AMERICAN ENGINEERING TESTING, INC.

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- MATERIALS
- FORENSICS

REPORT OF GEOTECHNICAL EXPLORATION AND PAVEMENT EVALUATION

120th Street S and Morgan Avenue S Roadway Improvements

Denmark Township, Minnesota

Report No. 28-20300

Date:

May 4, 2020

Prepared for:

Denmark Township
14008 90th Street S
Hastings, MN 55033

www.amengtest.com

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May 4, 2020

Denmark Township
14008 90th Street S
Hastings, MN 55033

Attn: Mr. Ryan Stempski, PE
Ryan.Stempski@focusengineeringinc.com

RE: Geotechnical Exploration and Pavement Evaluation
120th Street S and Morgan Avenue S Roadway Improvements
Denmark Township, Minnesota
AET Report No. 28-20300

Dear Mr. Stempski:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the 120th Street S and Morgan Avenue S Roadway Improvements project in Denmark Township, Minnesota. These services were performed according to our proposal dated March 16, 2020 and your authorization on April 7, 2020.

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.

Krystle R. Staker
Project Manager
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SIGNATURE PAGE

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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: Chunhua Han

Date: 4/29/2020 License #: 22493

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1.0 INTRODUCTION

We understand Denmark Township is planning roadway improvements on 120th Street S and Morgan Ave S from approximately 300 feet east of Margo Ave S to 122nd Street S.

To assist in planning and design, Denmark Township has authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration and pavement evaluation survey to include pavement coring with hand augers, ground penetrating radar (GPR), falling weight deflectometer (FWD), and perform a geotechnical engineering review for the project area. 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 Denmark Township dated March 16, 2020. The authorized scope of services consisted of the following:

- Perform falling weight deflectometer (FWD) testing in one direction of travel on 0.9 centerline miles at spacing intervals of 250 feet.
- Perform a ground penetrating radar (GPR) survey in both directions of travel on approximately 1.8 lane miles at a rate of 4 scans per foot.
- Obtain a total of 2, four-inch diameter pavement cores with hand augers through the base course.
- Laboratory testing.
- Geotechnical engineering review based on the data obtained and preparation of 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

We understand that 120th St S and Morgan Ave S will be designed as a 7-ton roadway. The roadway segment is primarily residential with occasional light commercial traffic. Traffic volumes are anticipated to be less than 400 ADT.

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.

3.1 References

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

4.0 PAVEMENT & SUBSURFACE EXPLORATION TESTING PROGRAM

4.1 Pavement Testing Program

4.1.1 Pavement Thickness Testing (GPR)

The pavement section thickness testing program conducted for this project consisted of a high speed (air coupled) GPR antenna that collected material layer thickness data at a rate of four scans per foot. The data was collected using a 2 GHz antenna, which generally allows material layer measurements at depths of 18 to 20 inches with a resolution less than about ½ inch. The GPR data collection is tied to GPS coordinates. The test data and details of the methods used appear in Appendix B.

The GPR data was collected on April 13, 2020 according to SIR-30 processor settings established by GSSI RoadScan system. A calibration file, required for data post-processing, was collected prior to testing. Figure 1 shows the GPR scanning routes. The GPR interface identification was accomplished using RADAN 7.0, a proprietary software package included with the GSSI RoadScan system. The software includes tools to aid in delineating pavement layer transitions, and automatically calculates their depths from the pavement surface using the calibration file(s) collected prior to testing. The identified layer(s) were also compared to the pavement core and hand auger data (when available) to validate the accuracy of the layer thicknesses.

The total depth of pavement is not always explicitly clear. Where gaps in clear identification of the pavement and base layer thicknesses are encountered, they 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 points. 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 (e.g. gravel vs. gravelly sand).

4.1.2 Digital Video Log (DVL)

To assist in the evaluation of the existing pavement surface condition, digital video was collected during the collection of GPR data. The collection process consists of high definition digital video cameras, mounted on a moving vehicle to capture images of the pavement surface for evaluation of surface distress. The DVL is reviewed to identify significant pavement distresses that may affect pavement section design recommendations.

4.1.3 Pavement Deflection Testing (FWD)

The pavement deflection testing program conducted for the project consisted of FWD testing on approximately 0.9 centerline miles. The testing was completed in one direction of travel, at interval spacing of 250 feet. After seating drops, data for four impulse loads (two at 6,000 lbs. and two at 9,000 lbs. nominal load) were collected at each test point. The test data and details of the methods used appear in Appendix C.

The FWD testing was performed on April 13, 2020 using a Dynatest 8000 falling weight deflectometer (FWD). The FWD data collection is tied to GPS coordinates. Figure 3 shows the approximate FWD test point locations.

The deflection data was analyzed using MnDOT methods for determining the in-place (effective) subgrade and pavement strength, as well as allowable axle loads for a roadway (MnDOT Investigation 183 revised in 1983). The MnDOT methods use the Hogg Model for estimating the subgrade R-value. The effective GE of a pavement system is estimated from the deflection relationship equation, derived from MnDOT Investigations 183 and 195. Our methodology uses MnDOT's Investigation 183 for calculation of an estimated load capacity in late spring and required overlay to estimate the structure for future assumed traffic loading.

4.2 Subsurface Field Exploration Program

The subsurface exploration program conducted for the project consisted of 2, four-inch diameter pavement cores with hand augers through the base course. The pavement cores were performed on April 22, 2020. The approximate pavement core locations were selected by AET after preliminary review of the GPR data.

4.3 Laboratory Testing Program

The laboratory testing program included visual/manual classification, moisture content and sieve analysis testing on the samples obtained from the pavement core locations. Pertinent laboratory information is included on the pavement core log reports and complete test reports are attached in Appendix A.

5.0 SITE CONDITIONS

5.1 Surface Observations

The surface of the bituminous pavement was observed at the time of testing and reviewed from the collected DVL. The major pavement distresses identified along the roadway include moderate to high severity longitudinal and transverse cracking, fatigue (alligator) cracking, delamination of fog seal, edge cracking and failure, and raveling. Other pavement distresses identified include potholes and depressions. Maintenance repairs observed include the application of a fog seal.

5.2 Pavement Thickness

5.2.1 Pavement Cores

AET performed 2, four-inch diameter pavement cores with hand augers through the aggregate base layer (C-1 and C-2). Bituminous pavement and possible aggregate base classified as A-1-a were encountered at each of the pavement core locations. Table 1 below shows the field downhole measurements of the pavement core and aggregate base thicknesses encountered at each test location. The bituminous thickness and material quality at C-1 and C-2 were quite different. The sand and oil mix at C-1 was severely stripped with only top 1 inch extracted as an intact core, while the bituminous mix at C-2 was moderately stripped with two, mostly intact layers extracted.

Table 1. Pavement Core/Hand Auger Results

Roadway	Core ID	Bituminous Thickness (in)	Base Thickness (in)	Total Thickness (in)
120th Street S, EB Lane	C-1	5.0	4.0	9.0
Morgan Ave S, NB Lane	C-2	3.0	8.0	11.0

Reports containing the photographs and measurements of the pavement cores are included in Appendix A. Figure 1 presents the pavement core locations.

5.2.2 Ground Penetrating Radar

The GPR data show clear interfaces between the bituminous and possible aggregate base with a picking rate of 100%. The GPR data show clear interfaces between the possible aggregate base and underlying soils with a picking rate of 100% in the east bound lane and a picking rate of 94% in the west bound lane. Table 2 below presents the surface layer of bituminous as "Surface" and the possible aggregate base layer as "Base." Table 2 also shows the statistical results of the bituminous surface and possible aggregate base layer thickness measurements by GPR. 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.

Table 2. GPR Thickness Results (inches)

Termini		Surface (inches)			Base (inches)		
Begin	End	Avg	CV	15th	Avg	CV	15th
~300 ft E of Margo Ave S	122nd St S	4.5	33%	2.9	6.6	27%	4.7

Note: Avg – Average; CV – Coefficient of Variation; 15th – 15th Percentile.

The plots identifying layer thicknesses, included in Appendix B, are data points collected at 3-inch spacing and averaged over 10 feet. Figure 2 presents a visual representation of the surface thickness in one direction.

5.3 Pavement Strength (FWD)

Table 3 summarizes the results of our FWD analysis. The layer thicknesses used in our analysis were the average thickness calculated from the GPR data. For estimating the spring load capacity presented in this table, we used the predicted 20-year ESAL forecast based on existing traffic. The subgrade R-value at each test location is also shown on Figure 3 attached at the end of this report.

Table 3. Summary of FWD Analysis Results

Begin	End	Effective R-value			Effective GE (inches)			Spring Load Capacity (tons/axle)		
		Avg	CV	15th	Avg	CV	15th	Avg	CV	15th
~300 ft E of Margo Ave S	122nd St S	12.4	42%	8.2	7.3	75%	1.8	6.6	36%	4.6

Note: Avg – Average; CV – Coefficient of Variation; 15th – 15th Percentile.

6.0 PAVEMENT RECOMMENDATIONS

6.1 Pavement Section Evaluation and Discussion

Based upon our review of the pavement condition and thickness, pavement cores, and effective subgrade R-values, it is in our opinion that the rehabilitation method most suitable for this roadway would be full reconstruction. The existing bituminous exhibited moderate to severe stripping and deterioration in the pavement cores and significant pavement distresses were observed at the surface. The FWD testing also identified areas that had an effective R-value of less than 10, requiring subgrade corrections to support traffic loads.

A full-depth reclamation approach may be considered; however, stockpiling of the recycled base to make subgrade corrections should be considered. This roadway segment would not be a candidate for a mill-and-overlay approach due to the poor bituminous condition or a resurfacing approach due to the areas of weak subgrade.

Please see the attached standard data sheets entitled "Definitions Relating to Pavement Construction" and "Bituminous Pavement and Subgrade Preparation" for definitions and more information related to pavement construction.

6.2 R-Value

We have used MnDOT's *Flexible Pavement Design Using Soil Factors* chart to correlate the R-value determined by the FWD testing to Soil Factors (S.F.). The 15th percentile of the effective R-value is 8.2 and our recommended S.F. for this roadway is 130.

6.3 Pavement Design

The current annual average daily traffic (AADT) along this roadway segment is less than 400. Using the *Flexible Pavement Design Using Soil Factors* chart, for a 7-ton roadway with less than 400 ADT and the S.F. correlated from the effective R-value, the minimum bituminous Granular

Equivalent (GE) is 7 and the total minimum GE is 14.

6.4 Full Reconstruction

The reconstruction approach will provide the best long-term pavement performance, rebuilding the pavement and subgrade of the existing road. With reconstruction, the intent is to improve the subgrade conditions as needed to provide proper strength and proper frost/drainage properties. Care should be taken to remove and correct for soils that are silty or clayey, which are considered highly frost susceptible and are slow draining materials.

6.4.1 Subgrade Preparation

Bituminous pavement and aggregate base should be removed from existing pavement areas. Pavement recycling for this project could be performed by milling and removing the existing bituminous surfaces and then removing the existing aggregate base for blending outside the existing roadbed to create a recycled aggregate base material.

The final subgrade should have proper stability within the critical subgrade zone. Where granular soils are exposed (i.e., sands to silty sands), we recommend applying surface compaction. This compaction should take place with at least 4 passes of a self-propelled vibratory roller compactor having a drum diameter of at least 3 feet. Overall stability should be evaluated during the compaction process (deflection judgments by an AET geotechnical/pavement engineer). Instability will likely be a result of wetter clayey/silty soils beneath the exposed sandy soils. If clayey soils are exposed, stability should be evaluated using the test roll procedure.

Where unstable soils are found, these soils should be improved by means of scarification, drying, and recompaction; or by subcutting and replacement. We recommend the final soils remaining in place pass a test roll prior to placing the aggregate base.

6.4.2 Pavement Section

Table 4 below shows our recommended pavement section based on the assumed traffic information, the subsurface conditions, and a "20-year" pavement life.

Table 4. Full Reconstruction Pavement Design

Layer	MnDOT Material Type (Spec.)	120th St S/ Morgan Ave S	G.E.
Bituminous Wear	SPWEA240C (PG58H-34)	1.5"	3.38
Bituminous Wear	SPWEB240C (PG58H-34)	2.0"	4.50
Aggregate Base	Class 5, 5Q, or 6 (3138)	6.5"	6.50
Subgrade Preparation	Per this report	12.0"	-
		Total GE	**14.38**

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 above;

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% to reduce cracking. If different bituminous mixes are utilized, a lower percentage of RAP may be needed.

6.4.3 Aggregate Base

New aggregate base placed for pavement support should meet the gradation and quality requirements for Class 5, 5Q, or 6 per MnDOT Spec. 3138. Any bituminous millings placed on the roadway as aggregate base should meet the requirements of 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.

6.5 Full Depth Reclamation (FDR)

FDR involves crushing both the bituminous and at least a portion of the aggregate base layer in-place and blending the material with the intent of creating a recycled aggregate base. A fresh bituminous surface is then placed over the reclaimed material.

Full-depth pavement reclamation can be either non-stabilized or stabilized. In stabilized reclamation, emulsified asphalt or cement is added to the reclaimed material, which stabilizes and improves the reclaimed aggregate base and allows for thinner bituminous surfacing. These processes require that appropriate material types and thicknesses be in-place.

We recommend a non-stabilized FDR to a reclamation depth of 9-inches. Once the reclamation process is complete, we recommend stockpiling the FDR material off the roadway to allow for improvements to the weak subgrade areas identified by the FWD testing and 12 inches of subgrade preparation per Section 6.4.1 of this report. The design presented in Table 5 will not result in an increase in grade.

Table 5. FDR Pavement Section

Layer	MnDOT Material Type (Spec.)	120th St S/ Morgan Ave S	G.E.
Bituminous Wear Upper	SPWEA240C (PG58H-34)	2.0”	4.5
Bituminous Wear Lower	SPWEB240C (PG58H-34)	2.0”	4.5
Full Depth Reclamation	FDR (2215.B)	5.0”	5.0
Subgrade Preparation	Per this report	12.0”	
		Total GE	**14.0**

We recommend the Full Depth Reclamation (FDR) be conducted in accordance with the applicable subsections of MnDOT Spec. 2215 Reclamation. We recommend the reclaimed FDR material and

bituminous millings placed on the roadway as aggregate base meet the requirements of MnDOT Spec. 3135 Modified Aggregate Bases.

6.6 Pavement Maintenance

Regardless of the improvement approach selected, all bituminous pavements require on-going maintenance to reach their design life. Even if placed and compacted properly over 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 patching of cracks and local distressed areas be implemented. Seal coating of the pavement surface after 3 to 5 years also helps prolong the pavement life.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

7.1.1 Water in Excavation

Groundwater was only measured in our borings in the ravine 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.

7.1.2 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.

7.1.3 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 recompacted back into place, or they should be removed and replaced with drier imported fill.

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

8.0 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".

Standard Sheets

Definitions Related to Pavement Construction
Bituminous Pavement and Subgrade Preparation

DEFINITIONS RELATING TO PAVEMENT CONSTRUCTION

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 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

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 draintile 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, draintile lines can be limited to finger drains at the catch basins. Even if a sand layer is not placed, strategically placed draintile 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.

Appendix A

Geotechnical Field Exploration and Testing
MnDOT Boring Log Descriptive Terminology
AASHTO Soil Classification System
Figure 1 – Pavement Core Locations & GPR Testing Route
Pavement Core Logs
Material Test Reports

Appendix A
Geotechnical Field Exploration and Testing
AET No. 28-20300

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by sampling 2 pavement cores. The locations of the pavement cores appear on Figure 1.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} 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_{60} 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_{60} 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 MnDOT Textural Soil Triangle. 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.

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.6 TEST STANDARD LIMITATIONS

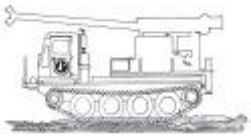
Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

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.

Minnesota Department of Transportation Geotechnical Section

Boring Log Descriptive Terminology (English Units)



USER NOTES, ABBREVIATIONS AND DEFINITIONS - Additional information available in Geotechnical Manual.

This boring was made by ordinary and conventional methods and with care deemed adequate for the Department's design purposes. Since this boring was not taken to gather information relating to the construction of the project, the data noted in the field and recorded may not necessarily be the same as that which a contractor would desire. While the Department believes that the information as to the conditions and materials reported is accurate, it does not warrant that the information is necessarily complete. This information has been edited or abridged and may not reveal all the information which might be useful or of interest to the contractor. Consequently, the Department will make available at its offices, the field logs relating to this boring.

Since subsurface conditions outside each borehole are unknown, and soil, rock and water conditions cannot be relied upon to be consistent or uniform, no warrant is made that conditions adjacent to this boring will necessarily be the same as or similar to those shown on this log. Furthermore, the Department will not be responsible for any interpretations, assumptions, projections or interpolations made by contractors, or other users of this log.

Water levels recorded on this log should be used with discretion since the use of drilling fluids in borings may seriously distort the true field conditions. Also, water levels in cohesive soils often take extended periods of time to reach equilibrium and thus reflect their true field level. Water levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that this boring was dry or that the contractor will not encounter subsurface water during the course of construction.

WATER MEASUREMENT

AB.....After Bailing
AC.....After Completion
AF.....After Flushing
w/C.....with Casing
w/M.....with Mud
WSD.....While Sampling/Drilling
w/AUG.....with Hollow Stem Auger

MISCELLANEOUS

NA.....Not Applicable
w/.....with
w/o.....with out
sat.....saturated

DRILLING OPERATIONS

AUG.....Augered
CD.....Core Drilled
DBD.....Disturbed by Drilling
DBJ.....Disturbed by Jetting
PD.....Plug Drilled
ST.....Split Tube (SPT test)
TW.....Thinwall (Shelby Tube)
WS.....Wash Sample
NSR.....No Sample Retrieved
WH.....Weight of Hammer
WR.....Weight of Rod
Mud.....Drilling Fluids in Sample
CS.....Continuous Sample

SOIL/CORE TESTS

SPT N_{60}.....ASTM D1586 Modified
Blows per foot with 140 lb. hammer and a standard energy of 210 ft-lbs. This energy represents 60% of the potential energy of the system and is the average energy provided by a Rope & Cathead system.
MC.....Moisture Content
COH.....Cohesion
?.....Sample Density
LL.....Liquid Limit
PI.....Plasticity Index
F.....Phi Angle
REC.....Percent Core Recovered
RQD.....Rock Quality Description
(Percent of total core interval consisting of unbroken pieces 4 inches or longer)
ACL.....Average Core Length
(Average length of core that is greater than 4 inches long)
Core Breaks.....Number of natural core breaks per 2-foot interval.

DISCONTINUITY SPACING

Fractures	Distance	Bedding
Very Close	<2 inches	Very Thin
Close	2-12 inches	Thin
Mod. Close	12-36 inches	Medium
Wide	>36 inches	Thick

DRILLING SYMBOLS

- Vane Shear Test
- WS — Washed Sample (Collected during plug drilling)
- Augered
- Plug Drilled
- Split Tube Sample (SPT N_{60} 2 in. spilt tube with liners)
- Thin Wall Sample (3 in. Shelby Tube)
- Core Drilled (NV Core Barrel unless otherwise noted)
- CS — Continuous Soil Sample
- A/J — Augered & Jetted
- Jet — Jetted
- A/P — Augered & Plug Drilled

RELATIVE DENSITY

Compactness - Granular Soils	BPF
very loose	0-4
loose	5-10
medium dense	11-24
dense	25-50
very dense	>50

Consistency - Cohesive Soils	BPF
very soft	0-1
soft	2-4
firm	5-8
stiff	9-15
very stiff	16-30
hard	31-60
very hard	> 60

COLOR

blk.....Black
grn.....Green
orng.....Orange
dk.....Dark
IOS.....Iron Oxide Stained
wht.....White
brn.....Brown
yel.....Yellow
lt.....Light

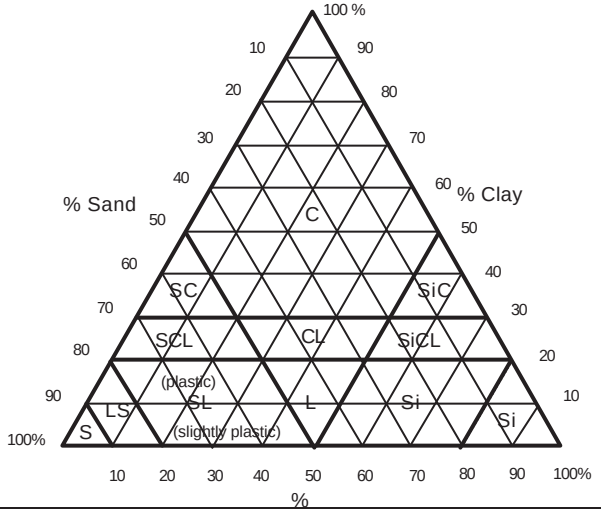
GRAIN SIZE /PLASTICITY

VF.....Very Fine
F.....Fine
Cr.....Coarse
pl.....Plastic
slpl.....Slightly Plastic

SOIL/ROCK TERMS

C.....Clay
L.....Loam
S.....Sand
Si.....Silt
Lmst.....Limestone
Sst.....Sandstone
Dolo.....Dolostone
wx.....weathered
G.....Gravel (No. 10 Sieve to 3 inches)
Bldr.....Boulder (over 3 inches)
T.....till (unsorted, nonstratified glacial deposits)

Mn/DOT Triangular Textural Soil Classification System



AASHTO SOIL CLASSIFICATION SYSTEM

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

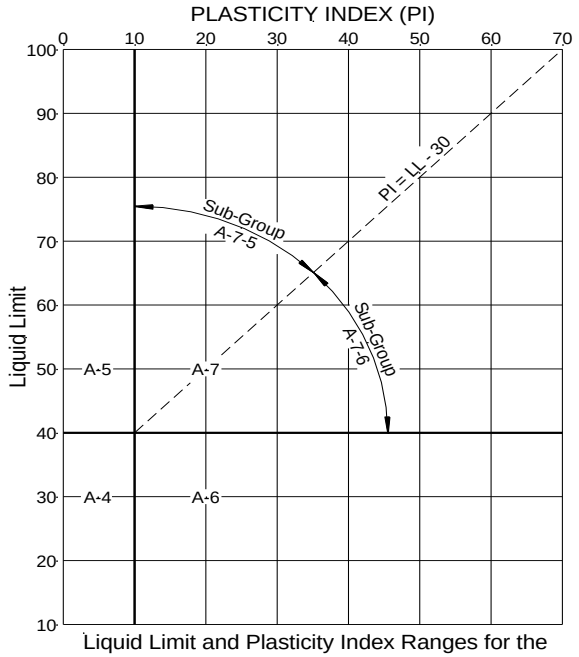
Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing No. 200 sieve)							Silt-Clay Materials (More than 35% passing No. 200 sieve)			
Group Classification	A-1			A-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
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			

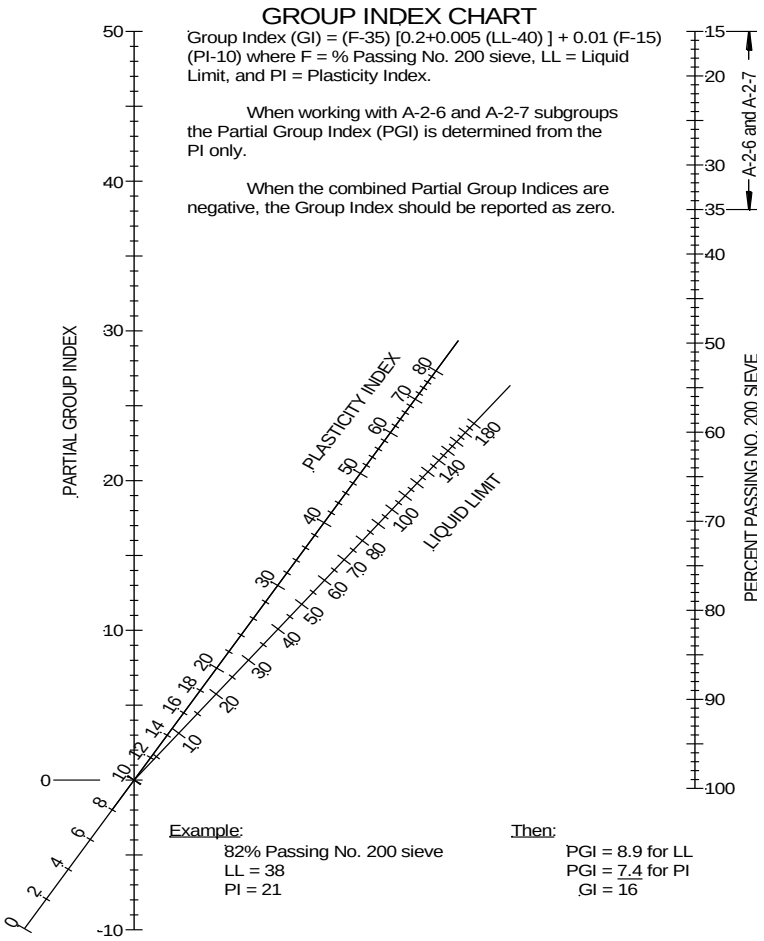
The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

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%.



Liquid Limit and Plasticity Index Ranges for the A-4, A-5, A-6 and A-7 Subgroups



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 classificaiton 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.

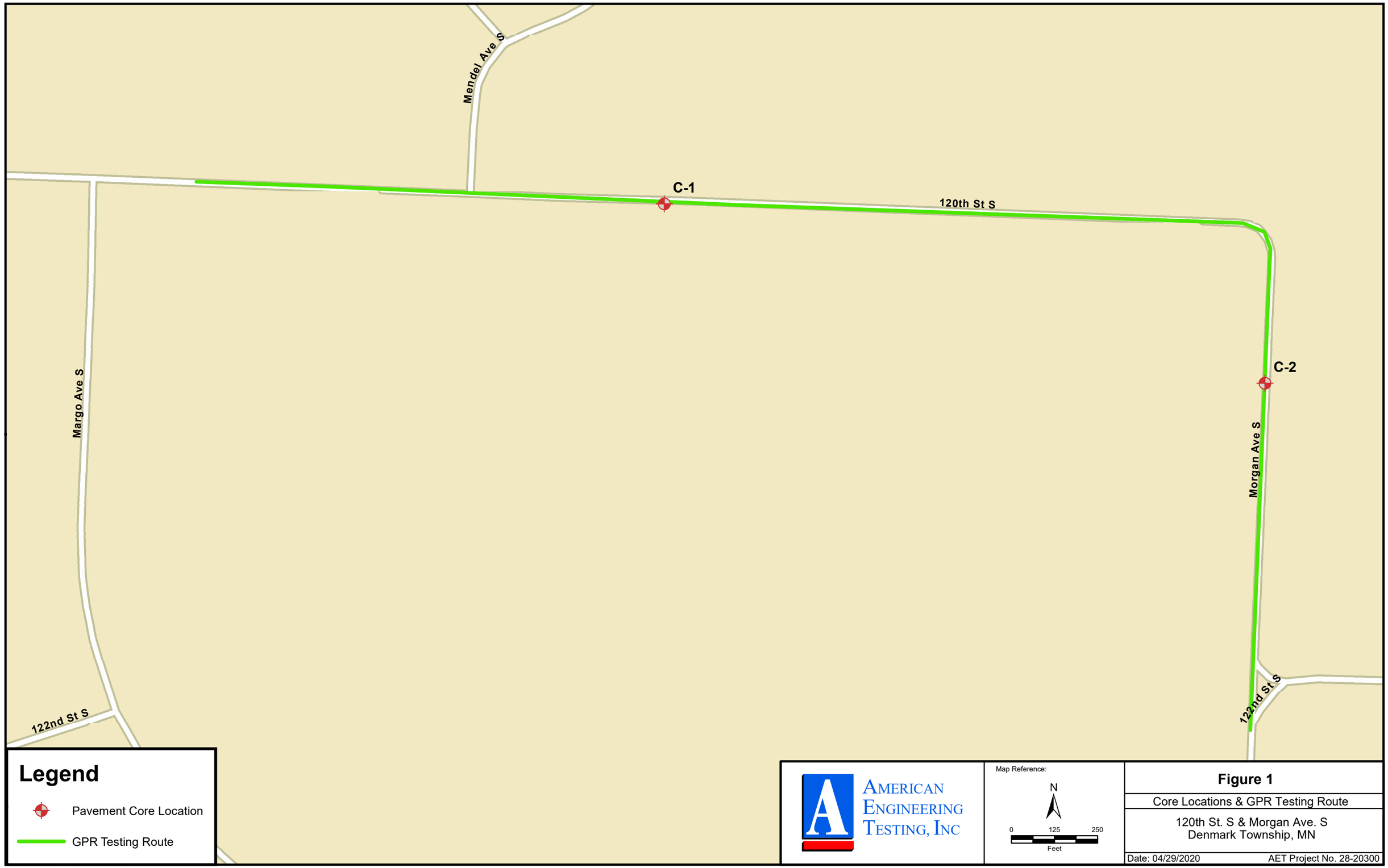


Figure 1

Core Locations & GPR Testing Route

120th St. S & Morgan Ave. S
Denmark Township, MN

Date: 04/29/2020 AET Project No. 28-20300

File: 28-20300.mxd Date: 04/29/2020

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
· ENVIRONMENTAL
· GEOTECHNICAL
· MATERIALS
· FORENSICS

Project: 120th St & Morgan Ave Roadway Improvements
AET Project Number: 28-20300
Roadway: 120th Street

Core: C-1
Date Cored: 4/22/2020
GPS Coordinates:
Latitude: 44.775511
Longitude: -92.854740
Location: EB Lane
Outside Wheel Path

Description:
Core Diameter: 4"
Bituminous Downhole Depth: 5"

Condition:
Bottom portion of core deteriorated.
Severe stripping in upper portion of core.

Possible Aggregate Base:
Hand Auger Depth: 8"
Classification: Crushed limestone base
Gravelly SP sandy loam,
A-1-a

Recovered Bituminous Core

Pavement Surface at Core Location

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
· ENVIRONMENTAL
· GEOTECHNICAL
· MATERIALS
· FORENSICS

Project: 120th St & Morgan Ave Roadway Improvements
AET Project Number: 28-20300
Roadway:

Core: C-2
Date Cored: 4/22/2020
GPS Coordinates:
Latitude: 44.774250
Longitude: -92.847960
Location: NB Lane
Outside Wheel Path

Description:
Core Diameter: 4"
Bituminous Downhole Depth: 3"

Condition:
Moderate stripping throughout core.
Core seperated at approximately 1-inch.

Possible Aggregate Base:
Hand Auger Depth: 11"
Classification: Crushed limestone base
Gravelly SP sandy loam,
A-1-a

Recovered Bituminous Core

Pavement Surface at Core Location

American Engineering Testing, Inc.
St. Paul
550 Cleveland Ave N
St. Paul, MN 55114
(651) 659-9001
Toll Free: (800) 972-6364

Albertville
5548 Barthel Ind Dr, Ste 500
Albertville, MN 55301
(763) 428-5573
www.amengtest.com

Material Test Report

Report No: MAT:20-05630-S1
Issue No: 1

Client: HASTINGS, CITY OF, PUBLIC WORKS **CC:**

Project: 120th St & Morgan Ave Roadway

Denmark Township MN

Job No: 28-20300

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Date of Issue: 4/29/2020
Reviewed By: Krystle Staker

Sample Details

Sample ID	20-05630-S1
Field Sample ID	C-1
Date Sampled	4/22/2020
Source	On-site
Material	Gravelly slightly plastic sandy loam; AASHTO: A-1-a
Specification	Gradation
Sampling Method	Sampled By American Engineering Testing
General Location	120th St
Location	EB Lane Depth: 5 - 9 in.
Date Submitted	4/24/2020

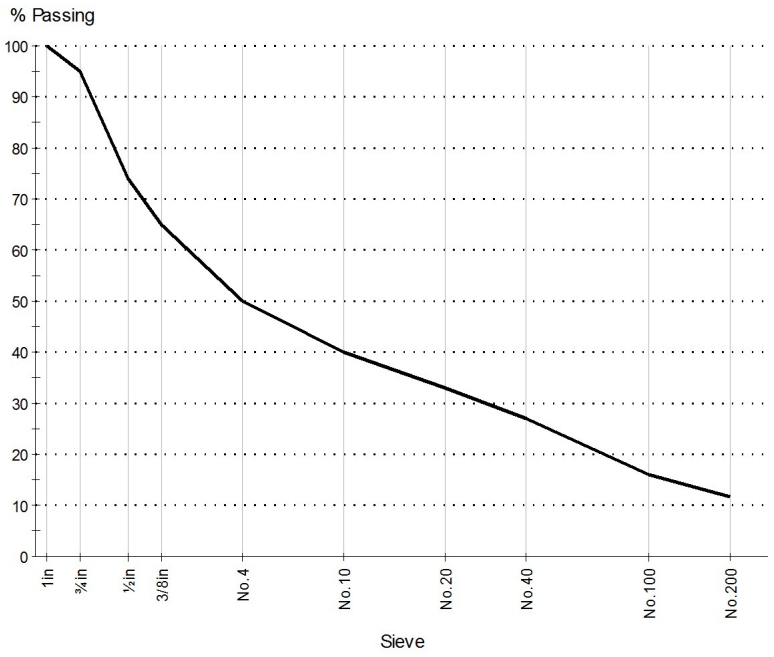
Other Test Results

Description	Method	Result	Limits

Particle Size Distribution

Method: AASHTO T 27, AASHTO T 11

Date Tested: 4/28/2020
Tested By: Garrett Renken



Sieve Size	% Passing	Limits
1in (25.0mm)	100	
¾in (19.0mm)	95	
½in (12.5mm)	74	
3/8in (9.5mm)	65	
No.4 (4.75mm)	50	
No.10 (2.0mm)	40	
No.20 (850µm)	33	
No.40 (425µm)	27	
No.100 (150µm)	16	
No.200 (75µm)	11.8	

Comments

N/A

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Albertville, MN 55301
(763) 428-5573
www.amengtest.com

Material Test Report

Report No: MAT:20-05630-S2
Issue No: 1

Client: HASTINGS, CITY OF, PUBLIC WORKS **CC:**

Project: 120th St & Morgan Ave Roadway

Denmark Township MN

Job No: 28-20300

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Date of Issue: 4/29/2020
Reviewed By: Krystle Staker

Sample Details

Sample ID	20-05630-S2
Field Sample ID	C-2
Date Sampled	4/22/2020
Source	On-site
Material	Gravelly slightly plastic sandy loam; AASHTO: A-1-a
Specification	Gradation
Sampling Method	Sampled By American Engineering Testing
General Location	Morgan Ave
Location	NB Lane Depth: 3 - 11 in.
Date Submitted	4/24/2020

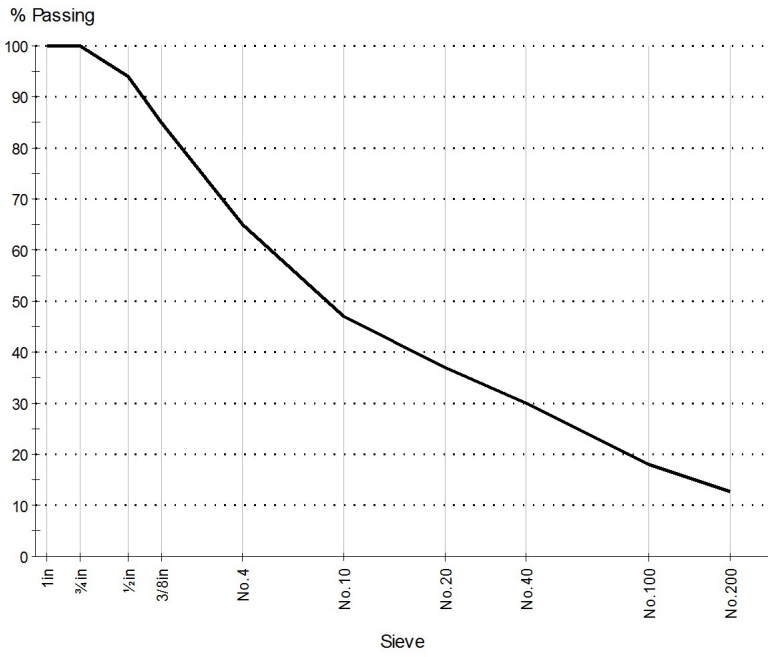
Other Test Results

Description	Method	Result	Limits

Particle Size Distribution

Method: AASHTO T 27, AASHTO T 11

Date Tested: 4/28/2020
Tested By: Garrett Renken



Sieve Size	% Passing	Limits
1in (25.0mm)	100	
¾in (19.0mm)	100	
½in (12.5mm)	94	
3/8in (9.5mm)	85	
No.4 (4.75mm)	65	
No.10 (2.0mm)	47	
No.20 (850µm)	37	
No.40 (425µm)	30	
No.100 (150µm)	18	
No.200 (75µm)	12.7	

Comments

N/A

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Appendix B

Ground Penetrating Radar Field Exploration and Testing
GPR Data Analysis Results
Figure 2 – Surface Thickness by GPR

Appendix B
Ground Penetrating Radar Field Exploration and Testing
AET Project No. 28-20300

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 GSSI Roadscan System that consists of a bumper-mounted, 2 GHz air-coupled antenna and a SIR-30 control and data acquisition processor, featuring dual channels. The GPR processor, including a SIR-30 data acquisition system, wheel-mounted DMI (Distance Measuring Instrument), and a tough book with the SIR-30 Field Program constitutes the newest, most sophisticated GSSI Test System, which fulfills or exceeds all requirements to meet ASTM-4748, ASTM D-6087 Standards. Figure B1 provides a view of this equipment.

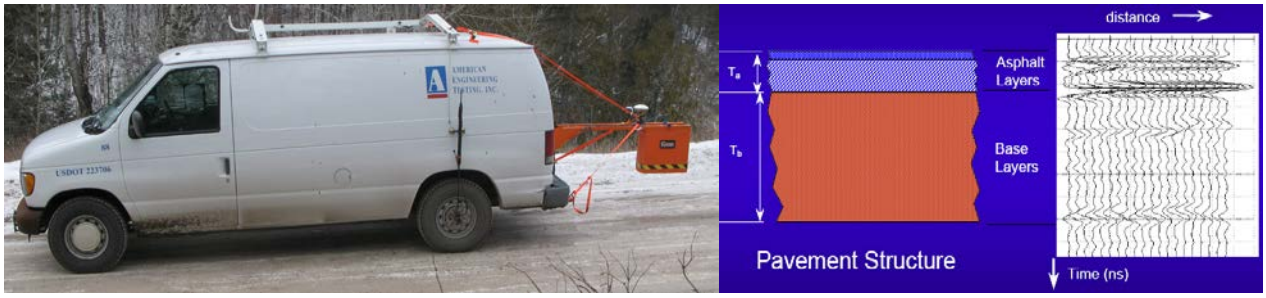

Figure B1 GSSI 2 GHz air-coupled GPR Test System

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 is capable of collecting radar waveforms at more than 100 signals per second, allows for data to be collected at driving speeds along the longitudinal dimension of the pavements or bridge decks with the antennas fixed at the rear or in front of the vehicle.

The antenna used for Roadscan is the Horn antenna Model 4105 (2 GHz). The 2 GHz antenna is the current antenna of choice for road survey because it combines excellent resolution with reasonable depth penetration (18-24 inches in pavement materials). The data collection is performed at normal driving speeds (45-55 mph), requiring no lane closures nor causing traffic congestion. At this peed the 2 GHz antenna is capable of collecting data at 1-foot interval (1 scan/foot).

The data were collected at a rate of about 1 vertical scans per foot. Each vertical scan consisted of 512 samples and the record length in time of each scan was 12 nanoseconds. Filters used during acquisition were 300 MHz high pass and 5,000 MHz low pass.

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 on-screen and in the field to identify reflections and ensure proper data collection parameters.

Field testing is performed in accordance with the standard ASTM procedures as described in ASTM D 4695-96, “Standard Guide for General Pavement Deflection Measurements”.

B.2.2 System Calibrations

Horn antenna processing is used to get the velocity of the radar energy in the material by comparing the reflection strengths (amplitudes) from a pavement layer interface with a perfect reflector (a metal plate). The calibration scan is obtained with the horn antenna placed over a metal plate at the same elevation as a scan obtained over pavement.

The same setting for data collection is used for metal plate calibration. Fifteen seconds are need for jumping up and down on the vehicle's bumper to collect the full range of motion for the vehicle's shocks. The filename of raw calibration file is recorded.

Survey wheel is calibrated by laying out a long distance (> 50 feet) with tape measure.

B.2.3 Linear Distance and Spatial Reference System

Distance measuring instrument (DMI) is a trailer mounted two phase encoder system. When DMI is connected to the SIR-30 it provides for automatic display and recording distance information in both English and metric units with a 1 foot (0.3 meters) resolution and four percent accuracy when calibrated using provided procedure in the Field Program.

Spatial reference system is a Trimble ProXH Global Positioning System (GPS) that consists of fully integrated receiver, antenna and battery unit with Trimble's new H-Star™ technology to provide subfoot (30 cm) post processed accuracy. The External Patch antenna is added to the ProXH receiver for the position of the loading plate. The External Patch antenna can be conveniently elevated with the optional baseball cap to prevent any signal blockage.

B.2.4 Camera Monitoring System

A battery operated independent DC-1908E multi-functional digital camera with a SD card is used for easy positioning of the loading plate or of the pavement surface condition at the testing locations.

B.3 SAMPLING METHODS

At the project level, the testing interval is set at 12 scans per foot in the Outside Wheel Path (OWP) = 2.5 ft ± 0.25 ft (0.76 m ± 0.08 m) for nominal 12 ft (3.7 m) wide lanes at a survey speed of approximately 10 mph. Where a divided roadbed exists, surveys will be taken in both directions if the project will include improvements in both directions. If there is more than one lane in one direction the surveys will be taken in the outer driving lane (truck lane) versus the passing lane of the highway. GPR tests are performed at a constant lateral offset down the test section. When GPR tests are performed on bridge decks, multiple survey lines are followed transversely at 2-foot spacing between survey lines.

At the network level, GPR tests on one scan per foot are set to be able to collect data on pavements at driving speeds, without statistically compromising the quality of the data collected. If GPR tests are for the in situ characterization of material GPR data will be collected at two scan per foot at slower driving speeds.

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

Beside the daily metal plate calibration the DMI is also calibrated monthly 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 LTPP 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.

To insure quality data, the GPR assessments only took place on dry pavement surfaces, and data was collected in each wheel path.

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.

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 Advance 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.

B.5.4 Data Interpretation

The EZ Tracker Layer Interpretation procedure uses the output from the first step to map structural layers and calculate the corresponding velocities and depths.

B.6 TEST LIMITATIONS

B.6.1 Test Methods

The data derived through the testing program have been used to develop our opinions about the pavement conditions at your site. However, because no testing program can reveal totally what is in the subsurface, conditions between test locations and at other times, may differ from conditions described in this report. The testing we conducted 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, and some anomalies which are present in the pavement may not be noted on the testing results. If conditions encountered during construction differ from those indicated by our testing, it may be necessary to alter our conclusions and recommendations, or to modify construction procedures, and the cost of construction may be affected.

B.6.2 Test Standards

Pavement 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.

B.7 SUPPORTING TEST METHODS

B.7.1 Falling Weight Deflectometer (FWD)

If the pavement layer moduli and subgrade soil strength are desired the deflection data are collected using a Dynatest 8000 FWD Test System that consists of a Dynatest 8002 trailer and a third generation control and data acquisition unit developed in 2003, called the Dynatest Compact15, featuring fifteen (15) deflection channels. The new generation FWD, including a Compact15 System and a standard PC with the FwdWin field Program constitutes the newest, most sophisticated Dynatest FWD Test System, which fulfills or exceeds all requirements to meet ASTM-4694, ASTM D-4695 Standards. The system provides continuous data at pre-set spacing.

B.7.2 Soil Boring/Coring Field Exploration

If both pavement thicknesses and subgrade soil types and conditions are desired the shallow coring/boring and sampling is used. The limited number of coring/boring is necessary to verify the GPR layer thickness data.

B.7.3 Pavement Surface Condition Survey

The type and severity of pavement distress influence the deflection response for a pavement. Therefore, GPR operators record any distress located from about 1 ft (0.3 m) in front of vehicle to about 30 ft (9 m) ahead. This information is recorded in the FWD file using the comment line in the field program immediately following the test.

American Engineering Testing, Inc.

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St. Paul, Minnesota 55114
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Fax: (651) 659-1379

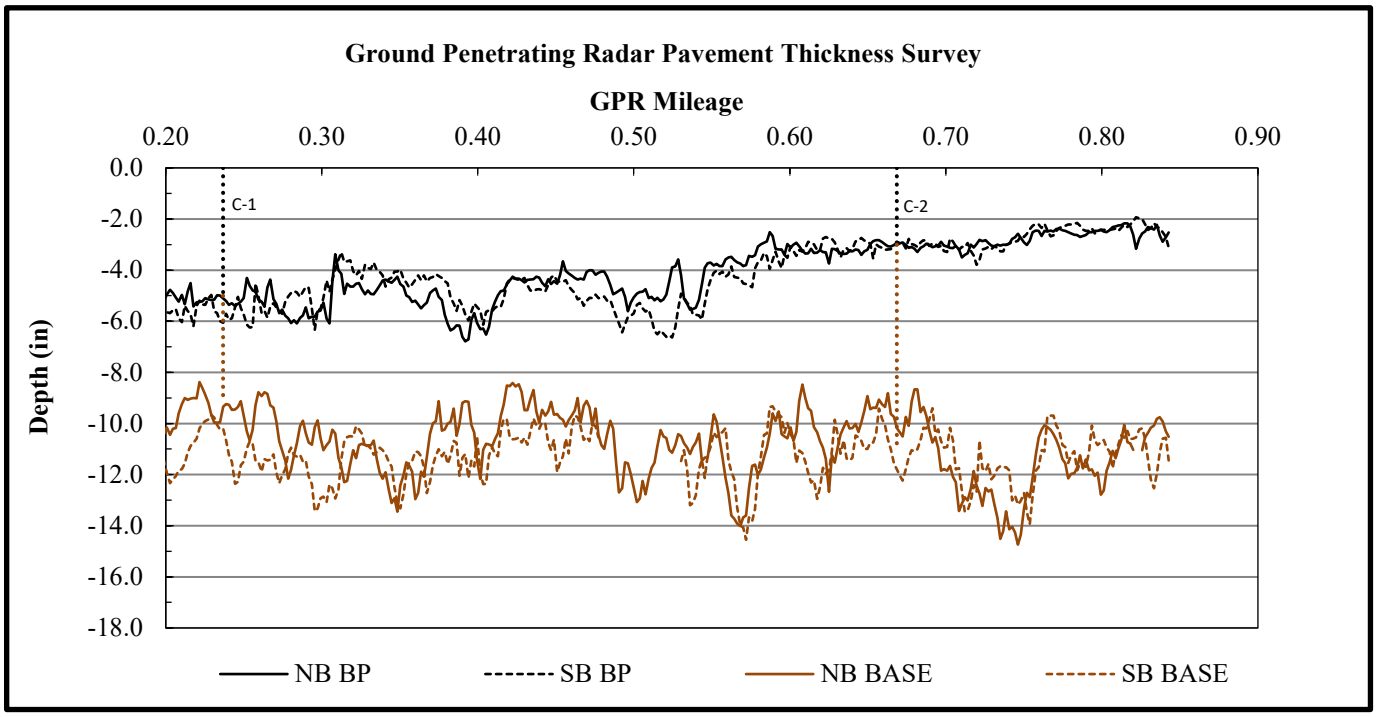
GENERAL INFORMATION: GROUND PENETRATING RADAR

Project:	120th St/Morgan Ave	**Date:**	4/28/20
AET Job No.:	28-20300	**Test Date:**	4/13/20
Road:	120th St/Morgan Ave	**Section/Grid:**	S01
From:	~300' E of Margo Ave	**To:**	122nd St

SUMMARY STATISTICS

Units: inches

	EB/SB				WB/NB			
Layer	**Average**	**CV**	**15th**	**Min.**	**Average**	**CV**	**15th**	**Min.**
BP	4.4	31%	2.9	2.2	4.7	34%	2.9	1.9
Base	6.4	30%	4.3	2.3	6.9	23%	5.2	3.7
BP + Base	10.8	12%	9.5	8.4	11.4	9%	10.4	9.0



*Gaps in data due to snow/ice covered pavement.

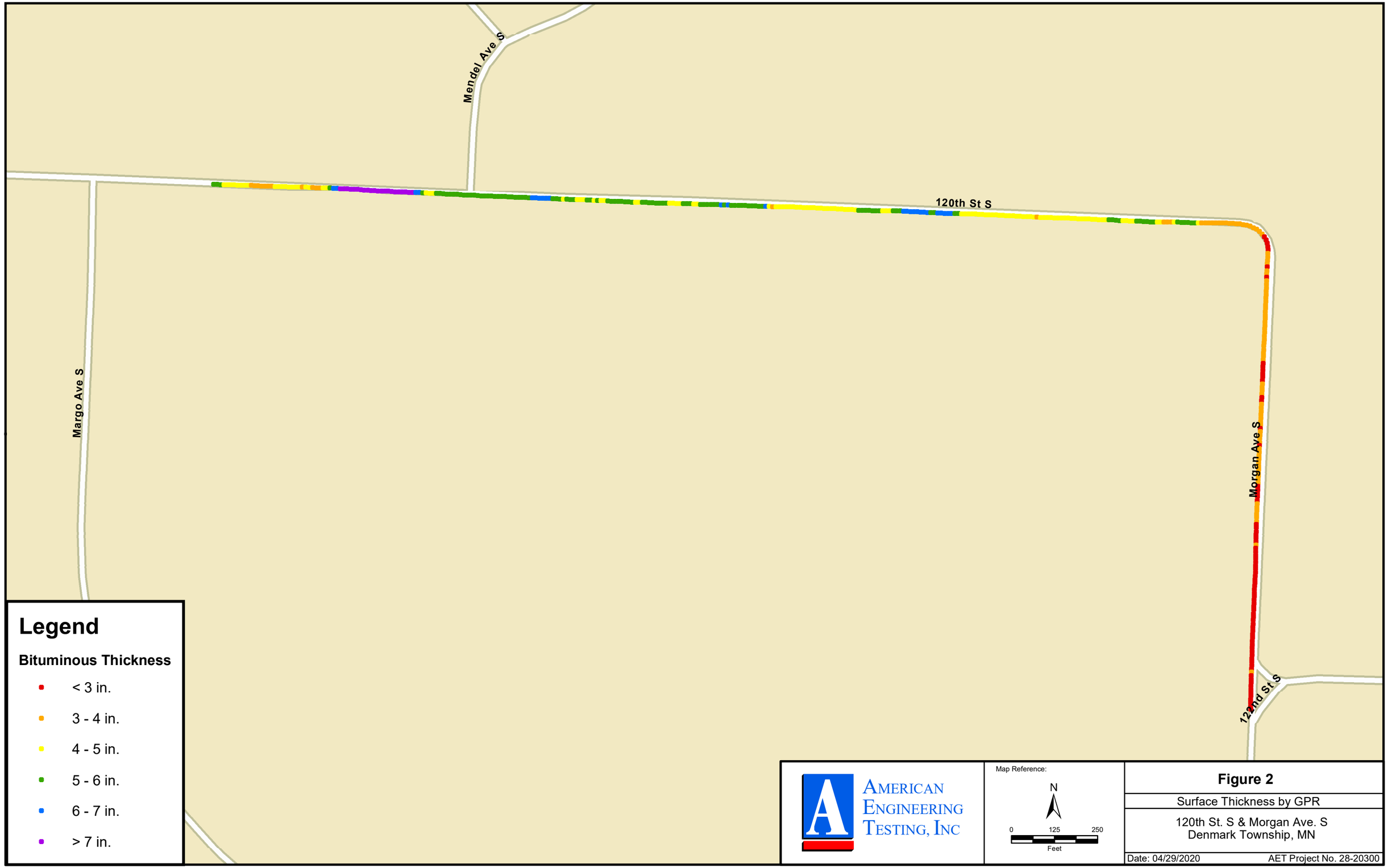


Figure 2

Surface Thickness by GPR

120th St. S & Morgan Ave. S
Denmark Township, MN

Date: 04/29/2020 AET Project No. 28-20300

File: 28-20300.mxd Date: 04/29/2020

Appendix C

Falling Weight Deflectometer Field Exploration and Testing
FWD Data Analysis Results
Figure 3 – Subgrade R-value

Appendix C
Falling Weight Deflectometer Field Exploration and Testing
AET Project No. 28-20300

C.1 PAVEMENT TESTING

The pavement structural conditions at the site were evaluated nondestructively using Falling Weight Deflectometer (FWD). The description of the equipment precedes the Deflection Data and Analysis Results in this appendix.

C.2 EQUIPMENT DESCRIPTION

C.2.1 Dynatest 8000 FWD Test System

The FWD owned by AET is a Dynatest 8000 FWD Test System that consists of a Dynatest 8002 trailer and a third generation control and data acquisition unit developed in 2003, called the Dynatest Compact15, featuring fifteen (15) deflection channels. The new generation FWD, including a Compact15 System and a standard PC with the FwdWin Field Program constitutes the newest, most sophisticated Dynatest FWD Test System, which fulfills or exceeds all requirements to meet ASTM-4694 Standards. Figure C1 provides a view of this equipment.

Figure C1 Dynatest 8002 FWD Test System

The FWD imposes a dynamic impulse load onto the pavement surface through a load plate. Total pulse is an approximately half sine shape with a total duration typically between 25 to 30 ms. The FWD is capable of applying a variety of loads to the pavement ranging from 1,500 lbf (7 kN) to 27,000 ibf (120 kN) by dropping a variable weight mass from different heights to a standard, 11.8-inch (300-mm) diameter rigid plate.

The drop weights and the buffers are constructed so that the falling weight buffer subassembly may be quickly and conveniently changed between falling masses of 440 lbm (200 kg) for highways and 770 lbm (350 kg) for airports. With the 440 lbm (200 kg) package for highways three drop heights are used with the target load of 6,000 lbf (27 kN) at drop height 1, 9,000 lbf (40 kN) at drop height 2, and 12,000 lbf at drop height 3 (53 kN). The drop sequence consists of two seating drops from drop height 3 and 2 repeat measurements at drop height 1 and 1 measurement at drop height 2 for flexible pavements and 2 repeat measurements at drop height 2 and 1 measurement at drop height 3 for rigid pavements. The data from the seating drops is not stored.

The FWD is equipped with a load cell to measure the applied forces and nine geophones or deflectors to measure deflections up to 100 mils (2.5 mm). The load cell is capable of accurately measuring the force that is applied perpendicular to the loading plate with a resolution of 0.15 psi (1 kPa) or better. The force is expressed in terms of pressure, as a function of loading plate size.

Nine deflectors at the offsets listed in the following table in the Long Term Performance Program (LTPP) configuration are capable of measuring electronically discrete deflections per test, together with nine (9) separate deflection measuring channels for recording of the data. One (1) of the deflectors measures the deflection of the pavement surface through the center of the loading plate, while seven (7) deflectors are capable of being positioned behind the loading plate along the housing bar, up to a distance of 5 ft (2.5 m) from the center of the loading plate and one (1) being positioned in front of the loading plate along the bar.

Deflector	D9	D1	D2	D3	D4	D5	D6	D7	D8
Offset (in.)	-12	0	8	12	18	24	36	48	60

Field testing is performed in accordance with the standard ASTM procedures as described in ASTM D 4695-96, "Standard Guide for General Pavement Deflection Measurements" and the calibration of our equipment is verified each year at the Long Term Pavement Performance Calibration Center in Maplewood, MN.

C.2.2 Linear Distance and Spatial Reference System
Distance measuring instrument (DMI) is a trailer mounted two phase encoder system. When DMI is connected to the Compact15 it provides for automatic display and recording distance information in both English and metric units with a 1 foot (0.3 meters) resolution and four percent accuracy when calibrated using the provided procedure in the Field Program.

Spatial reference system is a Trimble ProXH Global Positioning System (GPS) that consists of fully integrated receiver, antenna and battery unit with Trimble's new H-Star™ technology to provide subfoot (30 cm) post-processed accuracy. The External Patch antenna is added to the ProXH receiver for the position of the loading plate. The External Patch antenna can be conveniently elevated with the optional baseball cap to prevent any signal blockage.

C.2.3 Air and Pavement Temperature Measuring System
A temperature monitoring probe, for automatic recording of air temperature, is an electronic (integrated circuit) sensing element in a stainless steel probe. The probe mounts on the FWD unit in a special holder with air circulation and connects to the Compact15. A non-contact Infra-Red (IR) Temperature Transmitter, for automatic recording of pavement surface temperature only, features an integrated IR-detector and digital electronics in a weather proof enclosure. The IR transmitter mounts on the FWD unit in a special holder with air circulation and connects to the Compact15. Both probe and IR transmitter have a resolution of 0.9 ºF (0.5 ºC) and accuracy within ± 1.8ºF (1 ºC) in the 0 to 158 ºF (-18 to +70ºC) range when calibrated using the provided procedure.

C.2.4 Camera Monitoring System
A battery operated independent DC-1908E multi-functional digital camera with a SD card is used for easy positioning of the loading plate or recording of the pavement surface condition at the testing locations.

C.3 SAMPLING METHODS
At the project level, the testing interval is set at 0.1 mi. (maximum) or 10 locations per uniform section in the Outside Wheel Path (OWP) = 2.5 ft ± 0.25 ft (0.76 m ± 0.08 m) for nominal 12 ft (3.7 m) wide lanes. Where a divided roadbed exists, surveys will be taken in both directions if the project will include improvements in both directions. If there is more than one lane in one direction the surveys will be taken in the outer driving lane versus the passing lane of the highway. FWD tests are performed at a constant lateral offset down the test section.

C.4 QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA)
In addition to the annual reference calibration, the relative calibration of the FWD deflection sensors is conducted monthly but not to exceed 6 weeks during the months in which the FWD unit is continually testing. The DMI is also calibrated monthly by driving the vehicle over a known distance to calculate the distance scale factor. The accuracy of the FWD air temperature and infra-red (IR) sensors are checked on a monthly basis or more frequently if the FWD operator observes "suspicious" temperature readings.

Some care in the placement of the load plate and sensors is taken by the survey crew, especially where the highway surface is rutted or cracked, to ensure that the load plate lays on a flat surface and that the load plate and all geophones lie on the same side of any visible cracks. Liberal use of comments placed in the FWD data file at the time of data collection is required. Comments pertaining to proximity to reference markers, bridge abutments, patches, cracks, etc., are all important documentation for the individual evaluating the data.

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 LTPP 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.

C.5 DATA ANALYSIS METHODS

C.5.1 Inputs

The two-way AADT and HCADT are required to calculate the ESALs. The state average truck percent and truck type distribution are used when HCADT is not provided. The as-built pavement information (layer type, thickness, and construction year) are required and if not provided, GPR and/or coring and boring is needed.

C.5.2 Adjustments

Temperature adjustment to the deflections measured on bituminous pavements is determined from the temperature predicted at the middle depth of the pavement using the LTPP BELLS3 model that uses the pavement surface temperature and previous day mean air temperature. The predicted middle depth temperature and the standard temperature of 80 degrees Fahrenheit are used to calculate the temperature adjustment factor for deflection data analysis. Seasonal adjustment developed by Mn/DOT is also used.

C.5.3 Methods

For bituminous pavements, the deflection data were analyzed using the Mn/DOT method for determining the in-place (effective) subgrade and pavement strength, as well as allowable axle loads for a roadway (Investigation 603) revised in 1983 and automated with spreadsheet format in 2008. The Mn/DOT method uses Hogg Model for estimating the subgrade modulus and the Effective GE Equation (Investigation 603) for estimating the effective GE of pavements. The Mn/DOT method also uses the TONN method for estimating Spring Load Capacity and Required Overlay, as described in the Mn/DOT publication "Estimated Spring Load-Carrying Capacity".

For gravel roads, the deflection data were analyzed using the American Association of State Highway and Transportation Officials' (AASHTO) method for determining the in-place (effective) subgrade and pavement strength, as well as allowable axle loads for a roadway as in the AASHTO Guide for Design of Pavement Structures, 1993.

For concrete pavements, the deflection data were analyzed using the FAA methods for determining the modulus of subgrade reaction (k-value), effective elastic modulus of concrete slabs, load transfer efficiency (LTE) on approach and leave slabs of a joint, slab support conditions (void analysis) and impulse stiffness modulus ratio (durability analysis) as in the FAA AC 150/5370-11A, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavement, 2004.

C.6 TEST LIMITATIONS

C.6.1 Test Methods

The data derived through the testing program have been used to develop our opinions about the pavement conditions at your site. However, because no testing program can reveal totally what is in the subsurface, conditions between test locations and at other times, may differ from conditions described in this report. The testing we conducted identified pavement conditions only at those points where we measured pavement surface temperature, deflections, and observed pavement surface conditions. Depending on the sampling methods and sampling frequency, every location may not be tested, and some anomalies which are present in the pavement may not be noted on the testing results. If conditions encountered during construction differ from those indicated by our testing, it may be necessary to alter our conclusions and recommendations, or to modify construction procedures, and the cost of construction may be affected.

C.6.2 Test Standards

Pavement 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.

American Engineering Testing, Inc.
550 Cleveland Avenue North
St. Paul, Minnesota 55114
Phone: (651) 659-9001
Fax: (651) 659-1379

AET Project No. 28-20300
County: Dakota
Test Date: Apr 13, 2020
Section: 1
Roadway: 120th St. S/Morgan Ave S
From: ~300' E of Margo Ave S
To: 122nd St S

Prev. Day's Avg. Air Temp.: 36.5 °F
Total AC: 4.7 in.
Traffic Category: 2
Soil Type: P

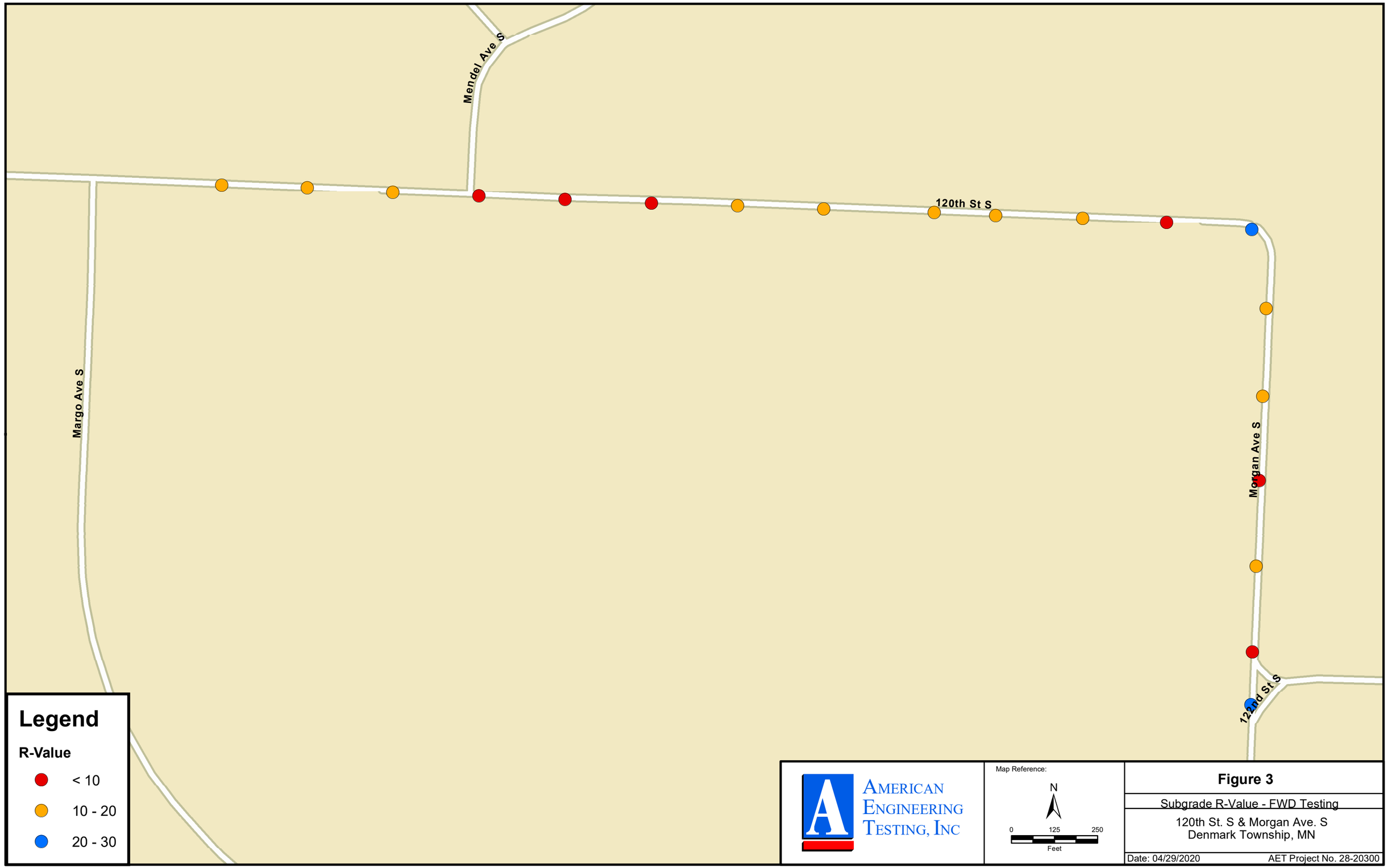
Station	Drop	Time	Air °F	Bit °F	Load	D1	D2	D3	D4	D4	D6	D7	D8	D9	Latitude	Longitude	Comments
0.0	1	13:04	49.0	46.5	6336	31.2	21.4	16.4	11.4	7.3	3.4	2.2	1.6	1.4	44.775535	-92.859694	120th St,Start
0.0	2	13:04	49.0	46.6	6323	30.8	21.2	16.3	11.4	7.3	3.5	2.2	1.6	1.4	44.775535	-92.859694	
0.0	3	13:05	49.1	46.6	9394	47.5	33.1	25.8	18.1	11.6	5.3	3.3	2.4	2.1	44.775535	-92.859694	
0.0	4	13:05	49.1	46.5	9358	47.3	33.1	25.8	18.2	11.7	5.4	3.3	2.5	2.1	44.775535	-92.859694	
250.4	1	13:06	49.2	46.0	6312	34.3	18.9	13.5	9.2	6.2	3.6	2.6	1.9	1.5	44.775537	-92.858738	
250.4	2	13:06	49.1	46.1	6304	33.7	18.8	13.4	9.2	6.2	3.6	2.6	1.9	1.5	44.775537	-92.858738	
250.4	3	13:06	49.1	46.3	9366	52.4	30.1	21.8	14.9	9.9	5.6	4.0	2.9	2.3	44.775537	-92.858738	
250.4	4	13:06	49.0	46.3	9302	51.8	30.1	21.8	14.9	9.9	5.6	4.0	2.9	2.3	44.775537	-92.858738	
500.0	1	13:08	48.6	44.0	6463	13.5	11.2	10.0	8.2	6.3	3.9	2.7	2.0	1.6	44.775528	-92.857781	
500.0	2	13:08	48.6	43.9	6474	13.4	11.1	9.9	8.1	6.3	3.9	2.7	2.2	1.6	44.775528	-92.857781	
500.0	3	13:08	48.6	43.9	9683	20.7	17.3	15.5	12.7	10.0	6.1	4.2	3.5	2.5	44.775528	-92.857781	
500.0	4	13:08	48.6	44.0	9660	20.7	17.3	15.4	12.7	10.0	6.1	4.2	3.1	2.5	44.775528	-92.857781	
751.3	1	13:09	49.3	45.0	6233	44.0	29.0	16.3	9.5	6.4	3.7	2.7	2.0	1.6	44.775521	-92.856815	120th St,IC,MENDEL ST,EB
751.3	2	13:09	49.3	45.1	6217	43.5	28.7	16.2	9.6	6.4	3.7	2.7	2.0	1.6	44.775521	-92.856815	
751.3	3	13:09	49.3	45.1	9151	63.1	42.2	24.8	15.1	9.8	5.5	4.1	3.0	2.4	44.775521	-92.856815	
751.3	4	13:09	49.3	45.1	9148	63.3	42.5	25.1	15.1	9.9	5.5	4.1	3.0	2.4	44.775521	-92.856815	
1001.3	1	13:10	49.9	46.5	6312	32.7	24.5	19.6	14.2	9.3	4.5	3.2	2.5	2.2	44.775519	-92.855852	
1001.3	2	13:10	49.9	46.5	6304	32.4	24.3	19.6	14.1	9.3	4.5	3.2	2.5	2.2	44.775519	-92.855852	
1001.3	3	13:11	49.9	46.4	9350	49.3	37.1	30.1	21.9	14.4	6.6	4.7	3.8	3.2	44.775519	-92.855852	
1001.3	4	13:11	49.9	46.4	9331	49.4	37.3	30.3	22.1	14.5	6.7	4.7	3.8	3.2	44.775519	-92.855852	
1253.0	1	13:12	49.3	45.8	6125	35.7	27.4	22.4	16.2	10.5	4.5	2.6	1.9	1.6	44.775511	-92.854886	
1253.0	2	13:12	49.3	45.9	6101	34.7	26.8	22.0	15.9	10.4	4.4	2.6	1.9	1.5	44.775511	-92.854886	
1253.0	3	13:12	49.2	46.0	9151	53.8	41.6	34.5	25.3	16.5	7.0	3.9	2.9	2.4	44.775511	-92.854886	
1253.0	4	13:12	49.2	46.1	9135	54.1	41.7	34.6	25.5	16.7	7.0	3.9	2.9	2.4	44.775511	-92.854886	
1503.4	1	13:13	49.2	46.0	6415	31.4	21.8	16.5	11.0	6.8	3.5	2.3	1.7	1.4	44.775517	-92.853923	
1503.4	2	13:13	49.2	46.0	6415	31.0	21.7	16.5	11.0	6.8	3.5	2.3	1.7	1.4	44.775517	-92.853923	
1503.4	3	13:13	49.1	46.0	9513	47.8	34.0	26.1	17.7	10.9	5.2	3.4	2.6	2.2	44.775517	-92.853923	
1503.4	4	13:13	49.1	46.0	9532	48.0	34.2	26.4	17.9	11.0	5.2	3.4	2.6	2.2	44.775517	-92.853923	
1753.9	1	13:14	49.1	44.5	6447	21.0	15.2	11.8	8.1	5.2	2.6	1.9	1.4	1.2	44.775514	-92.852961	
1753.9	2	13:14	49.1	44.5	6458	20.8	15.1	11.8	8.2	5.2	2.7	1.9	1.4	1.2	44.775514	-92.852961	
1753.9	3	13:14	49.1	44.4	9680	32.6	24.1	19.0	13.2	8.4	4.1	2.9	2.3	1.8	44.775514	-92.852961	
1753.9	4	13:15	49.1	44.5	9688	32.6	24.1	19.1	13.3	8.5	4.2	2.9	2.3	1.8	44.775514	-92.852961	
2076.3	1	13:16	49.7	44.0	6490	20.7	15.1	12.5	9.7	7.0	3.7	2.7	2.1	1.7	44.775517	-92.851723	
2076.3	2	13:16	49.7	44.0	6514	20.5	15.0	12.5	9.7	7.1	3.7	2.7	2.1	1.8	44.775517	-92.851723	
2076.3	3	13:16	49.7	44.0	9656	31.5	23.4	19.7	15.3	11.2	5.8	4.1	3.1	2.6	44.775517	-92.851723	
2076.3	4	13:17	49.8	44.0	9652	31.4	23.3	19.7	15.3	11.2	5.8	4.1	3.1	2.6	44.775517	-92.851723	
2256.5	1	13:17	50.4	46.1	6328	24.6	18.2	15.1	11.2	6.7	3.8	2.7	2.0	1.7	44.775509	-92.851034	
2256.5	2	13:17	50.4	46.1	6363	24.6	18.2	15.1	11.2	6.8	3.8	2.8	2.0	1.7	44.775509	-92.851034	
2256.5	3	13:18	50.5	46.0	9497	38.2	28.5	23.8	17.7	10.6	5.8	4.2	3.1	2.4	44.775509	-92.851034	
2256.5	4	13:18	50.5	45.9	9501	38.4	28.6	23.9	17.8	10.7	5.9	4.2	3.1	2.6	44.775509	-92.851034	
2509.0	1	13:18	51.2	45.2	6379	30.4	20.3	15.5	9.8	6.5	3.6	2.7	2.0	1.6	44.775511	-92.850062	
2509.0	2	13:19	51.2	45.2	6447	30.3	20.2	15.5	9.9	6.5	3.6	2.7	2.0	1.6	44.775511	-92.850062	
2509.0	3	13:19	51.3	45.2	9633	46.0	31.3	24.3	15.8	10.3	5.5	4.0	3.0	2.5	44.775511	-92.850062	
2509.0	4	13:19	51.4	45.2	9609	45.8	31.2	24.3	15.8	10.3	5.5	4.0	3.0	2.5	44.775511	-92.850062	
2753.0	1	13:20	52.3	46.2	6212	43.5	30.6	12.0	9.4	6.8	3.8	2.7	2.0	1.5	44.775502	-92.849124	
2753.0	2	13:20	52.3	46.2	6288	43.6	30.9	12.1	9.4	6.9	3.9	2.7	2.1	1.5	44.775502	-92.849124	
2753.0	3	13:20	52.4	46.3	9259	64.9	45.5	19.1	14.8	10.7	5.9	4.1	3.2	2.4	44.775502	-92.849124	
2753.0	4	13:20	52.4	46.4	9278	65.1	46.0	19.4	15.0	10.8	6.0	4.1	3.2	2.5	44.775502	-92.849124	
3002.1	1	13:21	53.3	47.3	6363	20.3	12.7	9.6	6.4	4.4	2.4	1.6	1.2	1.0	44.775471	-92.848168	
3002.1	2	13:21	53.3	47.4	6431	20.2	12.6	9.6	6.5	4.4	2.4	1.7	1.2	1.0	44.775471	-92.848168	
3002.1	3	13:21	53.4	47.4	9501	29.7	18.7	14.4	9.8	6.8	3.7	2.6	1.9	1.5	44.775471	-92.848168	
3148.7																	120th St,IT,MORGAN AVE S,SB
3002.1	4	13:21	53.4	47.4	9537	29.9	18.8	14.5	9.9	6.9	3.7	2.6	1.9	1.5	44.775471	-92.848168	
3253.0	1	13:23	52.6	44.5	6288	38.7	25.1	18.5	11.2	6.1	3.1	2.2	1.6	1.3	44.774845	-92.847978	
3253.0	2	13:23	52.6	44.5	6323	38.6	25.2	18.6	11.3	6.1	3.1	2.3	1.6	1.3	44.774845	-92.847978	
3253.0	3	13:23	52.5	44.4	9394	56.8	38.1	28.7	17.8	9.8	4.9	3.5	2.6	2.2	44.774845	-92.847978	
3253.0	4	13:23	52.5	44.3	9342	56.7	38.1	28.8	17.9	9.8	5.0	3.6	2.6	2.3	44.774845	-92.847978	
3506.4	1	13:24	51.4	46.4	6331	33.7	22.9	16.5	10.4	6.3	3.6	2.9	2.2	2.0	44.774146	-92.847983	
3506.4	2	13:24	51.4	46.4	6352	33.4	22.7	16.4	10.4	6.3	3.7	2.9	2.2	2.0	44.774146	-92.847983	
3506.4	3	13:24	51.4	46.3	9458	48.8	33.6	24.9	16.1	9.7	5.5	4.3	3.3	2.9	44.774146	-92.847983	
3506.4	4	13:24	51.3	46.3	9493	48.9	33.7	25.1	16.2	9.8	5.6	4.4	3.3	2.9	44.774146	-92.847983	
3751.7	1	13:25	50.3	46.6	6180	45.9	31.3	22.8	13.9	7.9	3.8	2.9	2.1	1.9	44.773474	-92.847988	
3751.7	2	13:25	50.3	46.6	6209	45.7	31.3	22.8	14.0	7.9	3.8	2.9	2.2	1.8	44.773474	-92.847988	
3751.7	3	13:25	50.2	46.5	9302	67.6	47.2	35.4	22.3	12.7	5.9	4.5	3.3	2.7	44.773474	-92.847988	
3751.7	4	13:26	50.1	46.5	9294	67.8	47.4	35.7	22.5	12.9	6.0	4.6	3.4	2.8	44.773474	-92.847988	
4002.6	1	13:27	49.2	43.7	6336	27.4	18.4	13.7	9.5	6.5	3.7	2.7	1.9	1.7	44.772789	-92.847989	
4002.6	2	13:27	49.2	43.7	6411	27.4	18.5	13.8	9.6	6.6	3.8	2.7	2.0	1.7	44.772789	-92.847989	

American Engineering Testing, Inc.
550 Cleveland Avenue North
St. Paul, Minnesota 55114
Phone: (651) 659-9001
Fax: (651) 659-1379

AET Project No. 28-20300
County: Dakota
Test Date: Apr 13, 2020
Section: 1
Roadway: 120th St. S/Morgan Ave S
From: ~300' E of Margo Ave S
To: 122nd St S

Prev. Day's Avg. Air Temp.: 36.5 °F
Total AC: 4.7 in.
Traffic Category: 2
Soil Type: P

Station	Drop	Time	Air °F	Bit °F	Load	D1	D2	D3	D4	D4	D6	D7	D8	D9	Latitude	Longitude	Comments
4002.6	3	13:27	49.2	43.7	9572	42.2	28.9	21.8	15.2	10.3	5.7	4.0	2.9	2.5	44.772789	-92.847989	
4002.6	4	13:27	49.1	43.5	9537	41.9	28.7	21.7	15.2	10.3	5.7	4.0	2.9	2.5	44.772789	-92.847989	
4253.4	1	13:28	48.0	42.2	6145	36.0	25.7	19.8	13.6	8.3	3.3	1.9	1.4	1.3	44.772106	-92.847997	
4253.4	2	13:28	48.0	42.1	6156	35.7	25.6	19.7	13.6	8.3	3.3	1.9	1.4	1.3	44.772106	-92.847997	
4253.4	3	13:28	47.9	42.0	9243	56.0	40.4	31.5	22.0	13.5	5.1	2.8	2.2	2.0	44.772106	-92.847997	
4253.4	4	13:28	47.8	41.9	9318	56.6	40.9	32.0	22.4	13.7	5.2	2.9	2.3	2.0	44.772106	-92.847997	
4404.7	1	13:29	46.6	43.4	6323	15.3	10.1	7.6	5.5	3.9	2.5	1.8	1.2	1.0	44.771689	-92.847991	
4404.7	2	13:29	46.6	43.4	6280	14.9	9.9	7.4	5.4	3.8	2.4	1.7	1.2	0.9	44.771689	-92.847991	
4404.7	3	13:29	46.5	43.4	9548	23.1	15.6	11.9	8.6	6.2	3.9	2.8	1.9	1.5	44.771689	-92.847991	
4404.7	4	13:29	46.5	43.4	9505	22.7	15.5	11.8	8.6	6.2	3.9	2.8	1.9	1.5	44.771689	-92.847991	
4527.1																	MORGAN AVE,IC,122ND ST,END



AMERICAN ENGINEERING TESTING, INC

Figure 3

Subgrade R-Value - FWD Testing

120th St. S & Morgan Ave. S
Denmark Township, MN

Date: 04/29/2020 AET Project No. 28-20300

File: 28-20300.mxd Date: 04/29/2020

Appendix D

Geotechnical Report Limitations and Guidelines for Use

Appendix D
Geotechnical Report Limitations and Guidelines for Use
Report No. 28-20300

D.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 ASFE[1], of which, we are a member firm.

D.2 RISK MANAGEMENT INFORMATION

D.2.1 Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the Client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. And no one, not even you, should apply the report for any purpose or project except the one originally contemplated.

D.2.2 Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

D.2.3 A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider several unique, project-specific factors when establishing the scope of a study. Typically factors include: Clients goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a rule, always inform your geotechnical engineer of project changes, even minor ones, and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

D.2.4 Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

1 ASFE, 8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733: www.asfe.org

D.2.5 Most Geotechnical Findings Are Professional Opinions
Site exploration identified subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

D.2.6 A Report's Recommendations Are Not Final
Do not over rely on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

D.2.7 A Geotechnical Engineering Report Is Subject to Misinterpretation
Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

D.2.8 Do Not Redraw the Engineer's Logs
Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognizes that separating logs from the report can elevate risk.

D.2.9 Give Contractors a Complete Report and Guidance
Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In the letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be able to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

D.2.10 Read Responsibility Provisions Closely
Some owners, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their report. 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.

D.2.11 Geoenvironmental Concerns Are Not Covered
The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.