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# REPORT OF GEOTECHNICAL EXPLORATION

CSAH 2 Rehabilitation  
Between CSAH 11 to 305<sup>th</sup> St  
Redwood County, Minnesota

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Report No. 28-20393

**Date:**

June 18, 2021

**Prepared for:**

Redwood County Highway Department  
1820 East Bridge Street, P.O. Box 6  
Redwood Falls, MN 56283



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June 18, 2021

Redwood County Highway Department  
1820 East Bridge Street, P.O. Box 6  
Redwood Falls, MN 56283

Attn: Mr. Anthony Sellner, PE – County Engineer  
[Anthony\\_S@co.redwood.mn.us](mailto:Anthony_S@co.redwood.mn.us)

RE: Report of Geotechnical Exploration  
CSAH 2 Rehabilitation  
Between CSAH 11 to 305<sup>th</sup> St  
Redwood County, Minnesota  
AET Report No. 28-20393

Dear Mr. Sellner:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the CSAH 2 Rehabilitation in Redwood County, Minnesota. These services were performed according to our proposal dated and your authorization on January 4, 2021.

We are submitting this report as an electronic pdf copy. Additional copies can be provided upon request. Please contact us if you have any questions about the report.

Sincerely,  
**American Engineering Testing, Inc.**

A handwritten signature in black ink that reads 'Thomas Evans' is enclosed within a thin black rectangular border.

Thomas Evans, P.E. (MN)  
Engineer II  
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**Report of Geotechnical Exploration**

CSAH 2 – Redwood County, MN

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**SIGNATURE PAGE**

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Megan J. L. Hoppe, P.E. (MN)  
Senior Geotechnical Engineer

**I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15**

**Name: Thomas Evans**

**Date: June 18, 2021**

**License #: 55092**

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## **1.0 INTRODUCTION**

We understand the Redwood County Highway Department (County) is planning road rehabilitation on CSAH 2 from 305<sup>th</sup> Street south to CSAH 11 in Redwood County, Minnesota. To assist in planning and design, the County has authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration to include bituminous pavement coring, standard penetration test (SPT) soil borings, flight auger borings, ground penetrating radar (GPR), and perform a geotechnical engineering review for the project areas. This report presents the results of these services and provides our engineering recommendations based on this data.

## **2.0 SCOPE OF SERVICES**

AET's services were performed according to our proposal to the County dated January 4, 2021. The authorized scope of services consisted of the following:

- Obtain 7 pavement cores (2 per mile).
- Perform 7 standard penetration test (SPT) borings to depths of 6 feet.
- Perform 7 flight auger borings to depths of 2 feet within the shoulder.
- Perform a ground penetrating radar (GPR) survey in both lanes.
- Soil laboratory testing.
- Conduct a geotechnical engineering review based on the gained data and prepare this report.

The services reported herein are intended for geotechnical purposes only. The scope is not intended to explore for the presence or extent of environmental contamination in the soil or groundwater. However, obvious contamination detected by us would be reported to you.

## **3.0 PROJECT INFORMATION**

### **3.1 General**

We understand the County is proposing improvements for an approximately 3.5-mile segment of CSAH 2 from CSAH 11 extending north to 305<sup>th</sup> Street. Possible rehabilitation options presented by the County included full depth reclamation (FDR), stabilized full depth reclamation (FDR), reconstruction, and mill and overlay. We also understand the County plans on paving 2.5 feet of the shoulder. CSAH 2 is currently a 2-lane bituminous roadway. We understand the grade can be raised up to 1 inch and CSAH 2 will be posed as a 10-ton road.

Traffic counts of CSAH 2 were obtained from the MnDOT Traffic Mapping Application. The measured AADT along CSAH 2 was 750 and 690 vehicles per day in 2019 and 2011, respectively. Using the State Aid 10-ton ESAL Traffic Forecast Calculator, the traffic information from 2011 and 2019, and the default rural truck traffic distribution, we calculated a growth rate of 0.97% and a 20-year Flexible ESAL value of 268,000.

We the understand there will be vertical and horizontal grade changes associated with this road segment. However, no drawings or cross-sections have been provided by the County at this time. The recommendations provided in this report are for areas where little to no grade changes are proposed. Once more information is known about the final layout and grading plan, additional borings and an updated report will likely be needed.

The above stated information represents our understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

### **3.2 Project Background**

The following background information about the construction history of CSAH 2 was provided by the County.

- 1947: Grading 28 feet wide with selected soils from adjacent cuts generally placed in the upper 1 foot; several areas of 2.5-foot deep subgrade treatments backfilled with selected soils from adjacent cuts; and gravel surfacing 0.5-foot thick.
- 1960: 1.5" road mix bituminous over 3" aggregate base over 5" subbase
- 1974/1975: 1" overlay
- 1985: 2" overlay
- Various seal coats

### **3.3 References**

Reference to pavement evaluation is made regarding the *2018 MnDOT Standard Specifications for Construction* (MnDOT Spec.), the *MnDOT Pavement Design Manual, Flexible Pavement Design, R-Value Method*, and *Flexible Pavement Design Using Soil Factors Chart*.

## **4.0 SUBSURFACE EXPLORATION AND TESTING**

The subsurface exploration program conducted for the project consisted of ground penetrating radar (GPR) testing, 7 standard penetration tests (SPT) borings, 7 flight auger borings, and 7 pavement cores.

### **4.1 Ground Penetrating Radar**

The pavement thickness testing program conducted for the project consisted of a high speed (air coupled) GPR antenna collecting pavement thickness data at a rate of four scans per foot. The data was collected using a 2 GHz antenna, which allows material layer measurements at depths of up to approximately 18 inches with a resolution less than about ½-inch. The data collected is linked to GPS, which allows us to plot the data overlain on an aerial map. The GPR test data and details of the methods used are provided in Appendix B.

The GPR data was collected on January 12, 2021 in both lanes. Scans of the pavement were collected according to SIR-30 processor settings established by GSSI RoadScan system. A calibration file, required for data post-processing, was collected at the beginning of the testing day.

GPR interface identification was accomplished using RADAN 7.5, a proprietary software package included with the GSSI RoadScan system. The software includes tools to aid in delineating pavement layer transitions, and it automatically calculates their depths from the pavement surface using the calibration file(s) collected prior to testing. The identified layers were compared to the soil boring and pavement core data collected at the test locations to validate the accuracy of the layer thicknesses.

Depending on pavement age and condition, the presence of moisture, ambient electromagnetic interference, and pavement structure, total depths of pavement and aggregate base are not always explicitly clear. Where gaps in clear identification of pavement and base layer thicknesses are encountered, the results are reported as a percent of the picking rate of the layer interface. A picking rate of 100 percent indicates the layer interfaces were visible in 100 percent of the scanned

#### **4.2 Field Exploration Program**

After preliminary review of the GPR data, AET selected the locations for 7 pavement cores, 7 SPT borings (C-1 through C-7), and 7 flight auger borings (S-1 through S-7) throughout the road segment. AET determined the depths and number of cores/borings after discussions with the County. The flight auger borings (S-) were performed in the shoulder adjacent to the SPT boring (C-) of the same number. Before drilling, we contacted Gopher State One Call to locate public underground utilities. The pavement cores and soil borings were performed on January 28, 2021.

Subsurface boring logs and details of the methods used appear in Appendix A. The boring logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value). The borings also indicate the lane in which they were performed.

Pavement core logs are provided in Appendix A. These logs include a photograph of the extracted core, as well as total recovered core height and comments on pavement condition.

The locations of the pavement cores and soil borings are illustrated on the Core/Boring Location Maps preceding the subsurface boring logs and pavement core logs in Appendix A. The soil boring locations were measured in the field by AET personnel using handheld GPS equipment with accuracy of approximately 10 feet. The elevations at the core/boring locations were estimated from Google Earth.

### 4.3 Laboratory Testing

The laboratory test program included water contents of selected soils, three sieve analyses, and two organic content tests. The water content, percent passing the #200 sieve values, and organic content test results appear on the individual boring logs adjacent to the samples upon which they were performed. The full sieve analysis test results are shown on the Gradation Curves sheet in Appendix A following the pavement core logs.

## 5.0 SITE CONDITIONS

### 5.1 GPR Data

The GPR data shows a clear interface between the bituminous pavement and possible aggregate base layer with a picking rate of 100%, as well as a clear interface between the possible aggregate base layer and underlying soils, with a picking rate of 100% throughout the road segment. The pavement cores and soil borings were used to aid in the interpretation of the GPR layer interfaces.

Table 5.1-1 below presents the surface layer of bituminous pavement as “BP” and the possible aggregate base layer as “Base.” Table 5.1-1 also shows the statistical results of the bituminous surface and possible aggregate base layer thickness measurements by GPR (averaged over 25-foot intervals). The 15th percentile represents the value at which 85% of the section has a pavement layer thickness that is greater than identified. This is the value we generally recommend using for pavement design purposes. The plots identifying layer thicknesses, included in Appendix B, are data points collected rate of 4 scans per foot and averaged over 50 feet.

**Table 5.1-1 – GPR Thickness Summary – S01 CSAH 2**

Layer	SB				NB				Picking Rate
	Average	CV	15th	Min.	Average	CV	15th	Min.	
<b>BP</b>	5.6	10%	5.0	4.3	5.8	12%	5.2	4.3	100 %
<b>Base</b>	9.6	15%	8.1	6.3	10.1	15%	8.5	6.0	100 %
<b>BP + Base</b>	15.2	11%	13.5	11.9	15.8	11%	14.0	12.5	

Note: BP – Bituminous Pavement. CV – coefficient of variation (Std Dev/Average). 15<sup>th</sup> – 15<sup>th</sup> percentile thickness value.

### 5.2 Pavement Section

The pavement encountered at the pavement core and soil boring locations consists of bituminous over a possible aggregate base layer. Table 5.2-1 below presents the bituminous and aggregate base thickness observed at the pavement core and soil boring locations.

**Table 5.2-1 - Pavement Thickness Summary**

<b>Boring/Core Number</b>	<b>Bituminous Thickness (in) <sup>A.</sup></b>	<b>Bituminous Downhole Thickness (in) <sup>B.</sup></b>	<b>Approximate Base Thickness (in)<sup>B.</sup></b>	<b>Approximate Total Thickness (in) <sup>B.</sup></b>
C-1	4.7	5	19	24
C-2	5.0	6	18	24
C-3	5.1	5½	14½	20
C-4	5.1	5¾	11	16¾
C-5	5.1	5½	10½	16
C-6	5.0	5½	18½	24
C-7	5.0	6	12	18

**Notes:** A. Measured from the recovered pavement core. Rounded to the nearest 0.1 inch.

B: Measured from the soil boring. Rounded to the nearest ¼-inch.

In summary, the bituminous thickness throughout the road segment ranged from 4.7 to 5.1 inches. The possible base thickness encountered at the boring locations below the bituminous ranged from 10½ to 19 inches. The possible aggregate base consists of silty sand with a little gravel (A-1-b).

### **5.3 Pavement Condition**

Bituminous condition was evaluated based on the pavement cores obtained at the site. Photographs of the pavement cores are provided on the pavement core logs in Appendix A. The bituminous cores show mostly slight to moderate stripping in the top half. However, the bottom half of the cores show crumbling and moderate to severe stripping.

Stripping occurs when water or water vapor gets between the asphalt film and the aggregates, thereby breaking the adhesive bond between the aggregate and asphalt binder. This will “strip” the asphalt from the aggregate, eventually leading to pavement failure. When stripping within the pavement becomes excessive, severe pavement deformation and fatigue cracking will occur, and then traffic loadings will result in local failures such as alligator cracking, potholes, and excessive rutting in the wheel paths.

The pavement condition was also evaluated based on the video taken during the GPR survey. The road segment showed medium to high severity longitudinal and transverse cracking, as well as alligator cracking and raveling. Localized areas of patching were also observed throughout the segment. Alligator cracking generally indicates a weak or soft subgrade and/or a pavement beyond its design life. The observed distresses indicate a pavement past its design life.

### **5.4 Subgrade Soils**

The soils below the aggregate base consist of various fill soils extending to depths ranging from 4.5 to 6.5 feet or more. The fill soils consist of slightly organic lean clay (A-6), clayey sand (A-6), and sandy lean clay (A-6). Till and alluvium were encountered below the fill soils in borings C-2,

C-3, and C-7. These soils consisted of sandy lean clay (A-6), clayey sand (A-6), and sand (A-3), which extended to the final drilling depths of 6.5 feet.

The gravel surfacing within the shoulders at the boring locations ranged from 9.5 inches to over 2 feet thick and generally consisted of silty sand with gravel (A-1-b). Clayey (A-6) soils were encountered below the aggregate shouldering penetrated by the shallow (2-foot deep) shoulder borings.

## **5.5 Groundwater**

Groundwater was not observed within the soil borings at the time of our exploration. However, groundwater can take hours to days or longer to stabilize in the clayey soils that were encountered throughout this site. Establishing a reliable groundwater level at this site would require the installation of piezometers, which was outside the scope of our work this project. Therefore, the lack of measurable groundwater at the boring locations may not represent the actual groundwater depths. In addition, perched groundwater conditions can develop over the clayey soils found at this site. Groundwater levels fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors.

## **5.6 Subgrade Soil Properties**

The soil borings performed indicate the subgrade soils consisting mostly of slightly organic lean clay. We performed two organic content tests on these slightly organic soils, and they were 3.9 and 4.3%. In our opinion, these soils have low strength and stability, and they are at least moderately compressible. Additionally, they are slow draining and have moderate to high frost susceptibility.

In our opinion, the natural clayey sand and sandy lean clay soils have low to moderate strength, are slow draining, and have moderate to high frost susceptibility. The sand alluvial soils have moderate to high strength, are fast draining, and have low frost susceptibility.

We estimate the limiting soils at the site have an R-value of 7, and this is the R-value we have used in our design assumptions.

## **6.0 PAVEMENT RECOMMENDATIONS**

### **6.1 Discussion**

We understand the County is considering rehabilitation options for this road segment that consists of mill and overlay, FDR, SFDR, and reconstruction.

In general, the bituminous cores showed slight to moderate stripping in the top half and moderate to severe stripping in the bottom half. Generally, a mill and overlay approach is not considered a

good rehabilitation method when the bituminous that is left in place contains severe stripping. However, due to the thickness of the in-place bituminous, it is our opinion that it is unlikely the milling equipment would break through the left-in-place bituminous during construction.

We evaluated this road segment for full depth reclamation (FDR) and stabilized full depth reclamation (SFDR) options. Based on the traffic information and the slightly organic clayey subgrade soils encountered at many of the boring locations, we calculated a required granular equivalency (GE) of 28.48 inches. This GE value was calculated using the 20-year, 10-ton ESAL's provided in **Section 3.1** and an R-value of 7 using MnDOT's Flexible Pavement Design workbook. We evaluated reclamation depths and base stabilization alternatives; however, the required GE was not attainable using the approaches we evaluated.

One option we evaluated included performing a 1-inch mill, 12-inch pre-grind, removing 5 inches of reclaimed material, compacting the remaining reclaimed material, and then paving 6 inches of new bituminous pavement. That option results in a GE of 20.5 inches. If we planned to stabilize the reclaimed material with cement or emulsion, it would result in a GE of 24.0 inches, which is still less than required for a 20-year design life.

The full reconstruction approach could include either a 1-foot subcut or the complete removal of organic soils. However, since our soil borings did not extend completely through the organic soils, additional soil borings would need to be performed to determine this the actual depth of removals. Therefore, our reconstruction recommendations are only associated with the 1-foot subcut option.

## **6.2 Mill and Overlay**

### **6.2.1 Discussion**

A mill and overlay consists of milling the upper portion of the bituminous pavement layer and leaving the lower portion in place. Subsequently, a new bituminous pavement surface is placed and compacted. This approach requires a sufficient thickness of bituminous such that enough bituminous remains to prevent the paving equipment from breaking through into the base layer; it appears that sufficient bituminous thickness is present throughout the project area.

However, based the cores extracted, the condition of the bituminous left in place after milling will be marginal. In addition, the cores were generally taken away from significant cracks. Surface cracking allows water infiltration which leads to faster deterioration of the bituminous; therefore, more significant stripping should be anticipated near cracked areas.

With a mill and overlay, reflective cracking of the larger longitudinal and transverse cracks will appear in the new surfacing in as little as 1 to 3 years after construction.

### **6.2.2 Mill and Overlay Section**

We reviewed the potential suitability and design life for a 2.0-inch mill and 3.0-inch overlay, which should extend the lifespan of the existing pavement for approximately 9 to 15 years based on the provided traffic information, the pavement condition, and the subgrade soils encountered. Further details are provided in the following section and table below.

**Table 6.2.2-1 – Mill and Overlay Section**

<b>Layer</b>	<b>MnDOT Material Type</b>	<b>Thickness</b>
Mill Existing Bituminous		2.0 inches
Bituminous Overlay	SPWEA240B (PG 58S-28)	3.0 inches (2 lifts)

### **6.2.3 Mill and Overlay Details**

Based on our review of the bituminous surface conditions and the extracted cores, it is our opinion that pre-overlay repairs at deteriorated areas could be significant for this project.

After milling and prior to overlaying, we recommend that deteriorated cracks and wheel-path areas be air blasted and power swept to remove loose material. Air blasting should be completed with high pressure (minimum of 100 psi) equipment. Removal of material at some deteriorated locations may require the use of a small milling machine or handwork, in addition to the high-pressure air blasting. Regardless of the patch depth, it is important to remove the entire existing deteriorated pavement.

Depressions resulting after air blasting, sweeping, or milling operations that are greater than 1.5 inches in depth and width should be filled with a Bituminous Patching Mixture meeting MnDOT Spec. 2231 and compacted with a small vibratory or pneumatic roller. Depressions equal to or less than 1.5 inches in depth and width can be filled with the bituminous overlay mixture.

We recommend a tack coat be applied between all bituminous layers and prior to placing any bituminous mixtures on the milled surface in accordance with MnDOT Spec. 2357. Please reference the attached standard sheet regarding “Bituminous Overlay Milling and Preparation” for further information.

## **6.3 Full Reconstruction**

### **6.3.1 Site Grading**

To prepare the existing subgrade for pavement placement, we recommend removing the existing bituminous and aggregate base. The aggregate base may be stockpiled to be reused as aggregate base if it meets the specifications for MnDOT Class 5, 5Q or 6, or the pavement could be reclaimed to produce MnDOT Spec. 3135 Modified Aggregate Bases. Excavations should continue to allow for the placement of a 1-foot sand subbase below the new aggregate base material.

Before placement of the sand subbase, the exposed subgrade soils should be prepared per MnDOT Spec. 2112, Subgrade Preparation, to a depth of 6 inches below the bottom of the subcut. The final subgrade should have proper stability within the critical subgrade zone. In clayey and silty soils, stability should be evaluated using the test roll procedure, and instability will likely be a result of wetter subgrade soils.

If unstable soils are found under the test roll, then these soils should be improved by means of scarification, drying, and recompaction, or by subcutting and replacement. The final soils which remain in place should pass a test roll prior to placing the sand subbase layer.

If organic soils are found to be present, we recommend removing these soils where present within the critical subgrade zone.

All new fill and any reworked soils should be placed and compacted per the requirements of MnDOT Spec. 2105.3F.1 (Specified Density Method). In ASTM terms, this specification requires soils placed within the critical subgrade zone (within 3 feet of top of subgrade elevation) be compacted to a minimum of 100% of the standard maximum dry unit weight defined in ASTM D 698 (Standard Proctor test). A reduced minimum compaction level of 95% of the standard maximum dry unit weight can be used below the critical subgrade zone.

### ***6.3.2 Geosynthetic Use***

We recommend the placement of a geotextile fabric between the sand subbase and the subgrade soils. It should consist of material at least meeting MnDOT Spec. 3733 Type 5.

### ***6.3.3 Sand Subbase***

We recommend the placement of a 12-inch thick sand subbase to improve the subgrade support, frost, and drainage characteristics of the pavement system. We recommend the sand subbase consist of Select Granular Material (MnDOT Spec. 3149.2.B.2).

If there is a need to vary the thickness of the sand subbase, we recommend the thickness have longitudinal tapers along the roadway no steeper than 20H:1V. Where intersecting cross streets, we recommend a transverse taper of 4H:1V, with the sand subbase overlaying the adjacent soils.

The sand subbase must be provided with proper subsurface drainage to minimize build-up of water within the sand. The sand subbase should be daylighted to the ditch wherever possible and should do so a minimum of 1 foot above the bottom of the ditch. If that condition cannot be met, subsurface drains should be installed. The drain lines should meet MnDOT Specification 2502 Subsurface Drains and be placed to provide drainage at the bottom of the Select Granular Material layer. Refer to MnDOT Standard Plan detail 5-297.430.

**6.3.4 Aggregate Base**

We recommend the aggregate base meet the gradation and quality requirements for Class 5, 5Q, or 6 per MnDOT Spec. 3138 or the pavement could be reclaimed to produce MnDOT Spec. 3135 Modified Aggregate Bases. Aggregate base placement and compaction should be performed according to MnDOT Spec. 2211. All aggregate base material (including existing, imported, or reclaimed) should be tested for compaction using the Penetration Index Method per MnDOT Spec. 2211.3.D.2.c.

**6.3.5 Bituminous Pavement Section**

Table 6.3.5-1 below shows the reconstruction recommended pavement section based on the subgrade soils found at the boring locations and the calculated traffic loading.

**Table 6.3.5-1 – Reconstruction Pavement Section**

<b>Layer</b>	<b>MnDOT Material Type (Spec.)</b>	<b>Thickness</b>
Bituminous Wear Upper	SPWEA240C (PG58H-34)	1.5"
Bituminous Wear Lower	SPWEA240C (PG58H-34)	1.5"
Bituminous Non-Wear	SPNWB230B (PG58S-28)	2.0"
Aggregate Base	Class 5, 5Q, or 6 (3138)	8.0"
Sand Subbase	Select Granular Material 3149.2B.2	12"
Geotextile	MnDOT 3733, Type 5	Yes

**7.0 BITUMINOUS PAVEMENTS****7.1 Bituminous Mixes**

The bituminous mixtures should meet the most current MnDOT Spec. 2360 (Plant-Mixed Asphalt Pavement) requirements. Compaction of all bituminous mixtures should be by the “Maximum Density Method.”

Use of recycled asphalt pavement (RAP) in the bituminous mix is a cost saving measure that is often suggested. If used, we recommend a maximum of 20% RAP with the mixes presented previously; however, there will be a higher probability of pavement thermal cracking when RAP is used. In addition, we recommend limiting RAP within the upper wear course to a maximum of 10% in order to reduce cracking. If bituminous mixes are utilized other than those recommended, a lower percentage of RAP may be needed.

For the reconstruction section, an “A” gradation could be substituted for the lower non-wear lift, if desired. We recommend using the “A” gradation for lifts 1.5 inches thick in order to reduce aggregate segregation. An “A” gradation generally provides a ‘finer’ pavement surface, while the aggregate size “B” generally accommodates RAP more readily than aggregate size “A”.

## **7.2 Pavement Maintenance**

The pavement designs presented are based on the design life specified; however, pavements require ongoing maintenance. Even if properly placed and compacted on stable subgrade conditions, bituminous pavements typically experience cracking in 1 to 3 years, primarily due to temperature-related expansion and shrinkage. We recommend that a regularly scheduled maintenance program consisting of sealing/patching of cracks and local distressed areas be implemented. Seal coating of the bituminous pavement surface after 3 to 5 years also helps prolong the pavement life.

## **8.0 CONSTRUCTION CONSIDERATIONS**

### **8.1 Potential Difficulties**

#### ***8.1.1 Water in Excavation***

Groundwater was not observed during the time of drilling. However, water may collect in the excavation bottoms during times of inclement weather or snow melt. To allow observation of the excavation bottom, and to reduce the potential for soil disturbance we recommend that all free-standing water within the excavations be removed prior to fill placement. The clayey subgrade soils exposed in the subcut excavation should be sloped to drain to the adjacent ditches.

#### ***8.1.2 Wet or Dry Soils***

The on-site materials may be wet or dry of the “optimum” condition, making proper compaction of those materials difficult unless they are mechanically moisture conditioned to near the standard optimum water content.

#### ***8.1.3 Disturbance of Soils***

The on-site soils can become disturbed under construction traffic, especially if the soils are wet. If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut soils can then be dried and recompact back into place, or they should be removed and replaced with drier imported fill.

#### ***8.1.4 Cobbles and Boulders***

The soils at this site can include cobbles and boulders. These oversized materials may make excavating procedures more difficult than normal if they are encountered. Generally, gravel larger than about 3 inches should not be used within the critical subgrade zone.

### **8.2 Observation and Testing**

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since subsurface conditions have the potential to vary greatly from our borings, we highly recommend an AET geotechnical engineer/technician provide observations to evaluate

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these potential changes. Materials testing should also be performed to document that project specifications have been satisfied.

**9.0 ASTM STANDARDS**

When we refer to an ASTM Standard in this report, we mean that our services were performed in general accordance with that standard. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

**10.0 LIMITATIONS**

Within the limitations of scope, budget, and schedule, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either express or implied, is intended.

Important information regarding risk management and proper use of this report is given in Appendix D entitled “Geotechnical Report Limitations and Guidelines for Use”.

**Report of Geotechnical Exploration**

CSAH 2 – Redwood County, MN

June 18, 2021

Report No. 28-20393

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## **Standard Sheets**

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Definitions Related to Pavement Construction  
Bituminous Pavement and Subgrade Preparation  
Bituminous Overlay Milling and Preparation

## DEFINITIONS RELATING TO PAVEMENT CONSTRUCTION

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**Top of subgrade:** Grade which contacts the bottom of the aggregate base layer.

**Sand subbase:** Uniform thickness sand layer placed as the top of subgrade which is intended to improve the frost and drainage characteristics of the pavement system by increasing drainage of excess water in the aggregate base and subbase, by reducing and “bridging” frost heaving, and by reducing spring thaw weakening effects.

**Critical subgrade zone:** The subgrade portion beneath and within three vertical feet of the top of subgrade. A sand subbase, if placed, would be considered the upper portion of the critical subgrade zone.

**Suitable Grading Material:** Mineral soil materials, typically from the project site, excluding the following: 1) soils which have an organic content exceeding 3%, 2) cohesive soils having a Liquid Limit exceeding 50%, 3) soils which include debris, cobbles, and/or boulders, and 4) soils which are considered not acceptable from an environmental standpoint. The soil must also be capable of attaining the specified compaction level at its current water content or at a water content that can be reasonably scarified, blended, and moisture conditioned to a uniform water content in order to uniformly meet compaction requirements.

**Granular Material:** Soils meeting MnDOT Specification 3149.2B.1. This refers to granular soils which, of the portion passing the 1" sieve, contain less than 20% by weight passing the #200 sieve.

**Select Granular Material:** Soils meeting MnDOT Specification 3149.2B.2. This refers to granular soils which, of the portion passing the 1" sieve, contain less than 12% by weight passing the #200 sieve.

**Select Granular Material (Super Sand):** Soils meeting MnDOT Specification 3149.2B.3. This material is cleaner and coarser than Select Granular Material (see specification for specific requirements).

**Compaction Subcut:** Construction of a uniform thickness subcut below a designated grade to provide uniformity and compaction within the subcut zone. Replacement fill can be the materials subcut, although the reused soils should be blended to a uniform soil condition, moisture conditioned as needed to meet MnDOT Specification 2105.F; and re-compacted per the Specified Density Method defined in MnDOT Specification 2105.3F.1.

**Test Roll:** A means of evaluating the near-surface stability of subgrade soils (usually non-granular). Suitability is determined by the depth of rutting or deflection caused by passage of heavy rubber-tired construction equipment, such as a loaded dump truck, over the test area. Yielding of less than 1" is normally considered acceptable, although engineering judgment may be applied depending on the equipment used, soil conditions present, and/or depth below final grade.

**Unstable Soils:** Subgrade soils which do not pass a test roll. Unstable soils typically have water content exceeding the *standard optimum water content* defined in ASTM:D698 (Standard Proctor test).

**Organic Soils:** Soils which have sufficient organic content such that the soils engineering properties are negatively affected (typically more than 3% organic content). These soils are usually black to dark brown in color.

## **BITUMINOUS PAVEMENT SUBGRADE PREPARATION AND DESIGN**

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### **GENERAL**

Bituminous pavements are considered layered “flexible” systems. Dynamic wheel loads transmit high local stresses through the bituminous/base onto the subgrade. Because of this, the upper portion of the subgrade requires high strength/stability to reduce deflection and fatigue of the bituminous/base system. The wheel load intensity dissipates through the subgrade such that the high level of soil stability is usually not needed below about 2 feet to 4 feet (depending on the anticipated traffic and underlying soil conditions). This is the primary reason for specifying a higher level of compaction within the upper subgrade zone versus the lower portion. Moderate compaction is usually desired below the upper critical zone, primarily to avoid settlements/sags of the roadway. However, if the soils present below the upper 3 feet subgrade zone are unstable, attempts to properly compact the upper 3 feet zone to the 100% level may be difficult or not possible. Therefore, control of moisture just below the 3 feet level may be needed to provide a non-yielding base upon which to compact the upper subgrade soils.

Long-term pavement performance is dependent on the soil subgrade drainage and frost characteristics. Poor to moderate draining soils tend to be susceptible to frost heave and subsequent weakening upon thaw. This condition can result in irregular frost movements and “pop-outs,” as well as an accelerated softening of the subgrade. Frost problems become more pronounced when the subgrade is layered with soils of varying permeability. In this situation, the free-draining soils provide a pathway and reservoir for water infiltration which exaggerates the movements. The placement of a well-drained sand subbase layer as the top of subgrade can minimize trapped water, smooth frost movements and significantly reduce subgrade softening. In wet, layered and/or poor drainage situations, the long-term performance gain should be significant. If a sand subbase is placed, we recommend it be a “Select Granular Borrow” which meets Mn/DOT Specification 3149.2B2.

### **PREPARATION**

Subgrade preparation should include stripping surficial vegetation and organic soils; where the exposed soils are within the upper “critical” subgrade zone (generally 2 feet deep for “auto only” areas and 3 feet deep for “heavy duty” areas), they should be evaluated for stability. Excavation equipment may make such areas obvious due to deflection and rutting patterns. Final evaluation of soils within the critical subgrade zone should be done by test rolling with heavy rubber-tired construction equipment, such as a loaded dump truck. Soils which rut or deflect 1" or more under the test roll should be corrected by either subcutting or replacement; or by scarification, drying, and recompaction. Reworked soils and new fill should be compacted per the “Specified Density Method” outlined in Mn/DOT Specification 2105.3F1 (a minimum of 100% of Standard Proctor density in the upper 3 feet subgrade zone, and a minimum of 95% below this).

Subgrade preparation scheduling can be an important consideration. Fall and Spring seasons usually have unfavorable weather for soil drying. Stabilizing non-sand subgrades during these seasons may be difficult, and attempts often result in compromising the pavement quality. Where construction scheduling requires subgrade preparation during these times, the use of a sand subbase becomes even more beneficial for constructability reasons.

### **SUBGRADE DRAINAGE**

If a sand subbase layer is used, it should be provided with a means of subsurface drainage to prevent water build-up. This can be in the form of draitile lines which dispose into storm sewer systems, or outlets into ditches. Where sand subbase layers include sufficient sloping and water can migrate to lower areas, draitile lines can be limited to finger drains at the catch basins. Even if a sand layer is not placed, strategically placed draitile lines can aid in improving pavement performance. This would be most important in areas where adjacent non-paved areas slope towards the pavement. Perimeter edge drains can aid in intercepting water which may infiltrate below the pavement.

## **BITUMINOUS OVERLAY MILLING AND PREPARATION**

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### **COLD MILLING OPERATION**

Cold milling is generally conducted longitudinally along the pavement profile. The forward speed of the machine, rotational velocity of the rotating drum, spacing of the carbide bits, and grade control of the cutting head should be closely controlled to produce a uniform texture throughout the project. The longitudinal profile should be held as close as practical to the same tolerance as new construction, since the milled profile will have a significant impact upon the ride of the overlaid pavement, especially when only a single lift of overlay is placed.

Normally, the recommended milling depth corresponds to the lift thickness of the original pavement. It is best to remove the entire layer as the bottom of the lift is typically where bonding and stripping issues occur. The depth of milling may require adjustment in the field to ensure that a full layer is removed and that portions of a layer are not left bonded to the underlying surface. Additionally, if there is a large amount of stripping present, the milling depth should be sufficiently deep to remove the stripped areas. This depth is typically determined by coring adjacent to cracks and looking at both the layer thickness and any evidence of stripping. The milling depth can be adjusted to remove areas with significant stripping present, or if the stripping is limited only to a few transverse cracks, a smaller milling machine can be brought in to remove additional material in these areas. Patching can be performed after the milling operation for cases where a minimal amount of stripping is present or in the areas where cracks are milled deeper than the remaining roadway.

Please note that the milling depth should also take into consideration the original pavement depth that will remain after the milling operation. It is likely that the milling machine will break through the underlying pavement if there will be less than 1.5 inches of the original pavement remaining, thereby causing problems with the milling operation and overlay.

### **PRE-OVERLAY PREPARATION**

It is recommended that a tack coat is applied between all bituminous layers and prior to placing any bituminous mixtures on the milled surface. The bituminous tack coat material should be applied at a uniform rate of 0.03 to 0.05 gal/yd<sup>2</sup> between bituminous layers and 0.07 to 0.10 gal/yd<sup>2</sup> on the milled bituminous surface prior to being overlaid. The application rates are for undiluted emulsions (as supplied from the refinery) or MC and RC liquid asphalts. The asphalt emulsion may be further diluted in the field in accordance with Mn/DOT Spec. 2357.

Prior to overlaying, it is recommended that deteriorated cracks and wheel-path areas are air blasted and power swept to remove loose material. Air blasting should be completed with high pressure (minimum of 100 psi) equipment. Removal of material at some deteriorated locations may require the use of a small milling machine or handwork, in addition to the high pressure air blasting. Regardless of the patch depth, it is important to remove the entire existing deteriorated pavement.

Depressions resulting after air blasting, sweeping, or milling operations that are greater than 1.5 inches in depth and width should be filled with a Bituminous Patching Mixture meeting Mn/DOT Spec. 2231 and compacted with a small vibratory or pneumatic roller. Depressions equal to or less than 1.5 inches in depth and width can be filled with the bituminous wear course mixture.

Consideration should be given to allow traffic to drive over deteriorated joints/cracks, after backfilling (if there are a large number of these distressed locations) with the recommended bituminous mixtures and proper compaction, for a period of seven days prior to placement of the wear course mixture. The proposed seven-day delay period will permit traffic to apply additional compaction to the joint/crack backfill. If further compaction is not deemed necessary, then patching of depressions greater than 1.5 inches in depth and width can be completed ahead of the paver and compacted with a small vibratory or pneumatic roller. As previously stated, the smaller depressions will be filled in by the wearing course paving operations.

If the pavement surface, after milling, is lower than the adjacent shoulders, the contractor (as directed by the Engineer), should construct outlet trenches and take other measures necessary to provide adequate surface drainage for the milled areas.

It is recommended that a notch at least 1 inch deep be milled to allow the placement of 1 inch minimum bituminous wearing course at the ends of transitions.

## **BITUMINOUS OVERLAY MILLING AND PREPARTION**

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Please note that as this will be a bonded overlay (i.e., bonded to the milled surface), the amount of pre-overlay repair that must be performed on an existing pavement is critical to the performance of the overlay. Similarly, reflection crack control measures must be applied to these overlays, such as the selection of bituminous mixture and PG binder type. Depending upon the frequency of existing transverse cracks it may be prudent to select a bituminous mixture and PG binder that will crack at the existing frequency but be more resistant to degradation from environmental effects such as moisture. Other considerations include subdrainage, traffic, pavement widening, and shoulders. As a general rule, all the distress types in an existing pavement that are likely to affect the performance of an overlay within a few years should be repaired. The designer should also consider the tradeoffs between pre-overlay repair and the thickness and type of overlay selected. For instance, if the existing pavement is severely deteriorated, an overlay type that is less sensitive to existing pavement conditions may be more cost effective without extensive pre-overlay repair.

### **BITUMINOUS PLACEMENT**

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The bituminous mixture should meet the most current Mn/DOT Spec. 2360 (Plant-Mixed Asphalt Pavement: Combined 2360/2360 Gyrotory/Marshall Design Specification) requirements. Compaction of all bituminous mixtures should be by the "Maximum Density Method".

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# Appendix A

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Geotechnical Field Exploration and Testing

Boring Log Notes

Unified Soil Classification System

AASHTO Soil Classification System

Core/Boring Location Maps 1-4

Subsurface Boring Logs

Pavement Core Logs

Gradation Curves

**Appendix A**  
**Geotechnical Field Exploration and Testing**  
**AET No. 28-20393**

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### **A.1 FIELD EXPLORATION**

The subsurface conditions at the site were explored by sampling 7 standard penetration test soil borings, 7 pavement cores, and 7 flight auger borings. The locations of the borings appear on the Core/Boring Location Maps, preceding the Subsurface Boring Logs in this appendix.

### **A.2 SAMPLING METHODS**

#### **A.2.1 Split-Spoon Samples (SS) - Calibrated to N<sub>60</sub> Values**

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2-inch O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N<sub>60</sub> blow count.

The most recent drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N<sub>60</sub> values. By using the PDA energy measurement equipment, we can determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30 inches. The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviation of the N-values using this method is significantly better than the standard ASTM Method.

#### **A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)**

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

#### **A.2.3 Sampling Limitations**

Unless observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of "topsoil" layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

### **A.3 CLASSIFICATION METHODS**

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

Visual-manual judgment of the AASHTO Soil Group is also noted as a part of the soil description. A chart presenting details of the AASHTO Soil Classification System is also attached.

**Appendix A**  
**Geotechnical Field Exploration and Testing**  
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The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

#### **A.4 WATER LEVEL MEASUREMENTS**

The ground water level measurements are shown at the bottom of the boring logs. The following information appears under “Water Level Measurements” on the logs:

- ♦ Date and Time of measurement
- ♦ Sampled Depth: lowest depth of soil sampling at the time of measurement
- ♦ Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- ♦ Cave-in Depth: depth at which measuring tape stops in the borehole
- ♦ Water Level: depth in the borehole where free water is encountered
- ♦ Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

#### **A.5 LABORATORY TEST METHODS**

##### **A.5.1 Water Content Tests**

Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

##### **A.5.2 Sieve Analysis of Soils (thru #200 Sieve)**

Conducted per AET Procedure 01-LAB-040, which is performed in general conformance with ASTM: D6913, Method A.

##### **A.5.3 Organic Content Tests**

Conducted per AET Procedure 20-SOI-010 which is performed in general conformance with ASTM: D2974.

#### **A.6 TEST STANDARD LIMITATIONS**

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

#### **A.7 SAMPLE STORAGE**

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

## BORING LOG NOTES

### DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

### TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q <sub>p</sub> :	Pocket Penetrometer strength, tsf ( <u>approximate</u> )
q <sub>c</sub> :	Static cone bearing pressure, tsf
q <sub>u</sub> :	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

### STANDARD PENETRATION TEST NOTES

#### (Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N<sub>60</sub> values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

**UNIFIED SOIL CLASSIFICATION SYSTEM**  
**ASTM Designations: D 2487, D2488**

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Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>				Soil Classification	
				Group Symbol	Group Name <sup>B</sup>
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines <sup>C</sup>	$Cu \geq 4$ and $1 \leq Cc \leq 3$ <sup>E</sup>	GW	Well graded gravel <sup>F</sup>
			$Cu < 4$ and/or $1 > Cc > 3$ <sup>E</sup>	GP	Poorly graded gravel <sup>F</sup>
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines <sup>D</sup>	$Cu \geq 6$ and $1 \leq Cc \leq 3$ <sup>E</sup>	SW	Well-graded sand <sup>I</sup>
			$Cu < 6$ and/or $1 > Cc > 3$ <sup>E</sup>	SP	Poorly-graded sand <sup>I</sup>
	Sands with Fines more than 12% fines <sup>D</sup>	Fines classify as ML or MH		SM	Silty sand <sup>G,H,I</sup>
		Fines classify as CL or CH		SC	Clayey sand <sup>G,H,I</sup>
Fine-Grained Soils 50% or more passes the No. 200 sieve  (see Plasticity Chart below)	Sils and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line <sup>J</sup>	CL	Lean clay <sup>K,L,M</sup>
			PI < 4 or plots below "A" line <sup>J</sup>	ML	Silt <sup>K,L,M</sup>
		organic	Liquid limit - oven dried < 0.75 Liquid limit - not dried	OL	Organic clay <sup>K,L,M,N</sup>
					Organic silt <sup>K,L,M,O</sup>
	Sils and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay <sup>K,L,M</sup>
			PI plots below "A" line	MH	Elastic silt <sup>K,L,M</sup>
		organic	Liquid limit - oven dried < 0.75 Liquid limit - not dried	OH	Organic clay <sup>K,L,M,P</sup>
					Organic silt <sup>K,L,M,Q</sup>
Highly organic soil	Primarily organic matter, dark in color, and organic in odor			PT	Peat <sup>R</sup>

**Notes**

<sup>A</sup>Based on the material passing the 3-in (75-mm) sieve.

<sup>B</sup>If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup>Gravels with 5 to 12% fines require dual symbols:

GW-GM well-graded gravel with silt  
 GW-GC well-graded gravel with clay  
 GP-GM poorly graded gravel with silt  
 GP-GC poorly graded gravel with clay

<sup>D</sup>Sands with 5 to 12% fines require dual symbols:

SW-SM well-graded sand with silt  
 SW-SC well-graded sand with clay  
 SP-SM poorly graded sand with silt  
 SP-SC poorly graded sand with clay

<sup>E</sup> $Cu = D_{60}/D_{10}$ ,  $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

<sup>F</sup>If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup>If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup>If fines are organic, add "with organic fines" to group name.

<sup>I</sup>If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup>If Atterberg limits plot is hatched area, soil is a CL-ML silty clay.

<sup>K</sup>If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.

<sup>L</sup>If soil contains  $\geq 30\%$  plus No. 200, predominantly sand, add "sandy" to group name.

<sup>M</sup>If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

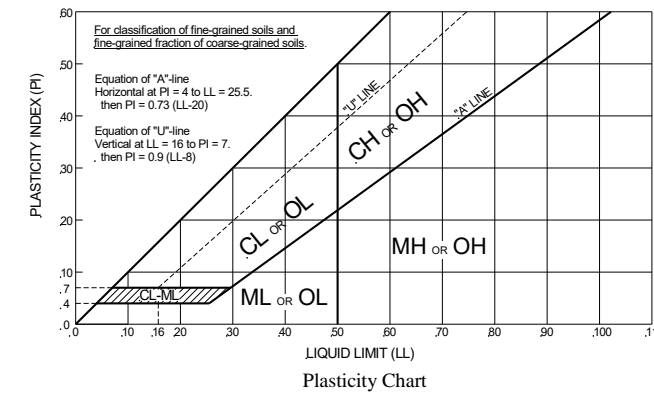
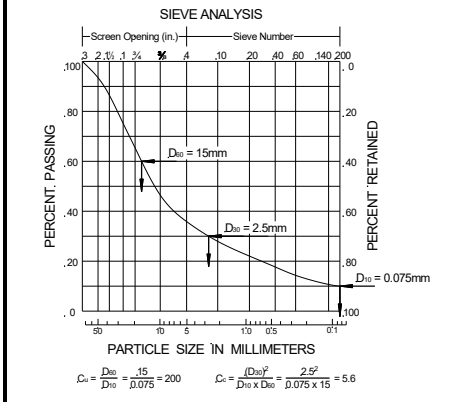
<sup>N</sup>PI  $\geq 4$  and plots on or above "A" line.

<sup>O</sup>PI < 4 or plots below "A" line.

<sup>P</sup>PI plots on or above "A" line.

<sup>Q</sup>PI plots below "A" line.

<sup>R</sup>Fiber Content description shown below.



**ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION**

Grain Size		Gravel Percentages		Consistency of Plastic Soils		Relative Density of Non-Plastic Soils	
Term	Particle Size	Term	Percent	Term	N-Value, BPF	Term	N-Value, BPF
Boulders	Over 12"	A Little Gravel	3% - 14%	Very Soft	less than 2	Very Loose	0 - 4
Cobbles	3" to 12"	With Gravel	15% - 29%	Soft	2 - 4	Loose	5 - 10
Gravel	#4 sieve to 3"	Gravelly	30% - 50%	Firm	5 - 8	Medium Dense	11 - 30
Sand	#200 to #4 sieve			Stiff	9 - 15	Dense	31 - 50
Fines (silt & clay)	Pass #200 sieve			Very Stiff	16 - 30	Very Dense	Greater than 50
				Hard	Greater than 30		
<b>Moisture/Frost Condition (MC Column)</b>		<b>Layering Notes</b>		<b>Peat Description</b>		<b>Organic Description (if no lab tests)</b>	
D (Dry):	Absence of moisture, dusty, dry to touch.	Laminations:	Layers less than 1/2" thick of differing material or color.	Term	Fiber Content (Visual Estimate)	Soils are described as <i>organic</i> , if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. <i>Slightly organic</i> used for borderline cases.	
M (Moist):	Damp, although free water not visible. Soil may still have a high water content (over "optimum").	Lenses:	Pockets or layers greater than 1/2" thick of differing material or color.	Fibric Peat:	Greater than 67%	Root Inclusions	
W (Wet/Waterbearing):	Free water visible, intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.			Hemic Peat:	33 - 67%	With roots: Judged to have sufficient quantity of roots to influence the soil properties.	
F (Frozen):	Soil frozen			Sapric Peat:	Less than 33%	Trace roots: Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.	

# AASHTO SOIL CLASSIFICATION SYSTEM

## AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

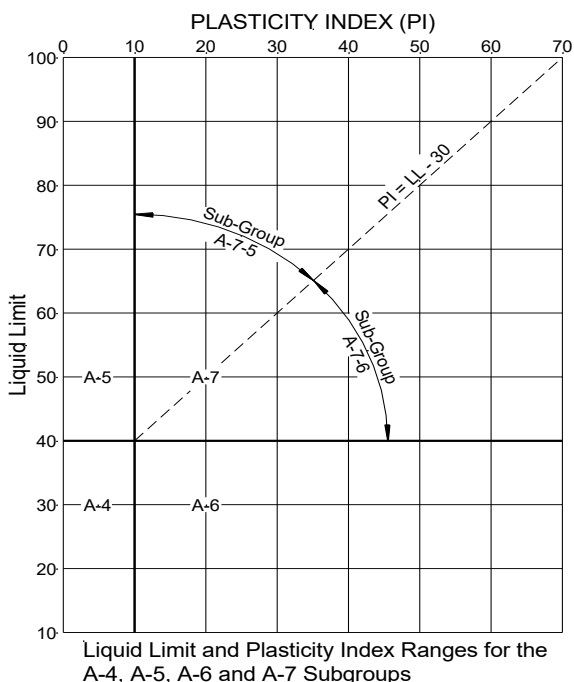
Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing No. 200 sieve)							Silt-Clay Materials (More than 35% passing No. 200 sieve)			
	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5
Sieve Analysis, Percent passing:											
No. 10 (2.00 mm) .....	50 max.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
No. 40 (0.425 mm) .....	30 max.	50 max.	51 min.	.....	.....	.....	.....	.....	.....	.....	.....
No. 200 (0.075 mm) .....	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of Fraction Passing No. 40 (0.425 mm)											
Liquid limit .....	.....	.....	.....	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index .....	6 max.	.....	N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Ratings as Subgrade .....	Excellent to Good							Fair to Poor			

The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

Group A-8 soils are organic clays or peat with organic content >5%.



**Definitions of Gravel, Sand and Silt-Clay**

The terms "gravel", "coarse sand", "fine sand" and "silt-clay", as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions are defined as follows:

**GRAVEL** - Material passing sieve with 3-in. square openings and retained on the No. 10 sieve.

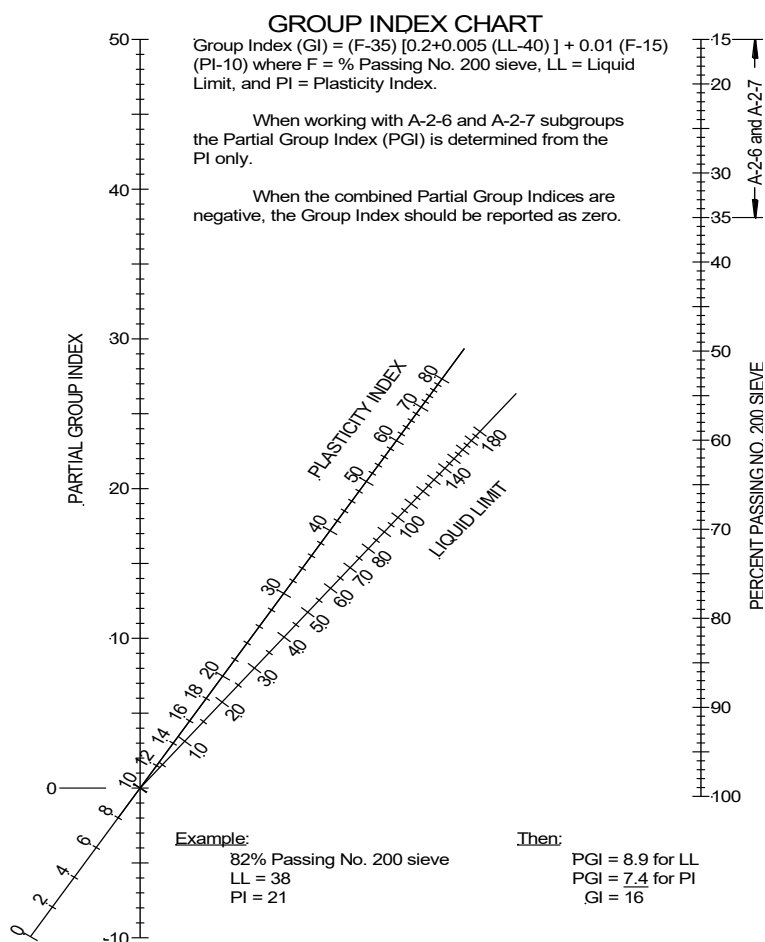
**COARSE SAND** - Material passing the No. 10 sieve and retained on the No. 40 sieve.

**FINE SAND** - Material passing the No. 40 sieve and retained on the No. 200 sieve.

**COMBINED SILT AND CLAY** - Material passing the No. 200 sieve

**BOULDERS** (retained on 3-in. sieve) should be excluded from the portion of the sample to which the classification is applied, but the percentage of such material, if any, in the sample should be recorded.

The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.





**AMERICAN  
ENGINEERING  
TESTING, INC.**

**CSAH 2 Pavement Rehabilitation  
Redwood County, Minnesota**

Core/Boring Location Map 1

Project No. 28-20393

Scale: Shown

Drawn by: TE

Reviewed by: JM

**March 1, 2021**



**CSAH 2 Pavement Rehabilitation  
Redwood County, Minnesota**

Project No. 28-20393

Core/Boring Location Map 2

Scale: Shown

Drawn by: TE

Reviewed by: JM

**March 1, 2021**



**AMERICAN  
ENGINEERING  
TESTING, INC.**

**CSAH 2 Pavement Rehabilitation  
Redwood County, Minnesota**

Core/Boring Location Map 3

Project No. 28-20393

Scale: Shown

Drawn by: TE

Reviewed by: JM

**March 1, 2021**



**AMERICAN  
ENGINEERING  
TESTING, INC.**

**CSAH 2 Pavement Rehabilitation  
Redwood County, Minnesota**

Core/Boring Location Map 4

Project No. 28-20393

Scale: Shown

Drawn by: TE

Reviewed by: JM

**March 1, 2021**



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-1 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **986** LATITUDE: **44.504683°** LONGITUDE: **-94.926117°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	qp	LL	PL	OC
0	5" Bituminous pavement	FILL			CORE						
1	19" FILL, mostly silty sand, a little gravel, dark brown, frozen (A-1-b) (possible aggregate base)				F	DS					
2	FILL, mostly lean clay with sand, slightly organic, black, possible cobbles at 5.5' (A-6)		8	M	SS	8	21				3.9
3											
4											
5											
6			28	M	SS	6	21				
<b>END OF BORING</b>											
Northbound lane											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>3.9</b>		<b>None</b>	
BORING COMPLETED:	<b>1/28/21</b>								
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-2 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **959** LATITUDE: **44.499682°** LONGITUDE: **-94.926143°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS							
							WC	DEN	LL	PL	%-#200			
	6" Bituminous pavement	FILL			CORE									
1	18" FILL, mostly silty sand, a little gravel, brown, frozen (A-1-b) (possible aggregate base)			F	DS									
2	FILL, mostly clayey sand, a little gravel, brown (A-6)													
3			10	M	SS	8	19							
4														
5	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)	COARSE ALLUVIUM												
6			23	M	SS	10								
<b>END OF BORING</b>														
Southbound lane														

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>3.8</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21





# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-4 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.481548°** LONGITUDE: **-94.926250°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	5.75" Bituminous pavement	FILL			CORE						
	11" FILL, mostly silty sand, a little gravel, brown, frozen (A-1-b) (possible aggregate base)				F	DS					
2	FILL, mixture of lean clay and clayey sand, slightly organic, black and brown (A-6)						24				
3	FILL, mostly clayey sand, a little gravel, brown (A-6)			6	M	SS	12	20			
4											
5	FILL, mostly lean clay, slightly organic, a little gravel, black (A-6)										
6				7	M	SS	10	33			
<b>END OF BORING</b>											
Southbound lane											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>4.1</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-5 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.475635°** LONGITUDE: **-94.926240°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	qp	LL	PL	OC
1	5.5" Bituminous pavement	FILL			CORE						
	10.5" FILL, mostly silty sand, a little gravel, brown (A-1-b) (possible aggregate base)										
2	FILL, mostly lean clay, slightly organic, black (A-6)				F	DS	26				
3			11	M	SS	12	30			4.3	
4											
5											
6			7	M	SS	6	39				
<b>END OF BORING</b>											
Northbound lane											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>4.2</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-6 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1023** LATITUDE: **44.468433°** LONGITUDE: **-94.926324°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS						
							WC	DEN	LL	PL	%-#200		
1	5.5" Bituminous pavement	FILL			CORE								
2	18.5" FILL, mostly silty sand, a little gravel, brown (A-1-b) (possible aggregate base)				F	DS							13
3	FILL, mostly lean clay, slightly organic, black (A-6)		10	M	SS	8	20						
4													
5													
6			7	M	SS	10	20						
<b>END OF BORING</b>													
Southbound lane													

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>4.1</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **C-7 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.458599°** LONGITUDE: **-94.926372°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS					
							WC	DEN	LL	PL	%-#200	
1	6" Bituminous pavement	FILL			CORE							
	12" FILL, mostly silty sand, a little gravel, brown, frozen (A-1-b) (possible aggregate base)				F	DS						
2	FILL, mostly lean clay, slightly organic, black (A-6)						26					
3			9	M	SS	12	22					
4												
5	SANDY LEAN CLAY, brown, firm (CL) (A-6)	TILL										
6			7	M	SS	12	28					
<b>END OF BORING</b>												
Northbound lane												

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-4½'</b>	<b>3.25" HSA</b>	<b>1/28/21</b>		<b>6.5</b>	<b>4.5</b>	<b>4.0</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-1 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **986** LATITUDE: **44.504684°** LONGITUDE: **-94.926085°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS							
							WC	DEN	LL	PL	%-#200			
1	10.5" FILL, mostly silty sand, a little gravel, trace roots, brown (A-1-b)	FILL												
1	FILL, mostly lean clay with sand, slightly organic, black (A-6)			F						23				
2	<b>END OF BORING</b>  Northbound shoulder													

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-2 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **959** LATITUDE: **44.499682°** LONGITUDE: **-94.926181°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS					
							WC	DEN	LL	PL	%-#200	
1	11.5" FILL, mostly silty sand with gravel, brown (A-1-b)	FILL										
1	FILL, mostly sandy lean clay, a little gravel, brown (A-6)			F			21					
2	<b>END OF BORING</b>  Southbound shoulder											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-3 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1012** LATITUDE: **44.486648°** LONGITUDE: **-94.926151°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS						
							WC	DEN	LL	PL	%-#200		
1	FILL, mostly silty sand with gravel, brown (A-1-b)	FILL											
2	<b>END OF BORING</b>  Northbound shoulder												

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-4 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.481549°** LONGITUDE: **-94.926286°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS						
							WC	DEN	LL	PL	%-#200		
1	FILL, mostly silty sand with gravel, brown (A-1-b)	FILL											
2	<b>END OF BORING</b>  Southbound shoulder												

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG	
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL		WATER LEVEL
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>			<b>None</b>
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21



# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-5 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.475635°** LONGITUDE: **-94.926203°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS					
							WC	DEN	LL	PL	%-#200	
1	13.5" FILL, mostly silty sand with gravel, brown (A-1-b)	FILL										
2	FILL, mostly clayey sand, a little gravel, brown (A-6)			F			44					
	<b>END OF BORING</b>											
	Northbound shoulder											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG	
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL		WATER LEVEL
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>			<b>None</b>
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21





# SUBSURFACE BORING LOG

AET JOB NO: **28-20393** LOG OF BORING NO. **S-7 (p. 1 of 1)**  
 PROJECT: **CSAH 2 from 350th St to CSAH 11; Redwood County, MN**  
 SURFACE ELEVATION: **1021** LATITUDE: **44.458600°** LONGITUDE: **-94.926340°**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	9.5" FILL, mostly silty sand, a little gravel, brown (A-1-b)	FILL					8				
	FILL, mostly clayey sand, a little gravel, black (A-6)						20				
2	<b>END OF BORING</b>  Northbound shoulder										

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
<b>0-2'</b>	<b>FA</b>	<b>1/28/21</b>		<b>2.0</b>	<b>0.0</b>	<b>2.0</b>		<b>None</b>	
BORING COMPLETED: <b>1/28/21</b>									
DR: <b>BK</b> LG: <b>AK</b> Rig: <b>4</b>									

AET\_CORP W-LAT-LONG 28-20393.GPJ AET+CPT+WELL.GDT 3/1/21

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-01  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.504683  
Longitude: -94.926117  
**Location:** NB lane

### Description:

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 5.00  
**Recovered Core Thickness (in):** 4.70

### Condition:

Core shows slight to moderate stripping throughout.



Recovered Bituminous Core

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-02  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.499682  
Longitude: -94.926143  
**Location:** SB lane

### Description:

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 6.00  
**Recovered Core Thickness (in):** 5.00

### Condition:

Core shows slight to moderate stripping throughout. The bottom crumbled during coring operations



Recovered Bituminous Core

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-03  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.486650  
Longitude: -94.926191  
**Location:** NB lane

### Description:

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 5.50  
**Recovered Core Thickness (in):** 5.10

### Condition:

Core shows moderate to severe stripping throughout.



Recovered Bituminous Core

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-04  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.481548  
Longitude: -94.926250  
**Location:** SB lane

**Description:**

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 5.75  
**Recovered Core Thickness (in):** 5.10

**Condition:**

Core shows moderate to severe stripping throughout.



Recovered Bituminous Core

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-05  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.475635  
Longitude: -94.926240  
**Location:** NB lane

### Description:

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 5.50  
**Recovered Core Thickness (in):** 5.10

### Condition:

Core shows slight stripping in upper 2 inches and moderate to severe stripping at the bottom.



Recovered Bituminous Core

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-06  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.468433  
Longitude: -94.926324  
**Location:** SB lane

**Description:**

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 5.50  
**Recovered Core Thickness (in):** 5.00

**Condition:**

Core shows moderate to severe stripping throughout.



**Recovered Bituminous Core**

## PAVEMENT CORE LOG

**Project:** CSAH 2, Redwood County, MN  
**AET Project Number:** 28-20393  
**Roadway:** CSAH 2 from 305th St to CSAH 11

**Core ID:** C-07  
**Date Cored:** 1/28/2021  
**GPS Coordinates:**  
Latitude: 44.458599  
Longitude: -94.926372  
**Location:** NB lane

### Description:

**Core Diameter (in):** 3  
**Bituminous Downhole Depth (in):** 6.00  
**Recovered Core Thickness (in):** 5.00

### Condition:

Core shows moderate to severe stripping throughout.



Recovered Bituminous Core



# **Appendix B**

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Ground Penetrating Radar Field Exploration and Testing  
GPR Data and Analysis Results Sheets

## Appendix B

### Ground Penetrating Radar Field Exploration and Testing

#### AET Project No. 28-20391

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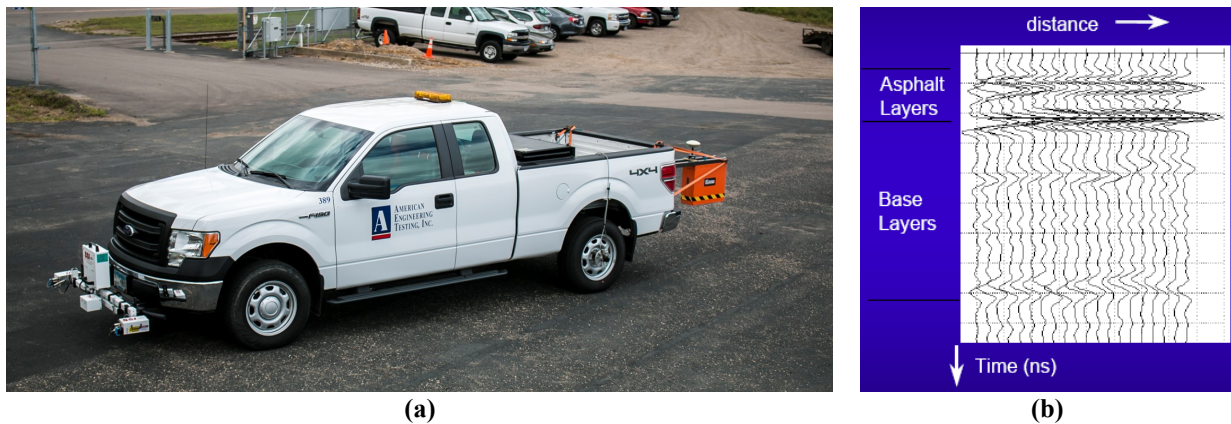
### B.1 FIELD EXPLORATION

The pavement structural conditions at the site were evaluated nondestructively using Ground Penetrating Radar (GPR). The description of the equipment precedes the GPR Data and Analysis Results in this appendix.

### B.2 EQUIPMENT DESCRIPTION

#### B.2.1 GSSI GPR Test System

The GPR test system owned by AET is a bumper-mounted, 2 GHz air-coupled antenna; dual-channel controller/data acquisition system; wheel-mounted DMI (Distance Measuring Instrument); and laptop with the GSSI controller software. AET uses GPR systems for testing and analysis that meets the ASTM D4748-10 Determining the Thickness of Bound Pavement Layers Using Short-Pulse Radar and D6087 Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar test standards. Figure A1 provides an example of a vehicle outfitted with the air-coupled antenna and the raw GPR data prior to processing.



**Figure B1. (a) GSSI 2 GHz Air-coupled GPR Test System mounted to the rear of an AET survey vehicle and (b) example of raw data collected using the GPR test system**

The GPR antenna emits a high-frequency electromagnetic wave into the material under investigation. The reflected energy caused by changes in the electromagnetic properties within the material is detected by a receiver antenna and recorded for subsequent analysis. The 2 GHz air-coupled GPR can collect radar waveforms at more than 100 signals per second, which allows for data to be collected at driving speeds along the longitudinal dimension of a road with the antennas fixed at the rear or in front of the vehicle.

AET prefers the 2 GHz antenna for road surveys as it combines excellent resolution with reasonable depth penetration (18-24 inches in pavement materials). As data collection is performed at normal driving speeds (45-55 mph), no lane closures are required. At this speed the 2 GHz antenna can collect data at 6-inch interval (2 scans/foot), however data collection varies by project. Specific data collection rates (in scans per foot) will be described in project reports. Vertical scans consist of 512 samples and the recorded length in time of each scan is 12 nanoseconds. Data acquisition uses 300 MHz high pass and 5,000 MHz low pass filters.

In a GPR test, the antenna is moved continuously across the test surface and the control unit collects data at a specified distance increment. In this way, the data collection rate is independent of the scan rate. Alternatively, scanning can be performed at a constant rate of time, regardless of the scan distance. Single point scans can be performed as well. Data is reviewed in the controller software in real-time during field testing to identify reflections and ensure proper data collection parameters.

#### B.2.2 System Calibrations

Prior to each use, the GPR test system is calibrated using metal plate and air calibration methods suggested by the GPR manufacturer. In addition, the DMI is calibrated to within +/- 1 foot/mile.

- Metal plate calibration is obtained with the antenna placed over a metal plate at the same elevation as a scan obtained over pavement. Time-based collection (as opposed to distance) is performed to provide the

## **Appendix B**

### **Ground Penetrating Radar Field Exploration and Testing**

#### **AET Project No. 28-20391**

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velocity of the radar energy in terms of reflection strengths (amplitudes) from a pavement layer interface relative to a perfect reflector (a metal plate).

- Air calibrations are also performed in time-based collection mode to account for the vertical travel of the antenna during vehicle-mounted testing. To approximate the range of travel encountered during testing, data is collected for fifteen seconds while an operator moves the vehicle vertically (by jumping up and down on the mounting point at the bumper) to record data. This information is used in later GPR analysis.
- The DMI is calibrated by laying out a long distance (typically 100 feet) with a tape measure, marking the termini, and traversing the known distance. Recorded distance in the controller software is confirmed against actual distance, and adjustments in the controller software are made to ensure that DMI information that is paired with GPR data is accurate.

#### **B.2.3 Linear Distance and Spatial Reference System**

The distance measuring instrument (DMI) is a trailer mounted two phase encoder system. When DMI is connected to the GPR controller it provides for automatic display and recording distance information in both English and metric units within a 1-foot (0.3 meters) resolution when calibrated using provided procedure in the controller software.

The spatial reference system is provided using either Trimble or EOS Arrow Global Positioning System (GPS) systems that consist of a fully integrated receiver, antenna, and battery unit to provide subfoot (30 cm) post processed accuracy. All GPS information is coupled with raw GPR data within the GPR controller software.

#### **B.2.4 Camera Monitoring System**

A truck-mounted, battery-operated independent 4K waterproof multi-functional digital camera with an SD card is used to capture digital video of the pavement surface during GPR data collection.

### **B.3 SAMPLING METHODS**

Sampling methods using the GPR test system comply with the test standard (ASTM D4748-10). Sampling rates (i.e. scans per foot), sampling location (e.g. right wheel path, middle lane, both wheel paths), and the use of alternative equipment for GPR collection, if applicable (e.g. ground-coupled antennas), are described in the body of the project report.

### **B.4 QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA)**

Beside the daily metal plate calibration, the DMI is also calibrated at regular intervals by driving the vehicle over a known distance to calculate the distance scale factor. The GPR will be monitored in real time in the data collection vehicle to minimize data errors. The GPR units will be identified with a unique number and that number will accompany all data reported from that unit as required in the QC/QA plan.

Scheduled preventive maintenance ensures proper equipment operation and helps identify potential problems that can be corrected to avoid poor quality or missing data that results if the equipment malfunctions while on site. The routine and major maintenance procedures established by the Federal Highway Administration's Long-Term Pavement Performance research program are adopted and any maintenance has been done at the end of the day after the testing is complete and become part of the routine performed at the end of each test/travel day and on days when no other work is scheduled.

As noted in the applicable test standard (ASTM D4748-10), quality assurance of GPR data is compromised when suboptimal test conditions exist. Such conditions may include wet surfaces (including standing water), ambient electromagnetic interference, or pavement distresses that can significantly scatter the GPR signal.

### **B.5 DATA ANALYSIS METHODS**

#### **B.5.1 Data Editing**

Field acquisition is seldom so routine that no errors, omissions, or data redundancy occur. Data editing encompasses issues such as data re-organization, data file merging, data header or background information updates, repositioning, and inclusion of elevation information with the data.

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**Ground Penetrating Radar Field Exploration and Testing**  
**AET Project No. 28-20391**

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**B.5.2 Basic Processing**

Basic data processing addresses some of the fundamental manipulations applied to data to make a more acceptable product for initial interpretation and data evaluation. In most instances this type of processing is already applied in real-time to generate the real-time display. The advantage of post survey processing is that the basic processing can be done more systematically and non-causal operators to remove or enhance certain features can be applied.

The Reflection Picking procedure is used to eliminate unwanted noise, detects significant reflections, and records the corresponding time and depth. It uses antenna calibration file data to calculate the radar signal velocity within the pavement.

**B.5.3 Advanced Processing**

Advanced data processing addresses the types of processing which require a certain amount of operator bias to be applied and which will result in data which are significantly different from the raw information which were input to the processing. This stage of analysis relies on supplementary resources (e.g. boring/coring logs, design plans, as-built records, historical records, conversations with road engineers/supervisors).

**B.5.4 Data Interpretation**

In some cases, automated layer interpretation modules within the analysis software can be used from preliminary analysis to map structural layers and calculate the corresponding velocities and depths. When used, the results from these modules require engineering review and approval.

**B.6 TEST LIMITATIONS**

**B.6.1 Test Methods**

The testing we performed identified pavement conditions only at those points where we measured pavement thicknesses and observed pavement surface conditions. Depending on the sampling methods and sampling frequency, every location may not be tested. Test conditions may limit the quality of the data collected, and some anomalies may be present in the pavement that compromise data and/or data collection at a given location.

Furthermore, because analysis procedures involve matters of engineering judgement, the final analysis developed represents our professional opinions about the subsurface conditions. More specifically, as relates to pavement systems, assessing layer thicknesses using GPR is a matter of engineering judgement. To enrich the analysis, we rely on supporting test methods and project information. However, even with supporting information, the distinction between layers in the road is not always explicit. Factors influencing definition of radar scans include ambient electromagnetic interference, the presence of moisture, the presence of voids, and the similarity of material layer type between layers.

Other factors external to related to methods and analysis data may require that we alter our conclusions and recommendations accordingly.

**B.6.2 Test Standards**

Pavement testing is performed in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

**B.7 SUPPORTING TEST METHODS**

**B.7.1 Soil Boring/Coring Field Exploration**

If both pavement thicknesses and subgrade soil types and conditions are desired, pavement cores and soil borings are obtained. The limited number of cores and borings are necessary to verify the GPR layer thickness data.

**B.7.2 Pavement Surface Condition**

Certain pavement distresses may affect the electromagnetic signal to an extent that complicates the analysis of GPR data. The results of a pavement condition survey are useful to identify near-surface features (e.g. stripped asphalt) or sub-surface features (e.g. local saturated layers due to ingress of water at the surface) when reviewing GPR data.

**Appendix B**  
**Ground Penetrating Radar Field Exploration and Testing**  
**AET Project No. 28-20391**

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When we do not perform a standard pavement condition survey alongside GPR data, we rely on GPR operators to note possible distresses as they traverse the pavement from about 1 ft (0.3 m) in front of vehicle to about 30 ft (9 m) ahead. These test notes are consulted during GPR analysis, however they are not a substitute for a conventional rigorous pavement condition survey.



## American Engineering Testing, Inc.

550 Cleveland Avenue North

St. Paul, Minnesota 55114

Phone: (651) 659-9001

Fax: (651) 659-1379

### GENERAL INFORMATION: GROUND PENETRATING RADAR

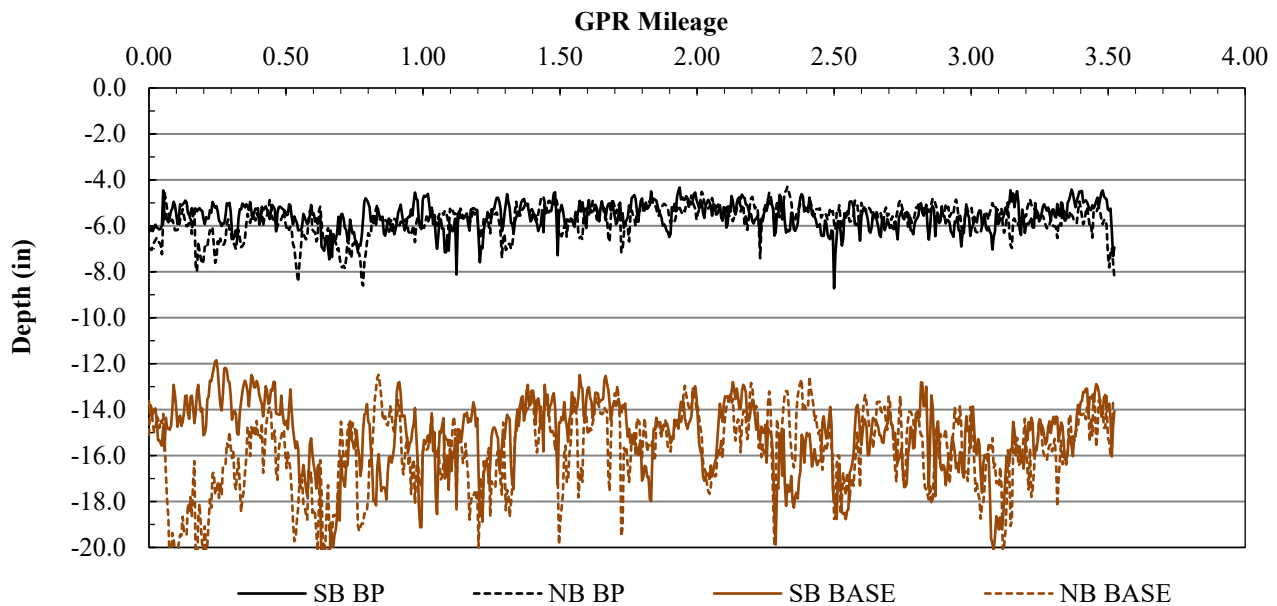
<b>Project:</b> CSAH 2, Redwood County	<b>Date:</b> 3/30/21
<b>AET Job No.:</b> 28-20393	<b>Test Date:</b> 1/12/21
<b>Road:</b> CSAH 2	<b>Section/Grid:</b> S-01
<b>From:</b> 305th St	<b>To:</b> CSAH 11

### SUMMARY STATISTICS

Units: inches

Layer	SB				NB			
	Average	CV	15th	Min.	Average	CV	15th	Min.
BP	5.6	10%	5.0	4.3	5.8	12%	5.2	4.3
Base	9.6	15%	8.1	6.3	10.1	15%	8.5	6.0
BP + Base	15.2	11%	13.5	11.9	15.8	11%	14.0	12.5

### Ground Penetrating Radar Pavement Thickness Survey



**Report of Geotechnical Exploration**

CSAH 2 – Redwood County, MN

June 18, 2021

Report No. 28-20393

AMERICAN

ENGINEERING

TESTING, INC.

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# **Appendix C**

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Geotechnical Report Limitations and Guidelines for Use

# Appendix C

## Geotechnical Report Limitations and Guidelines for Use

### Report No. 28-20393

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#### C.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by GBA<sup>1</sup>, of which, we are a member firm.

#### C.2 RISK MANAGEMENT INFORMATION

##### C.2.1 Understand the Geotechnical Engineering Services Provided for this Report

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

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

##### C.2.2 Geotechnical Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client.

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

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

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

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

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<sup>1</sup> Geoprofessional Business Association, 1300 Piccard Drive, LL14, Rockville, MD 20850  
Telephone: 301/565-2733: [www.geoprofessional.org](http://www.geoprofessional.org), 2019

## **Appendix C**

### **Geotechnical Report Limitations and Guidelines for Use**

#### **Report No. 28-20393**

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#### **C.2.3 Read the Full Report**

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

#### **C.2.4 You Need to Inform Your Geotechnical Engineer About Change**

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

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

As a general rule, always inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

#### **C.2.5 Most of the “Findings” Related in This Report Are Professional Opinions**

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

#### **C.2.6 This Report’s Recommendations Are Confirmation-Dependent**

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

#### **C.2.7 This Report Could Be Misinterpreted**

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

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

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

#### **C.2.8 Give Constructors a Complete Report and Guidance**

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical engineering report, along with any attachments or appendices, with your contract documents, but be certain to note conspicuously that you’ve included the material for information purposes only. To avoid misunderstanding, you may also want to note that “informational purposes” means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, only from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and be sure to allow enough time to permit them to do so.

## **Appendix C**

### **Geotechnical Report Limitations and Guidelines for Use**

#### **Report No. 28-20393**

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Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

#### **C.2.9 Read Responsibility Provisions Closely**

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

#### **C.2.10 Geoenvironmental Concerns Are Not Covered**

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

#### **C.2.11 Obtain Professional Assistance to Deal with Moisture Infiltration and Mold**

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