Summary – We recommend you consider removal and replacement (Option 1) within the wetland area between stations 806+00 – 810+00. Within the wetland area between stations 784+00 – 792+00, if an RSS is not a desireable alternative, you could consider geosynthetic reinforcement, staging fill placement with a final surcharge (Option 2). Wick drains (Option 3) could be included if a reduced surcharge time is desired.

5.3 Stability and Settlement Analysis of Surcharged Embankment (Options 2/3)

Stability Analysis – A stability analysis was performed to determine what geotextile strength would be required if a 5ft high surcharge was placed on the widened roadway embankment over the soft soils and still maintain an acceptable factor of safety with respect to embankment stability.

When fill is placed over peat/soft clay soils, failure of those soils could occur during construction. In the event of failure, a rotational shear failure plane would extend through the new fill and into the buried peat/soft clay soils resulting in the formation of a mud wave outside the embankment. This shear movement could also be exhibited more slowly as creep movement of the buried peat occurs which would lead to the formation of a longitudinal crack within the embankment during construction.

Embankment stability with respect to rotational shear failure extending through the widened roadway embankment and out into the undisturbed soft soils was analyzed with the computer modeling program, Slope-W by Geostudios, Inc.,

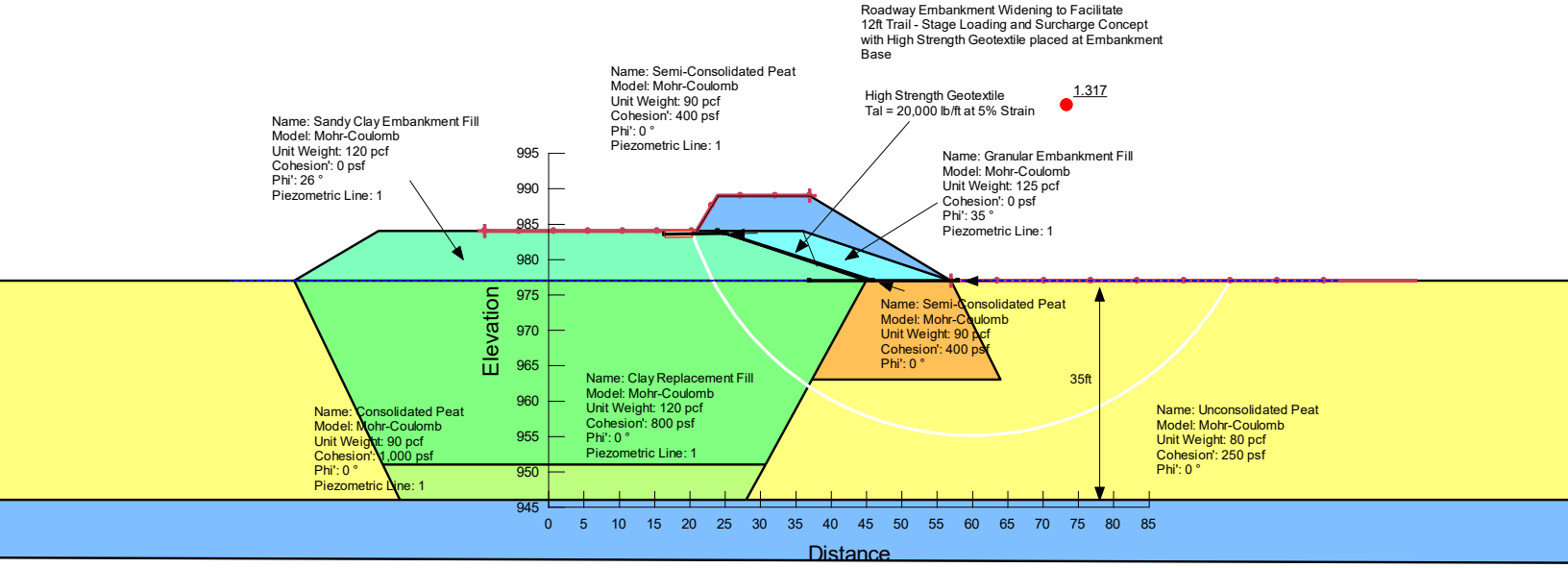
Similar to Section 5.1, we developed a preliminary cross section for this analysis based existing embankment and soil conditions within the wetland area between stations 784+00 – 792+00. The preliminary cross section considers an existing embankment height of approximately 7ft and a proposed trail width of 12ft. The existing embankment side slope is approximately 4H:1V. The widened roadway embankment will extend approximately 10-15ft out over the undisturbed swamp deposited soils. A 7ft roadway embankment height with 4H:1V side slopes was assumed. A 5ft surcharge was assumed over the widened portion of the embankment and ending with a temporary grade separation structure approximately 20ft from the CSAH 112 centerline. This surcharge would temporarily increase the embankment side slopes to approximately 2H:1V.

The soil profile was developed based on the results of the subsurface exploration, specifically soil boring B-76. The soil profile consists of the existing 27ft of soft clay replacement fill placed for the existing roadway embankment. Beneath the clay replacement fill, a 7ft thick layer of consolidated amorphous peat was modeled. Outside of the existing roadway embankment footprint, the soil profile was modeled with a 35ft thick layer of unconsolidated peat soil layer.

The soil strength parameters used for this analysis are as included in Table No. 4 in Section 5.1. The embankment was assumed to be constructed using a stage loading technique which allows for the underlying peat soils to become partially consolidated and susceptible to an increase in density and strength gain. The semi-consolidated peat beneath the widened roadway embankment was assumed to have a density of 90pcf and a undrained shear strength of 400 psf.

The results of the stability analysis are illustrated in Figure No. 5. The results indicate that a high strength, high modulus geotextile (with a T_{al} of 20,000 lbs/ft. at 5% strain) placed at the base of embankment and a stage loading concept to facilitate peat strength gain are required to obtain an acceptable factor of safety of 1.3.

Figure No. 5: Surcharged Embankment Stability Evalutation: High Strength Geotextile placed at base of embankment, Tensile Strength @5% Strain = 20,000 lb/ft



As shown in Figure No. 5, the inclusion of a high strength geotextile with a strength at 5% strain of 20,000 lbs/ft per the ASTM D-4595 tensile strength procedure, placed on the existing embankment grade prior to surcharge placement, results in a factor of safety of 1.3. A factor of safety of 1.3, for the short term or undrained condition, is generally considered acceptable according by the Federal Highway Administration (FHWA) design manual NHI-10-024.

5.4 Recommendations for Option 2: High Strength Geotextile, Staged Loading with Final Surcharge

The following recommendations are provided based on the results of the subsurface exploration, laboratory testing and our analysis and experience with similar projects. These recommendations could be applied along the CSAH 112 wetland areas approximately between stations 784+00 – 792+00 and 806+00 – 810+00, if the Embankment Surcharge method is selected.

5.5 Reinforcement Geotextile Placement, Staged Fill Placement and Final Surcharge

If a surcharge method for settlement mitigation is selected at one or both wetland encroachment locations, we recommend that a high strength reinforcement geotextile be used to increase the short-term factor of safety during the surcharge period. We recommend a specifically designed Geotextile Special product be used. Final geotextile limits and strength requirements should be based on further probes prior to construction in order to determine the lateral extent of the organic soils adjacent to the existing roadway embankment. At this time, we assume reinforcement geotextile limits of

between stations 784+00 – 792+00 and 806+00 – 810+00. These limits should be considered preliminary and should be reviewed and revised prior to construction.

Based on existing information, a Geotextile Special with the following properties could be considered:

- A minimum ultimate tensile strength, (ASTM D-4595), of 41,000 pounds per foot in the machine direction,
- A minimum tensile strength at 5% elongation, (ASTM D-4595) of 20,000 pounds per foot in the machine direction,
- A minimum seam or panel attachment strength, of 1,100 pounds per foot in the cross direction,

All test values should be required to represent the *minimum average roll values*, i.e. the average of the test results of any roll of a lot should meet or exceed the specified average roll value. Prequalification testing and manufacturer's certifications should be required.

In the geotextile deployment areas, the geotextile should be placed with its' machine direction perpendicular to the road centerline and should be keyed into a 3ft anchor trench constructed at the existing embankment slope crest, extend down the embankment side slope and out to 5ft beyond the surcharged embankment toe on the wetland side of the embankment. Fill should be placed on the crest of the existing embankment first, then on the side slopes of the existing embankment. The initial lift of fill should always be placed/pushed perpendicular to the road centerline to tension the high strength geotextile. We recommend a low ground pressure D-3 or equivalent dozer be used to spread the surcharge fill.

As a guideline for all areas, no more than 2ft of fill should be placed during any continuous 14-day period, though longer periods could be required if pore water pressure dissipation, and hence consolidation of the soft soils, is slow. Staged fill placement should allow the soft soils to relieve excess pore water pressure and to gain strength as more fill is placed. Placement of fill over soft soils should be expected to cause settlement to occur with time. Settlement plates should be placed at the base of the surcharge and read weekly during surcharge construction and monthly during the surcharge period are recommended.

Based on our experience with similar projects, we recommend that a 5ft surcharge be placed and left in place for a period of 9 - 12 months to reduce the potential for additional settlement over the long term. This surcharge period could be reduced or increased, depending on the results obtained from the geotechnical monitoring program.

The surcharge (fill placed above the top of pavement elevation) could be constructed with Common Borrow (Select Grading material).

Embankment settlement during construction and under the surcharge weight will occur. We estimate up to 1½ - 2ft of settlement, or possibly more, could occur. Settlement should be expected to occur during fill placement and at a decreasing rate during the surcharge period.

We recommend a construction monitoring program, consisting of settlement plates and vibrating wire piezometers, be implemented to evaluate the time between staged loadings and the length of time the surcharge needs to remain in-place. We would be pleased to prepare a proposal to you for this monitoring. Even with a surcharge, long-term settlement and differential movement should be expected. A maintenance program should be incorporated into any design over peat/soft organic soils.

If buried utility lines, such as gas mains or fiber optic lines are located within or near the toe of the existing embankment, we recommend that these utility lines either be relocated outside the influence of the surcharged roadway embankment or temporarily placed at the swamp grade prior to surcharge placement, as the increased vertical and lateral stresses induced on the swamp soils by surcharge placement may cause distress to these utility lines.

Additionally, any overhead power pole foundations present near the embankment toe at surcharge locations will be subject to additional lateral stresses and potential lateral movement as the surcharge is constructed and the underlying soft soils settle. This lateral movement could cause distress to any overhead power lines or could result in power pole overturning. We recommend that the power company be contacted prior to surcharge placement so that relocation or additional pole bracing could occur. We would be pleased to provide further assistance on utility relocation, if required.

6.0 SUMMARY

If the surcharge embankment option is chosen as a settlement mitigation measure, or if an RSS grade separation structure is chosen to reduce wetland disturbance, we would be pleased to provide you with the following to be inserted within your Plans and Special Provisions for the project:

1) Plans and Special Provisions for the RSS

2) A specification for surcharge construction, including a material and installation specification for the reinforcement geotextile, and an installation specification for staged loading and the final surcharge;

3) An instrumentation plan and installation specification.

There are inherent risks associated with embankment support above peat/swamp desposited soils. These risks must be accepted in exchange for the cost savings that are planned by not using a higher-cost, lower-risk alternative such as excavation/replacement. Some of the risks with geotextile reinforced embankments and with RSSs constructed over soft ground include:

- Failure during construction.
- Extended construction schedule/delays.
- Additional costs for construction modifications such as failure repair, stabilizing berms,
- Long term settlement/differential settlement which could crack or otherwise distress the pavement.

Proper geotechnical monitoring during construction will reduce, but not eliminate, the risk of poor performance. Monitoring during construction can also reveal problems that must be corrected to reduce the possibility of poor performance. Such corrections can involve additional time or expenditures. If the risks outlined herein are unacceptable, the County should consider the total excavation of the peat/soft ogranic soils and replacement with structural fill.

7.0 GENERAL QUALIFICATIONS

This report has been prepared in order to aid in the evaluation of proposed roadway and to assist Hennepin County in the design of this project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects relevant to soil and foundation characteristics. In the event that any changes in the design, as outlined in this report, are planned, we should be informed so that changes can be reviewed and the conclusion of this report modified or approved in writing. As a check, we recommend that we be authorized to review project plans and specifications to confirm that our report recommendations have been interpreted in accordance with our intent. Without this review, we will not be responsible for misinterpretations of our data, or analysis and/or our recommendations nor how these are incorporated into the final design.

The analysis and recommendations are based on the data obtained from soil borings performed at the locations indicated in this report and our experience with similar projects. This report does not reflect any variations which may occur between these borings. In the performance of subsurface explorations, specific information is obtained at specific locations and at specific times. It is a well-known fact that variations in soil conditions occur in most sites between boring locations. The nature and extent of the variation may not become evident until the course of construction. If variations appear during roadway embankment or RSS construction, it will be necessary for a re-evaluation of the recommendations of this report after performing on-site observations during the construction period and noting the characteristics of any variations.

APPENDIX

1. Soil Boring Location Diagram

2. Soil Boring Logs - 2018

3. Soil Boring Logs - 2012

4. General Notes
   Classification of Soils for Engineering Purposes

5. Laboratory Testing Results

1. Soil Boring Location Diagram

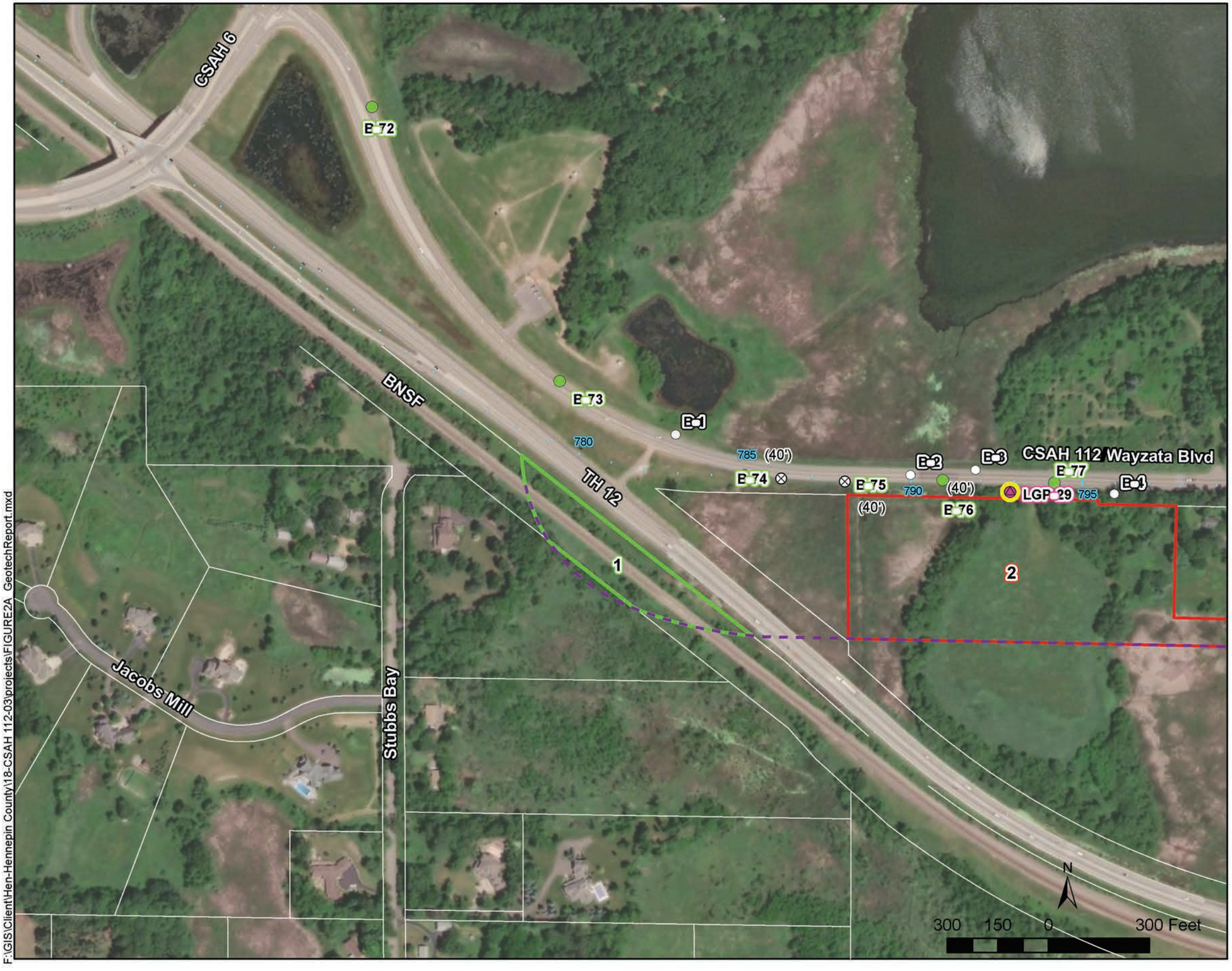


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FIGURE 2A

PROJECT AREA LAYOUT MAP
County State Aid Highway 112
Willow Drive to East of CSAH 6
Long Lake, Minnesota

LANDMARK ENVIRONMENTAL, LLC

LEGEND

- Approximate Project
- Project Area
- Stationing

Sites

- High
- Medium
- Low
- Previous Investigation Boring
- Previous Geotechnical Boring

Proposed Supplemental Phase II Boring

- Soil + Soil Vapor
- Soil + Soil Vapor + Groundwater

Geotechnical Boring

- Field Screen/Possible Soil
- Soil

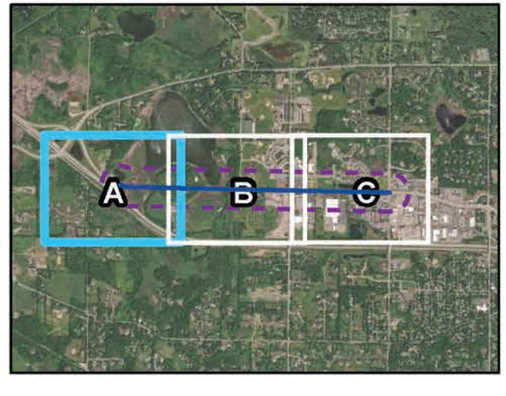




FIGURE 2B

PROJECT AREA LAYOUT MAP
County State Aid Highway 112
Willow Drive to East of CSAH 6
Long Lake, Minnesota

LANDMARK ENVIRONMENTAL, LLC

LEGEND

- Approximate Project
- Project Area
- Stationing

Sites

- High
- Medium
- Low
- Previous Investigation Boring
- Previous Geotechnical Boring

Proposed Supplemental Phase II Boring

- Soil + Soil Vapor
- Soil + Soil Vapor + Groundwater

Geotechnical Boring

- Field Screen/Possible Soil
- Soil

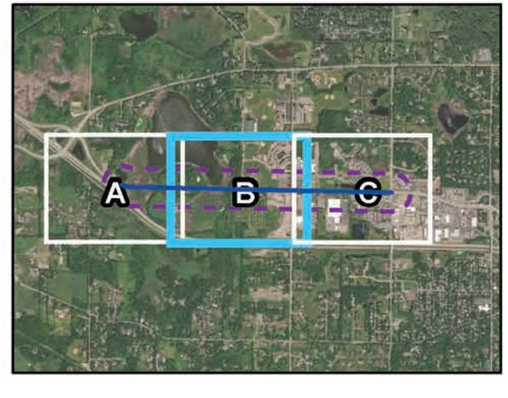


FIGURE 2C

PROJECT AREA LAYOUT MAP
County State Aid Highway 112
Willow Drive to East of CSAH 6
Long Lake, Minnesota

LANDMARK ENVIRONMENTAL, LLC

LEGEND

- Approximate Project
- Project Area
- Stationing

Sites

- High
- Medium
- Low

- Previous Investigation Boring
- Previous Geotechnical Boring

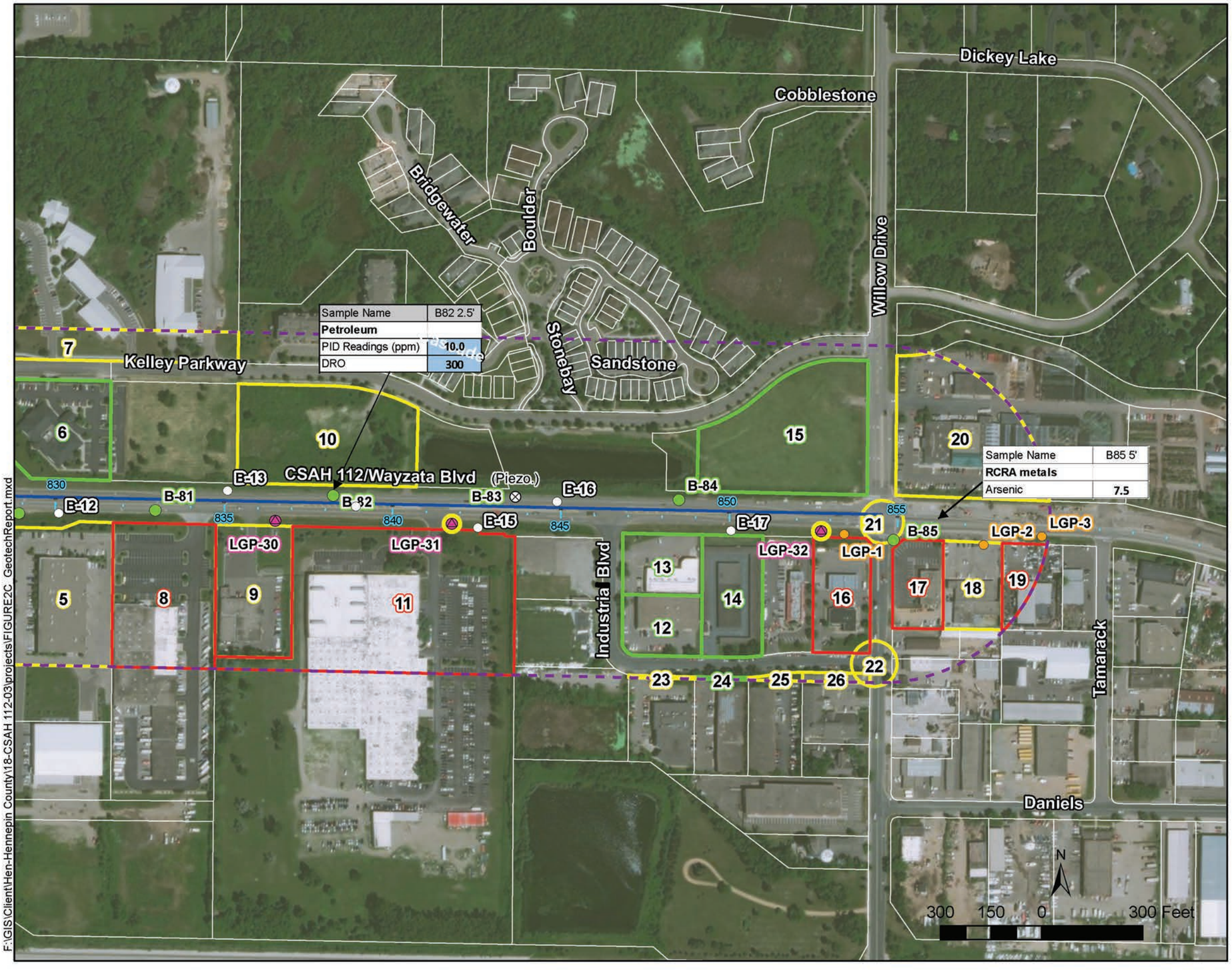
Proposed Supplemental Phase II Boring

- Soil + Soil Vapor
- Soil + Soil Vapor + Groundwater

Geotechnical Boring

- Field Screen/Possible Soil
- Soil





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2. Soil Boring Logs - 2018

BORING NO. B-72

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
			7 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)								
	89	SS	Sand, fine to medium grained, medium dense, brown, moist, Fill (SP)	20	83	0.0					
	90	SS		12	58	0.0					
5	91	SS	Silty Clay with trace sand, stiff to very stiff, gray-brown (CL)	18	63	0.0		2.5			
	92	SS		13	67	0.0		4.0			
	93	SS		12	75	0.0		4.0			
10	94	SS		6	50	0.0		1.5			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-73

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
			6 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)								
	83	SS	Sand, fine to medium grained, medium dense, brown, moist, Fill (SP)	14	78	0.4					
	84	SS		14	67	0.0					
5	85	SS	Silty Sand, fine to medium grained, medium dense, brown-gray, wet (SM)	10	63	0.0					
	86	SS		11	63	0.0					
	87	SS	Clayey Silt to Silty Clay, medium stiff, brown (ML-CL)	8	58	0.0		0.5			
10	88	SS	Silty Clay with trace sand, stiff, brownish-red mottled (CL)	10	75	0.0		2.0			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	4 ft, WD
WL	7 ft, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-74

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
	31	SS	7 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	26	89						
	32	SS	Sand with some silt, fine grained, medium dense, brown, moist, Fill (SP-SM)	11	75			0.5			
5	33	SS	Silty Clay with trace sand, medium stiff, gray-brown mottled, Fill (CL)	12	75						
	34	SS		28	75						
	35	SS		29	71						
10	36	SS	Silty Sand, fine grained, medium dense, brown, moist to wet, Fill (SM)	10	71						
15	37	SS		3	67						
20	38	SS	Clayey Silt, very soft, blue-gray (ML)	3	67		36.8	0.1			
25	39	SS	Sand, fine to medium grained, medium dense, gray, saturated (SP) Bentonite Added 25-40ft	18	67						
30	40	SS		11	78			1.5			
35	41	SS	Silty Clay with trace sand, stiff, gray (CL)	11	94			1.5			
40	42	SS		14	39			1.0			
			Soil Boring Termination Depth = 41ft Soil Boring Drilled with Hollow Stem Auger Soil Boring backfilled with Grout upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	11 ft, WD
WL	11 ft, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-75

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
	43	SS	9 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	13	72						
	44	SS	Sand with some silt, fine grained, brown, moist, Fill (SP-SM)	6	67						
5	45	SS	Silty Clay with trace sand, soft to stiff, brown-gray mottled, Fill (CL)	5	78			1.8			
	46	SS		4	89			0.3			
10	47	SS	Silty Clay with some Peat, medium stiff, blue-gray-black (CL)	4	83		22.6	0.8	100.4		
15	48	SS	Peat, amorphous with shells, soft, black (PT)	2	89		141.5	0.3	31.9	22.6	
20	49	SS		7	78			0.5			
25	50	SS		8	89			2.0			
30	51	SS	Silty Clay, medium stiff to stiff, gray (CL)	10	67			0.8			
35	52	SS		11	83			1.8			
40	53	SS		11	89			3.0			
			Soil Boring Termination Depth = 41ft Soil Boring Drilled with Hollow Stem Auger Soil Boring backfilled with Grout upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-76

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
	54	SS	9 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	9	78	0.0					
	55	SS		6	22	0.0		0.1			
5	56	SS	Sandy Silty Clay, very soft, brown, Fill (SM-SC)	3	67	0.0		0.1			
	57	SS		4	78	0.0		0.1			
10	58	SS		1	72	0.0	18.4	1.3			
15	59	SS	Silty Clay with trace sand, gray-blue mottled, soft, Fill (CL)	4	78			0.3			
20	60	SS	Sandy Silty Clay, stiff, brown-gray mottled, Fill (SC-SM)	5	83			1.0			
25	61	SS	Silty Clay with trace sand, medium stiff, gray, Fill (CL)	4	89		24.5	0.5			
30	62	SS	Peat, amorphous with shells, stiff, black (PT)	12	11			0.5			
35	63	SS		4	83		93.7	1.0		14.6	
40	64	SS	Clayey Silty Sand, loose, gray, moist (SC-SM)	8	67						
			Soil Boring Termination Depth = 41ft Soil Boring Drilled with Hollow Stem Auger Soil Boring backfilled with Grout upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-77

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			3 Inches Bituminous 1 Inch Aggregate Base								
	1	SS	Clayey Silty Sand, medium dense, brown-black, moist, Fill (SC)	9	72	0.0					
	2	SS		6	75	0.0	20.8	0.5			
5	3	SS		7	75	0.0		2.0			
	4	SS	Silty Clay with trace sand, medium stiff to stiff, brown-gray (CL)	12	75	0.0		3.0			
	5	SS		11	83	0.0		3.0			
10											
	6	SS		18	75	0.0		3.0			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-78

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			4 Inches Bituminous								
	77	SS	9 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	10	78	0.0					
	78	SS		3	58	0.0	17.7	3.0			
5	79	SS		6	71	0.0		1.8			
	80	SS	Silty Clay with trace sand and gravel, stiff to very stiff, brown-gray mottled, Fill (CL)	8	75	0.0		1.8			
	81	SS		9	25	0.0		2.0			
10	82	SS		7	58	0.0		2.0			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-79

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			4 Inches Bituminous								
	7	SS	9 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	14	78	0.0					
	8	SS	Silty Clay, stiff, brown-gray, Fill (CL)	10	75	0.1		2.0			
5	9	SS	Clayey Silt, soft, brown (ML)	6	75	0.0	23.6	0.3			
	10	SS	Silty Sand, fine grained, loose, gray, wet to saturated (SM)	10	75	0.0					
	11	SS		8	75	0.0		3.0			
10			Silty Clay with trace sand, stiff, brown-red mottled (CL)								
	12	SS		11	75	0.0		2.5			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	7 ft, WD
WL	7 ft, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-80

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
	13	SS	14 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	11	89	0.0					
	14	SS	Silty Clay with trace sand, medium stiff, black-brown mottled, Fill (CL)	7	75	0.0	22.2		98.8		
5	15	SS	Silty Sand, fine grained, loose, moist to wet, gray (SM)	5	67	0.0					
	16	SS		4	75	0.0		0.1			
	17	SS	Clayey Silt to Silty Clay, very soft to medium stiff, gray-brown (ML-CL)	3	83	0.0		0.3			
10	18	SS		3	88	0.0		0.8			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	7 ft, WD
WL	9 ft, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-81

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			5 Inches Bituminous								
	19	SS	14 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	16	89	0.0					
	20	SS	Sandy Clay, stiff, black-brown mottled, Fill (SC)	7	75	0.0					
5	21	SS		7	75	0.0					
	22	SS	Silty Sand, fine grained, loose, moist to wet, gray (SM)	4	79	0.0		0.1			
	23	SS	Clayey Silt to Silty Clay, very soft to medium stiff, gray-brown (ML-CL)	2	75	0.0		0.1			
10	24	SS		4	88	0.0		0.5			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	8 ft, WD
WL	9 ft, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-82

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			15 Inches Bituminous								
	71	SS	4 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)	20	78	10.0					
			Sand, fine to medium grained, medium dense, brown, moist, Fill (SP)								
	72	SS		9	63	0.2	19.0	2.5			
			Silty Clay with some sand, medium stiff to stiff, brown-black mottled, Fill (CL)								
5	73	SS		5	63	0.0		0.8			
	74	SS		4	75	0.0		0.8			
	75	SS	Clayey Silt to Silty Clay, medium stiff to stiff, gray-red mottled (ML-CL)	5	92	0.0		1.0			
10											
	76	SS		3	88	0.0		0.8			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-84

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			6 Inches Bituminous								
			2 Inches Aggregate Base								
	65	SS	Sand, fine to medium grained, medium dense, brown, moist, Fill (SP)	12	78	0.0					
	66	SS	Silty Clay with trace sand, stiff, brown-black, Fill (CL)	7	25	0.0		1.5			
5	67	SS		7	75	0.0		2.5			
	68	SS		8	75	0.0	17.2	1.5			
			Silty Clay, medium stiff to stiff, brown-gray mottled (CL)								
	69	SS		6	75	0.0		0.5			
10											
	70	SS		4	83	0.0		1.3			
			Soil Boring Termination Depth = 12ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-29-18	
BORING COMPLETED 8-29-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

BORING NO. B-85

PROJECT:	CLIENT:
Hennepin County CSAH 112, Phase 3	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Orono, MN	Hennepin County

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS: PID (ppm)	W (%)	Q_p (tsf)	γ_{dry} (pcf)	O/C (t%)	P200 (%)
			10 Inches Bituminous								
			9 Inches Agg. Base - Sand with some silt and gravel, fine to medium grained, brown, moist (SM)								
	25	SS	Sand with some silt, fine to medium grained, medium dense, brown, moist, Fill (SM-SP)	24	83	0.0					
	26	SS		12	58	0.0					
5											
	27	SS	Silty Clay, stiff, gray (CL)	7	75	0.0		1.8			
	28	SS	Sand, fine to medium grained, loose, gray, wet (SP)	6	75	0.0					
10	29	SS		6	75	0.0					
	30	SS	Silty Clay, stiff, gray (CL)	10	75	0.0		1.0			
			Soil Boring Termination Depth = 12.5ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfilled with Soil upon Completion								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	7 ft, WD
WL	8 ft, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 8-28-18	
BORING COMPLETED 8-28-18	
RIG CME752	FOREMAN br
DRAWN nl	JOB# 95423-E

BORING W/MC/QP/P200 HENNEPIN COUNTY CSAH 112 PHASE 3.GPJ UNITWT.GDT 9/12/18

3. Soil Boring Logs - 2012

BORING NO. B-1

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 984.6 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	1	SS	Silty Sand with little gravel, brown, loose, moist (Fill) (SM)	5	67				
3	2	SS		3	67				0.5
5	3	SS	Silty Clay with little sand, brown, medium stiff to stiff (Fill) (CL)	5	78	19			1.3
8	4	SS	Organic Silty Clay, black, stiff (OL-CL)	10	78				1.8
10	5	SS		7	94				1.0
15	6	SS	Silty Clay with a trace sand, brown, stiff to very stiff (CL)	14	94				2.0

Boring drilled with Hollow Stem Auger
Boring Termination Depth = 15.5 ft
Boring backfilled with Soil Upon Completion

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	3 ft, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-11-12	
BORING COMPLETED 6-11-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-2

PROJECT: Hennepin County CSAH 112

CLIENT: Hennepin County

LOCATION: Long Lake, MN

ARCHITECT - ENGINEER: SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 983.3 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS OC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
1			11 inches Bituminous						
2			9 inches Concrete						
3	210	SS	Silty Clay with trace sand and organics, brown-black, medium stiff (Fill) (CL)	6	67				0.5
4									
5	211	SS	Clayey Sand, brown, loose, moist (Fill) (SC)	5	56	19		41.2	
6									
7									
8	212	SS		6	61				2.0
9									
10	213	SS		5	56				1.0
11									
12									
13			Silty Clay with trace sand and gravel, brown-gray, stiff (Fill) (CL)						
14									
15	214	SS		6	67				1.5
16									
17									
18									
19									
20	215	SS		5	78				0.5

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-21-12	
BORING COMPLETED 6-21-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-2

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS OC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
21–23			Silty Clay with trace sand and gravel, brown-gray, stiff (Fill) (CL)						
24–26	216	SS	Peat, fibrous, black, very stiff (PT)	13	89				3.0
27–30	217	SS	Peat, amorphous, black, soft (PT)	7	67	51			0.3
31–35	218	SS	Peat, amorphous, black, soft (PT)	9	78				0.3
36–39			Silty Clay, gray, soft (CL)						
40	219	SS	Silty Clay, gray, soft (CL)	11	78				0.3

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-21-12	
BORING COMPLETED 6-21-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-2

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS OC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
			Silty Clay, gray, soft (CL)						
			Soil boring drilled with Hollow Stem Auger Boring Termination Depth = 40.5ft Borehole backfilled with grout upon completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-21-12	
BORING COMPLETED 6-21-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-3

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 990.4 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
			6 inches Bituminous						
1			6 inches Crushed Bituminous Base Course						
			6 inches Medium Coarse Sand, brown, medium dense, moist (Roadway Base Course) (SP)						
2	7	SS		12	67				
3			Silty Clay with trace sand, brown, very stiff (Fill) (CL)						
4	8	SS		7	67	20			2.5
5	9	SS	Silty Clay with trace organics, black, medium stiff (OL-CL)	6	67				0.5
6									
7									
8	10	SS		7	89				0.8
9									
10	11	SS		10	94				1.5
11			Silty Clay, brown, medium stiff to stiff (CL)						
12									
13									
14									
15	12	SS		16	94				1.8
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-11-12	
BORING COMPLETED 6-11-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-4

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 997.7 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
			4 inches Bituminous						
1	13	SS	15 inches Medium to Coarse Sand with silt, brown, medium dense, moist (Roadway Basecoarse) (SP-SM)	14	67				
2									
3	14	SS		8	78	17			1.8
4									
5	15	SS		8	89				1.5
6									
7									
8	16	SS		10	94				2.0
9			Silty Clay with trace sand, brown, stiff to very stiff (CL)						
10	17	SS		10	94				1.3
11									
12									
13									
14									
15	18	SS		10	94				1.3
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-11-12	
BORING COMPLETED 6-11-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-5

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 996.0 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	19	SS	Siltey Clayey Sand, brown, loose, moist (SC)	2	67	16		30.5	0.3
2									
3	20	SS		4	33				0.3
4									
5	21	SS		7	89				1.0
6									
7									
8	22	SS		10	89				1.3
9			Silty Clay with trace sand, brown, soft to stiff (CL)						
10	23	SS		11	89				1.8
11									
12									
13									
14									
15	24	SS		12	89				1.3
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	4 ft, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-11-12	
BORING COMPLETED 6-11-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-6

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 985.9 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1			13 inches Bituminous						
2	220	SS	6 inches Fine to Medium Sand with little gravel, brown, medium dense, moist (Roadway Base Course) (SP)	12	56				
3									
4	221	SS		13	67				3.0
5	222	SS		5	33				1.0
6									
7									
8	223	SS		5	22				2.7
9			Silty Clay with trace sand and gravel, medium stiff to very stiff (Fill) (CL)						
10	224	SS		9	67				1.3
11									
12									
13									
14									
15	225	SS		7	83				0.5
			Soil boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5ft Borehole backfilled with soil upon completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-21-12	
BORING COMPLETED 6-21-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-7

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 984.8 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	QC (pcf)	P200 (%)	Qp (tsf)
1			14 inches Bituminous						
2	226	SS	8 inches Fine to Medium sand, brown, medium dense, moist (Roadway Base Course) (SP)	14	33				
3									
4	227	SS		10	56				4.0
5			Silty Clay with trace sand and gravel, brown-gray, very stiff (Fill) (CL)						
6	228	SS		8	44	18			2.0
7									
8	229	SS		4	33				0.1
9			Peat, amorphous, brown-black, very soft (PT)						
10	230	SS		5	33	24	3.1		0.3
11			Clayey Sand with trace organics, black, loose, wet (SC)						
12									
13									
14			Silty Clay with trace organics, brown-black, stiff (CL)						
15	231	SS		9	83				1.3
			Soil boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5ft Borehole backfilled with soil upon completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-21-12	
BORING COMPLETED 6-21-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-8

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1005.2 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS QC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
1	25	SS	Silty Medium Coarse Sand, brown, loose, moist (Fill) (SP-SM) Silty Clay with trace organics, black, stiff (Fill) (CL-OL)	7	67				1.3
3	26	SS	Silty Fine Sand with little crushed bituminous, brown-black, medium dense, moist (Fill) (SM)	17	83	8		9.2	
5	27	SS	Silty Clay with trace sand, brown-gray, medium stiff (CL)	4	67				0.8
8	28	SS	Clayey Silt, brown-gray, very soft to medium stiff (ML)	6	89	30			0.1
10	29	SS		6	94				1.0
15	30	SS		8	89				1.3

Boring drilled with Hollow Stem Auger
Boring Termination Depth = 15.5 ft
Boring backfilled with Soil Upon Completion

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	8 ft, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-11-12	
BORING COMPLETED 6-11-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-9

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1026.1 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	31	SS	Silty Medium Coarse Sand, brown, loose, moist (Basecoarse Material) (SP-SM)	6	72				
2									
3	32	SS	Silty Clay, brown-black, stiff (Fill) (CL)	6	67				1.8
4									
5	33	SS		4	89	33			0.3
6									
7									
8	34	SS	Silty Clay to Clayey Silt, brown-gray, soft to medium stiff (ML-CL)	8	89				0.5
9									
10	35	SS		12	89				1.0
11									
12									
13									
14			Silty Clay, gray, medium firm (CL)						
15	36	SS		7	89				0.5
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	9 ft, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-10

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1028.0 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1			7 inches Bituminous 10 inches Concrete						
2									
3	38	SS	Silty Clay with trace organics, black, very stiff (Fill) (CL)	13	67	15			3.0
4									
5	39	SS		5	61				0.8
6									
7									
8	40	SS		7	83				1.0
9									
10	41	SS	Silty Clay with trace sand, brown-gray, medium stiff to stiff (CL)	8	89				1.5
11									
12									
13									
14									
15	42	SS		10	94				2.0
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-11

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1026.6 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS QC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
1	43	SS	Silty Clay with trace organics, black, stiff (CL-OL)	6	67				1.0
2									
3	44	SS	Silty Organic Clay, black, soft (OL)	4	67	29	3.8		0.3
4									
5	45	SS		3	72	31			0.3
6									
7									
8	46	SS		5	78				0.8
9									
10	47	SS	Sitly Clay to Clayey Silt, gray-brown, soft to medium stiff (ML-CL)	5	89				0.5
11									
12									
13									
14									
15	48	SS		8	89				1.0
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-12

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1026.4 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	49	SS	Fine Sand with trace gravel, brown, loose, moist (Fill) (SP)	3	67				
2			Silty Clayey Sand with trace organics, brown-black, medium dense, (Fill) (SC)						
3	50	SS		5	67	15		34.8	0.5
4			Silty Clay with little sand, brown, stiff (CL)						
5	51	SS		7	67				1.5
6									
7									
8	52	SS	Clayey Silt, gray-brown, medium stiff (ML)	4	89				0.5
9									
10	53	SS		4	89				0.8
11									
12									
13									
14			Silty Clay, gray, medium stiff (CL)						
15	54	SS		7	89				0.8
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-13

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1025.2 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	55	SS	Silty Organic Clay, black, stiff (Fill) (OL)	7	67				1.0
2									
3	56	SS		11	72				1.8
4									
5	57	SS	Sandy Silty Clay, brown-gray, very soft (SC-SM)	7	78	17			0.1
6									
7									
8	58	SS	Silty Clay to Clayey Silt, gray, medium stiff (CL-ML)	5	83				0.5
9									
10	59	SS		5	83				0.8
11									
12			Silty Clay, gray, medium stiff (CL)						
13									
14									
15	60	SS		7	83				0.5
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-14

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1023.2 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1			11 inches Bituminous						
2			8 inches Concrete						
3	62	SS	Silty Clay with trace organics, black-brown, very stiff (Fill) (CL)	17	67				2.0
4									
5	63	SS		6	83	23			0.1
6			Clayey Silt, gray, very soft to soft (ML)						
7									
8	64	SS		6	89				0.8
9									
10	65	SS		6	89				0.5
11									
12			Silty Clay, gray, medium stiff (CL)						
13									
14									
15	66	SS		10	89				1.3
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 15.5 ft Boring backfilled with Soil Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-15

PROJECT: Hennepin County CSAH 112

CLIENT: Hennepin County

LOCATION: Long Lake, MN

ARCHITECT - ENGINEER: SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION (SURFACE ELEVATION: 1015.8 ft.)	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
1	75	SS	Silty Organic Clay, black, soft (Topsoil)	3	44				
2									
3	76	SS	Silty Clay with little sand, brown, very soft to soft, (Fill) (CL)	4	56	22			0.3
4									
5	77	SS		4	61				0.1
6									
7			Silty Clay with trace organics, black, soft (CL-OL)						
8	78	SS		6	56	31			0.3
9									
10	79	SS	Silty Clay to Clayey Silt, brown-gray, soft (CL-ML)	4	56				0.3
11									
12									
13									
14									
15	80	SS		7	89				0.3
16									
17									
18			Silty Clay, brown-gray, stiff (CL)						
19									
20	81	SS	Silty Clay, brown-gray, stiff (CL)	8	78				1.0

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-13-12	
BORING COMPLETED 6-13-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-15

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS OC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 20.5 ft Piezometer P-1, with 5ft screen installed in borehole upon completion of drilling						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	4ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-13-12	
BORING COMPLETED 6-13-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-16

PROJECT: Hennepin County CSAH 112

CLIENT: Hennepin County

LOCATION: Long Lake, MN

ARCHITECT - ENGINEER: SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 1016.2 ft.	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	OC (pcf)	P200 (%)	Qp (tsf)
0			6 inches Bituminous						
1			10 inches Fine Sand, brown, medium dense, moist (Roadway Base Course) (SP)						
2	67	SS		11	67				
3	68	SS	Silty Clay with trace sand, brown, very stiff (Fill) (CL)	9	72				2.5
4			Silty Organic Clay, black, stiff (OL)						
5	69	SS		6	78				2.0
6									
7									
8	70	SS		6	83	27			0.8
9									
10	71	SS		7	89				0.8
11									
12			Silty Clay with trace sand, brown-gray, medium stiff (CL)						
13									
14									
15	72	SS		9	89				0.8
16									
17									
18									
19									
20	73	SS		6	89				0.3

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

BORING NO. B-16

PROJECT:	CLIENT:
Hennepin County CSAH 112	Hennepin County
LOCATION:	**ARCHITECT - ENGINEER:**
Long Lake, MN	SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS W (%)	LABORATORY TESTS OC (pcf)	LABORATORY TESTS P200 (%)	LABORATORY TESTS Qp (tsf)
21									
22									
23			Silty Clay with trace sand, brown-gray, medium stiff (CL)						
24									
25	74	SS		6	89				0.3
			Boring drilled with Hollow Stem Auger Boring Termination Depth = 25.5 ft Boring backfilled with Grout Upon Completion						

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	
WL	Dry, WD
WL	Dry, AD
CAVE IN DEPTH	3ft

GTE
GALE-TEC ENGINEERING, INC.

BORING STARTED 6-12-12	
BORING COMPLETED 6-12-12	
RIG CME 75 HT	FOREMAN br
DRAWN nl	JOB# 95423

BLUE EARTH HENNEPIN COUNTY CSAH 112.GPJ UNITWT.GDT 8/6/12

4. General Notes

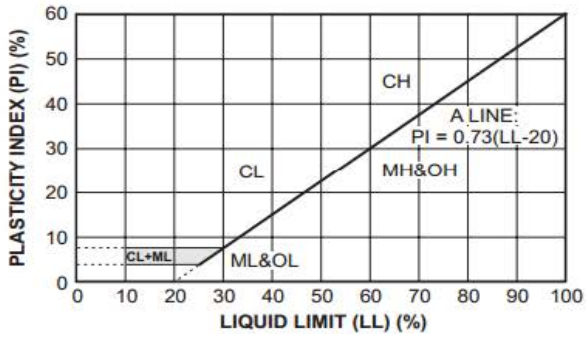
Classification of Soils for Engineering Purposes

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

(ASTM: D 2487 and 2488)

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	**Gravels** (More than half of coarse fraction is *larger* than No. 4 sieve size)	**Clean Gravels** (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size cuve. Depending on percentage of lines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% ----------GW,GP,SW,SP More than 12%----------GM,MG,SM,SC 5 to 12%----------*Borderline* cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels w/ Fines (Appreciable amount of fines)	GM d	Silty gravels, gravel-sand-silt mixtures		Atterberg Limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GM u			Atterberg Limits below "A" line or P.I. greater than 7	
			GC	Clayey gravels, gravel-sand-silt mixtures			
	Sands (More than half of coarse fraction is *smaller* than No. 4 sieve size)	**Clean Sands** (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands w/ Fines (Appreciable amount of fines)	SM d	Silty sands, sand-silt mixtures		Atterberg Limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			SM u			Atterberg Limits below "A" line or P.I. greater than 7	
			SC	Clayey sands, sand-clay mixtures			
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve size)	**Silts and Clays** (Liquid limit *less* than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or slayey silts with slight plasticity	For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg Limits plotting in (CL+ML) area are borderline classifications requiring use of dual symbols.		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit *greater* than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils			
			CH	Inorganic clays of high plasticity, fat clay			
			OH	Organic clays of medium to high plasticity, organic silts			
	Higly Organic Soils		Pt	Peat and other highly organic soils			

PLASTICITY CHART



GALE-TEC ENGINEERING, INC.

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SL : SS with Liner
SS : Split Spoon – 1 3/8" I.D., 2" O.D., unless otherwise noted
ST : Shelby Tube – 2" O.D., unless otherwise noted
PA : Power Auger
DB : Diamond Bit – NX: BX: AX
AS : Auger Sample
JS : Jar Sample
VS : Vane Shear
OS : Osterberg Sampler – 3" Shelby Tube
HS : Hollow Stem Auger
WS : Wash Sample
FT : Fish Trail
RB : Rock Bit
BS : Bulk Sample
PM : Pressuremeter test – in situ

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCL : Wet Cave In
DCL : Dry Cave In
WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casing Removal
AB : After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days of observation, and additional evidence of ground water elevations must be sought.

GRADATION DESCRIPTION & TERMINOLOGY

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive, and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine-grained soils on the basis of their strength or consistency, and their plasticity.

Major Component of Sample	Size Range	Descriptive Term(s) (Of Components Also Present in Sample)	Percent Dry Weight
Boulders	Over 8" (200mm)	Trace	1 – 9
Cobbles	8" to 3" (200mm to 75mm)	Little	10 – 19
Gravel	3" to #4 sieve (75mm to 2mm)	Some	20 – 34
Sand	#4 to #200 sieve (2mm to 0.074mm)	And	35 – 50
Silt	Passing #200 sieve (0.074mm to 0.005mm)		
Clay	Smaller than 0.005mm		

CONSISTENCY OF COHESIVE SOILS:

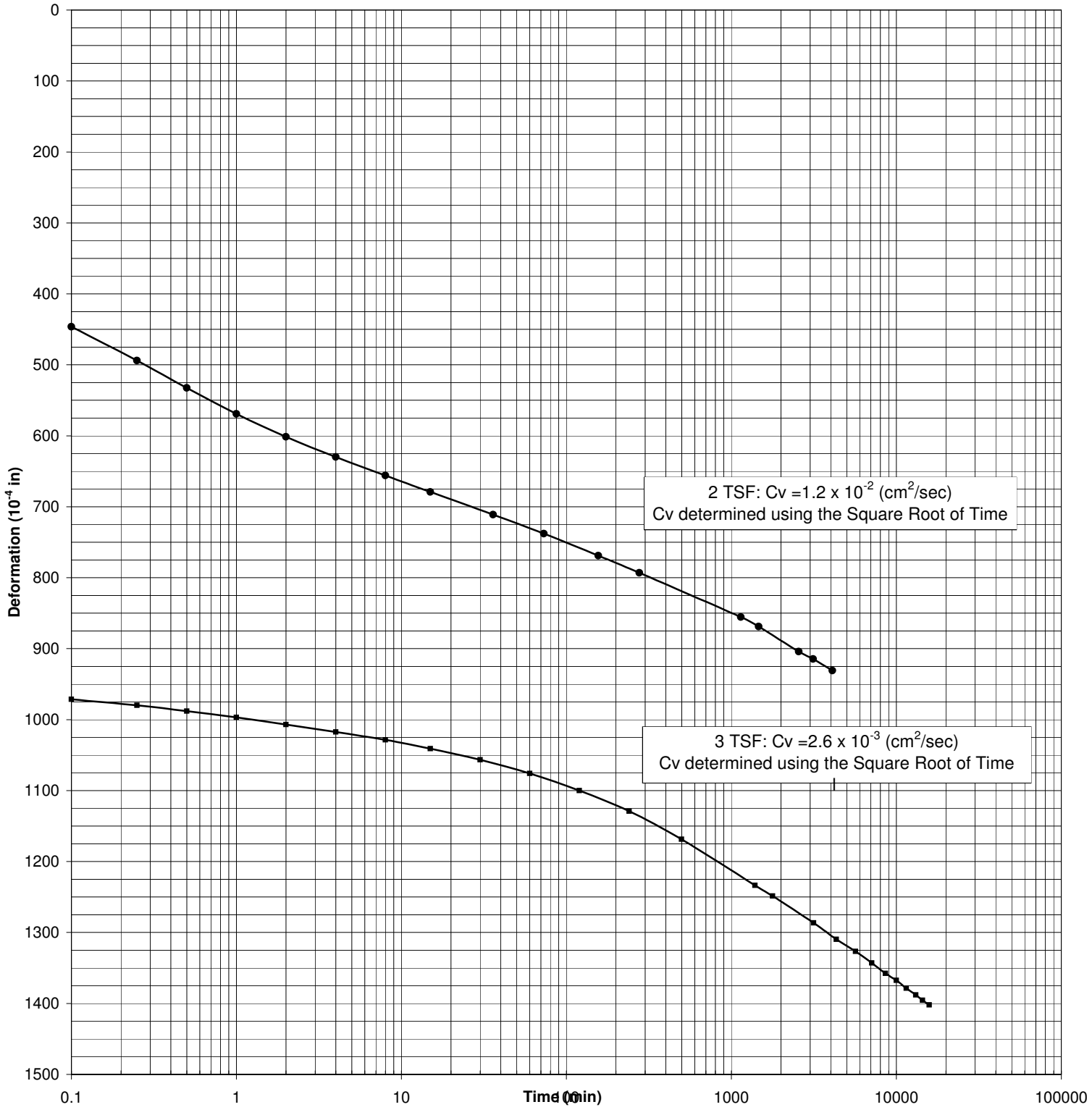
Unconfined Comp. Strength, Qu, tsf	Consistency
<0.25	Very Soft
0.25 – 0.49	Soft
0.50 – 0.99	Medium (Firm)
1.00 – 1.99	Stiff
2.00 – 3.99	Very Stiff
4.00 – 8.00	Hard
>8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

N – Blows / ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50 – 80	Very Dense
80+	Extremely Dense

5. Laboratory Testing Results

Consolidation Log of Time Curves



Project: Hennepin County CSAH 112 - Phase 3			Date: 10/30/18
Sample #:	Boring #: B-76	Depth ft: 32-34	Job #: 11669
Soil Type: Sapric Peat w/shells (PT)			
Initial W/C (%): 116.6	Dry Density (pcf): 36.3 LL:	PL: PI:	Gs: 2.44
Organic Content (%)	Initial Height (in.): 0.745	Diameter (in.): 2.500	e_o= 3.201
Seating Load: 2 tsf	Test Load: 3 tsf	Cv= 0.24 ft^2/day	Cα= 0.096

SOIL ENGINEERING TESTING, INC.