REPORT OF GEOTECHNICAL EXPLORATION AND REVIEW

Proposed Riverview Apartments

54th Street and Riverview Road
Minneapolis, Minnesota

AET Project No. 28-00333

Date:

February 18, 2011

Prepared for:

EnPro Assessment Corporation
1950 Stanford Ave
St. Paul, MN 55105

February 18, 2011

EnPro Assessment Corporation
1950 Stanford Ave
St. Paul, MN 55105

Attn: Ms. Jane Willard

RE: Geotechnical Exploration and Review
Proposed Riverview Apartments
54th Street and Riverview Road
Minneapolis, Minnesota
AET Project No. 28-00333

Dear Ms. Willard:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the above reference project in Minneapolis, Minnesota. These services were performed according to our proposal to you dated January 10, 2011.

We are submitting five copies of the report to you.

Please contact me if you have any questions about the report. I can also be contacted for arranging construction observation and testing services during the earthwork phase.

Sincerely,

American Engineering Testing, Inc.

Megan J. L. Hoppe
Staff Engineer
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Prepared for:

EnPro Assessment Corporation
1950 Stanford Ave
St. Paul, MN 55105

Ms. Jane Willard

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Date: 2/21/11 **License #: 13180**

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GEOTECHNICAL EXPLORATION AND REVIEW
FOR
PROPOSED RIVERVIEW APARTMENTS
54TH STREET AND RIVERVIEW ROAD
MINNEAPOLIS, MINNESOTA
AET PROJECT NO. 28-00333

1.0 INTRODUCTION

A new apartment building is proposed for construction northwest of the intersection of 54th Street East and Riverview Road in Minneapolis, Minnesota. To assist in planning and design, you have authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration program at the site, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above 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 you dated January 10, 2011. The authorized scope of services consists of the following:

- Perform 12 standard penetration test borings to depths ranging from 10 to 35 feet, with drilling and sampling according to environmental protocol directed by EnPro.
- Conduct soil laboratory testing.
- Perform a geotechnical engineering analysis based on the gained data and prepare this report.

Many of the borings obstructed on bedrock or apparent bedrock before the planned termination depth. A 10-foot rock core was performed in Boring 4, in order to confirm the subsurface bedrock profile in this area of the site. After our initial drilling was completed, two additional borings were requested to provide more infiltration information for the area below the proposed driveway.

AET's services are intended for geotechnical purposes only. Environmental sampling and testing was performed during drilling at this site by EnPro. A separate report will be issued by EnPro presenting the results of their environmental services.

3.0 PROJECT INFORMATION

We understand the proposed structure will include a partial below-grade parking level and 3 full above-grade levels. The lowest floor will be a cast-in-place concrete parking level, and the upper 3 floors will consist of wood framed residential areas. We understand the lowest floor will be at about elevation 813.55. The building will include an elevator in the vicinity of Boring 4. We assume the elevator pit will extend down to about elevation 809½. We assume maximum column loads for the building will not exceed 250 kips and maximum wall loads will be 9 kips per lineal foot. We understand an infiltration practice is currently proposed below the driveway.

Our foundation design assumptions include a minimum factor of safety of 3 with respect to localized shear or base failure of the foundations. We assume the structure will be able to tolerate total settlements of up to 1 inch, and differential settlements over a 30 foot distance of up to ½ inch.

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.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of 14 standard penetration test (SPT) borings, one of which included an NQ bedrock core. The approximate boring locations are shown on Figure 1 in Appendix A. The borings were located in the field by AET personnel by taping from nearby site features.

Surface elevations were measured in the field by AET personnel using an engineer's level. The benchmark reference was the top nut of the hydrant located near the northwest corner of 54th Street East and Riverview Road. This elevation was assumed to be 813.87, as indicated by Sunde Land Surveying.

4.2 SPT Borings

Subsurface boring logs of the SPT borings and details of the methods used appear in Appendix A. The subsurface 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).

4.3 Laboratory Testing

The laboratory test program included numerous water content tests, as well as Atterberg limits and s swell test on a sample of weathered shale. The test results appear in Appendix A, either on the individual boring logs adjacent to the samples upon which they were performed or on the data sheet following the subsurface boring logs.

5.0 SITE CONDITIONS

5.1 Surface Observations

The site consists of nine vacant residential lots, which are primarily turf covered but include some trees and shrubs. Surface elevations at the site generally fall to the east. Surface elevations at the boring locations range from a high of elevation 820.1 at Boring 3 down to elevation 812.1 at Boring 14.

5.2 Subsurface Soils/Geology

The subsurface profile encountered in the borings typically consists of fill over naturally deposited coarse alluvial or glacial till sands and then bedrock.

The fill encountered at the boring locations consists of a variety of soil materials and often includes organics or debris. The fill materials have variable and often low N-values, which we judge to indicate low levels of compaction.

The coarse alluvium found at the boring locations includes sand and sand with silt. These coarse alluvial soils range from loose to medium dense, based on the N-values.

The glacial till encountered typically consists of clayey sand with varying and sometimes substantial amounts of gravel. The till also includes some sandy lean clay, fat clay with gravel, gravel with clayey sand, and silty sand. The cohesive till ranges from firm to hard in consistency, while the granular till is medium dense to very dense.

Bedrock or apparent bedrock was encountered in all but one of the borings (Boring 10). The uppermost bedrock consists of shale of the Decorah formation. The upper portion of the shale is weathered. The rock coring performed at Boring 4 confirms that the underlying bedrock is limestone of the Platteville Formation.

5.3 Ground Water

Ground water was measured in 6 of the borings (Boring 1-3, 6, 9, and 12) during drilling. The measured water levels ranged from about 10 to 14 feet below the surface. These measurements correspond to ground water elevations of about 804 to 808. With the lowest floor elevation of 813.55, there appears to be at least 5 feet of separation between the highest measured water elevation and the lowest floor slab elevation.

The subsurface profile at this site contains interbedded layers of faster draining materials, such as granular soils and fractured limestone, and slower draining materials, such as cohesive soils, shale, and sound limestone. The water levels measured during drilling may represent perched conditions, which should be anticipated at this site. Ground water levels fluctuate due to varying seasonal and annual rainfall, snow melt amounts, as well as other factors.

5.4 Review of Soil Properties

5.4.1 Strength

The fill materials at this site do not appear to have been placed and compacted with the intent of future building support. In our opinion, the new structure should not be supported on these fill soils. Some of the naturally deposited coarse alluvial soils are loose and glacial till clays are firm, based on the N-values. The presence of these materials will limit the allowable bearing pressure at this site.

5.4.2 Compressibility

The existing fill and organic soils are potentially compressible and should be removed from below the building areas. The coarse alluvial and glacial till soils are not judged to be significantly compressible under the anticipated building loads. The underlying bedrock is not judge to be significantly compressible.

5.4.3 Drainage

The coarse alluvial granular soils and glacial till gravels are judged to be relatively fast draining materials. The remaining site soils and bedrock are judged to be moderate to slow draining materials. The layered nature of the subsurface profile at this site will result in perched ground water levels at various elevations.

5.4.4 Frost Susceptibility

Most of the soils at this site are at least moderately susceptible to frost heaving and thaw weakening. The exceptions include the coarse alluvial sands and sands with silt.

5.4.5 Expansion Potential

In general, the overburden soils are not judged to be overly expansive. However, the fat clay soils and underlying weathered shale has the potential to swell upon wetting. Based on the swell test performed, the maximum swell pressure of the shale is about 4200 psf and the maximum swell percent is approaching 3.6%. Generally, the upper 3 feet of the shale is considered susceptible to swelling, resulting in a maximum potential swell of up to 1½ inches under no load. In order to keep foundation and floor slab heave due to shale swelling to acceptable levels, an overburden soil weight should be maintained over the shale.

6.0 BUILDING RECOMMENDATIONS

6.1 Excavation

To prepare the building area for foundation and floor slab support, we recommend complete excavation of the existing fill, any organic soils, and soft clays, thereby exposing the competent glacial till or alluvial soils. This would result in excavation depths at the boring locations as shown in the following table.

Table 6.1.1 – Recommended Excavation Depths

Boring Location	Surface Elevation (ft)	Excavation Depth (ft)	Approximate Excavation Elevation (ft)
1	819.0	9	810
2	819.5	2	817½
3	820.1	11½	808½
4	818.4	7	811½
5	816.3	6½	810
6	814.3	6½	808
7	813.8	4½	809½

Boring Location	Surface Elevation (ft)	Excavation Depth (ft)	Approximate Excavation Elevation (ft)
8	819.1	9	810
9	818.7	2	816½

The depths and elevations indicated in preceding table are based on the soil conditions at the specific boring locations. Since conditions will vary away from and between the boring locations, we recommended that AET geotechnical personnel observe and confirm the competency of the soils in the entire excavation bottom prior to new fill or footing placement.

Where the excavation extends below foundation grade, the excavation bottom and resultant engineered fill system must be oversized laterally beyond the planned outside edges of the foundations to properly support the lateral loads exerted by that foundation. This excavation/engineered fill lateral extension should at least be equal to the vertical depth of fill needed to attain foundation grade at that location (i.e., 1:1 lateral oversize).

6.2 Fill Types and Placement

We recommend that fill placed for support of the building foundations and floor slab consist of granular soils containing less than 30% passing the No. 200 sieve. Soils used for engineered fill should be free of organic material, debris, and oversized particles (generally greater than 4 to 6 inches).

Fat clays and weathered shale should not be reused for engineered fill. It appears, based on observations of the soil samples retrieved from the borings, that much of the existing fill present at the site will not be suitable for re-use as engineered fill, due to the organic material and debris present. EnPro's environmental report should be reviewed to evaluate the impact of contaminated soils on the earthwork correction.

If there are areas where fill is placed on slopes, we recommend benching the sloped surface (benches cut parallel to the slope contour) prior to placing the fill. Benching is recommended where slopes are steeper than 4:1 (H:V).

6.3 Compaction

Fill placed to attain grade for foundation and floor slab support should be compacted in thin lifts, such that the entire lift achieves a minimum compaction level of 95% of the standard maximum dry unit weight per ASTM:D698 (Standard Proctor test).

6.4 Foundation Design

The structure can be supported on conventional spread foundations supported on competent native soils or newly placed and compacted fill. We recommend perimeter foundations for heated building space extend such that the bottom is a minimum of 42 inches below exterior grade. We recommend foundations for unheated building spaces (such as canopy, stoop, or garage entry foundations) extend a minimum of 60 inches below lowest unheated grade.

Based on the conditions depicted by the borings and the soil correction recommendations, it is our opinion the building foundations can be designed based on a net maximum allowable soil bearing pressure of 2,500 psf. It is our judgment this design pressure will have a factor of safety of at least 3 against localized shear or base failure. Under this loading, we judge that total settlement and differential settlements should not exceed 1 inch and ½ inch, respectively.

The foundations should be proportioned to exert as close to 2,500 psf as practical, in order to reduce the potential for differential shale heave of the foundations. Based on the 2,500 psf contact foundation pressure, typical assumed bottom-of-footing elevations (808½ to 811½), the elevation of the weathered shale encountered at the boring locations (802½ to 807), and the swell test performed, we estimate maximum shale heave of the foundations on the order of ⅓-inch to ⅔-inch.

6.5 Floor Slab Design

The recommended grading procedures should prepare the building area for floor slab support. The floor slab can be supported on the new compacted fill placed above the competent native soils. All fill supporting the floor slabs should be compacted to a minimum of 95% of the Standard Proctor Maximum Dry Density. For concrete slab design, we estimate the silty sands compacted as recommended above should provide a Modulus of Subgrade Reaction (k-value) of at least 150 pci.

Based on the swell test performed and 6½ to 11 feet of soil between the shale and the basement floor slab, we estimate maximum basement floor slab heave of ⅔-inch to 1-inch, respectively. We recommend the basement floor slab be designed and constructed as a floating slab which is independent of the walls, in order to better accommodate the potential for floor slab heave.

For the lower elevator pit area, we estimate maximum heave of the mat foundation/elevator pit slab will be about ½-inch. This estimate is based on the mat foundation/elevator pit slab exerting at least 1250 psf at the elevation of the shale and at least 4½ feet of soil overburden above the shale at the elevator pit location.

In our opinion, an underfloor drainage system is not needed for the basement/parking level floor at this site. The exception would be at the elevator pit, which should include a draintile and sump system. For recommendations pertaining to moisture and vapor protection of interior floor slabs, we refer you to the attached standard sheet entitled "Floor Slab Moisture/Vapor Protection."

6.6 Basement Backfilling/Water Control

In addition to the draintile and sump system recommended previously for the elevator pit, an exterior perimeter draintile system should be installed for the proposed below-grade level at this site. Our recommendations for backfilling basement/below-grade walls and installing draintile systems appear on the attached standard sheet entitled "Basement/Retaining Wall Backfill and Water Control." To avoid water intrusion issues into the basement and elevator pit, it is very important that these details be incorporated into the design. In addition, construction monitoring should be performed to ensure that proper materials and construction methods are implemented.

6.7 Exterior Building Backfilling

Many of the on-site soils are at least moderately frost susceptible; therefore, certain design considerations are needed to mitigate these frost effects. This is especially important for patio areas directly adjacent to the building. For details, we refer you to the attached sheet entitled "Freezing Weather Effects on Building Construction."

7.0 SITE RECOMMENDATIONS

7.1 Infiltration Design

Table 12.INF.7 from the Minnesota Stormwater Manual (Version 2, January 2008) published by the Minnesota Pollution Control Agency (MPCA) gives estimates of design infiltration rates based on soil type. The proposed infiltration area is near Borings 11, 13 and 14. The predominant soils encountered in these borings are clayey sands and sandy lean clays (USCS classifications of SC and CL). For these soils, a design infiltration rate of 0.2 inches per hour or less would be applicable.

7.2 Pavements

7.2.1 Definitions

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

7.2.2 Existing Subgrade Soils

Based on the available information and our experience, we estimate the existing subgrade soils at this site have a subgrade R-value of about 10 or less. These soils will not provide adequate subsurface drainage for long-term pavement performance. Therefore, we recommend a drained sand subbase layer be constructed to provide better support than the on-site material, especially during the spring-thaw period.

7.2.3 Excavation

In the new pavement areas, we recommend removing any surface vegetation, organic soils, and overly soft or wet clays when present within 3 feet of the pavement surface. Based on the conditions at the boring locations, we anticipate the resulting excavation depth will be about 2 to 3 feet in the parking and driveway areas.

7.2.4 Test Roll

After subcutting and before placing new fill in the pavement areas, we recommend the exposed soils be test-rolled (as described on the attached standard sheet or per Mn/DOT Specification 2111) to determine if unstable zones exist. If unstable soils are encountered, either they should be subcut and replaced, or they should be scarified, dried, and recompacted until proper stability is achieved.

7.2.5 Compaction

New fill and reworked soils should be compacted per Mn/DOT Specification 2105.3F1 (Specified Density Method). This requires that soils within 3 feet of the top of subgrade be compacted to a minimum of 100% of the Standard Proctor maximum dry density (ASTM:D698). Soils within this upper zone should also be placed and compacted at a water content between 65% and 102% of the optimum water content (based on the Standard Proctor). A reduced minimum compaction level of 95% of the Standard Proctor density can be used below the upper 3 foot zone.

7.2.6 Sand Subbase

Once the subgrade soils have achieved the proper stability, we recommend placement and compaction of a minimum 12-inch thick sand subbase layer. A thicker sand subbase layer will provide better performance and allow for a thinner pavement section. We recommend the sand subbase consist of Select Granular material per MnDOT specification 3149.2B2.

Because many of the soils at this site will not allow water to readily percolate, the sand subbase layer should be provided with a proper means of subsurface drainage in order to prevent build-up of water within the sand. Prior to sand subbase placement, the final excavation bottom should be sloped or shaped to promote drainage to the subbase drainage lines, catch basins, and outlets. The subcut excavation bottom should <u>not</u> include depressions, which will act as reservoirs for water collection.

Subbase drains should be placed at the outside edge of the subcut excavation and at the bottom of the subbase layer within the Select Granular material. The drainage lines should consist of 4-inch diameter perforated polyethylene tubing per Mn/DOT Specification 3278. They should be wrapped in a Type I geotextile fabric per Mn/DOT specification 3733.

7.2.7 Subgrade R-value

In regards to pavement support, limiting soils within the upper 3 feet of the soil profile at this site will consist of lean clays and sandy lean clays, for which we estimate a subgrade R-value of 10 when properly stabilized. With 12 inches of sand subbase over the on-site clays, an R-value of 20 can be used for pavement design. With 24 inches of sand subbase over the on-site clays, an R-value of 30 can be used for pavement design.

7.2.8 Pavement Thickness Designs

We are presenting both bituminous and concrete pavement designs based on a single traffic situation (light duty). The light duty design refers to parking areas and low frequency drive areas which are intended for automobiles and passenger trucks/vans, with very limited (1 truck per day or less) truck traffic, such as garbage or delivery trucks.

Our recommended bituminous and concrete pavement designs are based on the sand subbase options presented previously. These designs are based on a 20-year pavement design life.

Table 7.2.8a - Proposed Bituminous Pavement for Light Duty Traffic

Design R-Value	10	20	30
Material	**Thickness (inches)**		
Bituminous Wear (MVWE35035B)	2	1½	1½
Bituminous Non-Wear (MVNW35030B)	2	2	1½
Class 5 Aggregate Base	12	8	5
Select Granular Borrow	0	12	24

For smoothness and density, we recommend placement of the bituminous in maximum 2-inch lifts.

Table 7.2.8b – Proposed Concrete Pavement for Light Duty Traffic

Design Modulus of Subgrade Reaction k	50	100	200
Material	**Thickness (inches)**		
Concrete (f'_c=4000 psi)	5	4.5	4
Class 5 Aggregate Base	10	6	4
Select Granular Borrow	0	12	24

The concrete design assumes that no dowels are needed for load transfer. Although the Class 5 aggregate base is not necessarily needed for strength reasons, it was added to the concrete design to assist in construction and for controlling potential "mud pumping" at the joints. The design assumes a minimum concrete compressive strength (f'_c) of 4000 psi at 28 days.

We recommend that the Class 5 aggregate base material be compacted to 100% of the standard maximum dry unit weight per ASTM:D698 (Standard Proctor test). The Class 5 aggregate base should meet the requirements of Mn/DOT specification 3138.2.

7.3 Utilities

Please see the following standard data sheets for additional recommendations on utility bedding and backfilling: "Bedding/Foundation Support of Buried Pipe" and "Standard Recommendations for Utility Trench Backfilling."

8.0 CONSTRUCTION CONSIDERATIONS

8.1 Potential Difficulties

8.1.1 Cobbles and Boulders

The soils at this site can include debris, cobbles, and/or boulders. This may make excavating procedures somewhat more difficult than normal if they are encountered.

8.1.2 Runoff Water in Excavation

Water can be expected to collect in the excavation bottoms during times of inclement weather or snow melt. To allow observation of the excavation bottoms, to reduce the potential for soil disturbance, and to facilitate filling operations, we recommend water be removed from within the excavations during construction.

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

8.2 Excavation Backsloping

If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce sideslope erosion or running which could require slope maintenance.

8.3 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied.

9.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, our services have been conducted 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 B entitled "Geotechnical Report Limitations and Guidelines for Use."

FLOOR SLAB MOISTURE/VAPOR PROTECTION

Floor slab design relative to moisture/vapor protection should consider the type and location of two elements, a granular layer and a vapor membrane (vapor retarder, water resistant barrier or vapor barrier). In the following sections, the pros and cons of the possible options regarding these elements will be presented, such that you and your specifier can make an engineering decision based on the benefits and costs of the choices.

GRANULAR LAYER

In American Concrete Institute (ACI) 302.1R-04, a "base material" is recommended over the vapor membrane, rather than the conventional clean "sand cushion" material. The base layer should be a minimum of 4 inches (100 mm) thick, trimmable, compactable, granular fill (not sand), a so-called crusher-run material. Usually graded from 1½ inches to 2 inches (38 to 50 mm) down to rock dust is suitable. Following compaction, the surface can be choked off with a fine-grade material. We refer you to ACI 302.1R-04 for additional details regarding the requirements for the base material.

In cases where potential static water levels or significant perched water sources appear near or above the floor slab, an under floor drainage system may be needed wherein a draintile system is placed within a thicker clean sand or gravel layer. Such a system should be properly engineered depending on subgrade soil types and rate/head of water inflow.

VAPOR MEMBRANE

The need for a vapor membrane depends on whether the floor slab will have a vapor sensitive covering, will have vapor sensitive items stored on the slab, or if the space above the slab will be a humidity controlled area. If the project does not have this vapor sensitivity or moisture control need, placement of a vapor membrane may not be necessary. Your decision will then relate to whether to use the ACI base material or a conventional sand cushion layer. However, if any of the above sensitivity issues apply, placement of a vapor membrane is recommended. Some floor covering systems (adhesives and flooring materials) require installation of a vapor membrane to limit the slab moisture content as a condition of their warranty.

VAPOR MEMBRANE/GRANULAR LAYER PLACEMENT

A number of issues should be considered when deciding whether to place the vapor membrane above or below the granular layer. The benefits of placing the slab on a granular layer, with the vapor membrane placed below the granular layer, include reduction of the following:

- Slab curling during the curing and drying process.
- Time of bleeding, which allows for quicker finishing.
- Vapor membrane puncturing.
- Surface blistering or delamination caused by an extended bleeding period.
- Cracking caused by plastic or drying shrinkage.

The benefits of placing the vapor membrane over the granular layer include the following:

- A lower moisture emission rate is achieved faster.
- Eliminates a potential water reservoir within the granular layer above the membrane.
- Provides a "slip surface", thereby reducing slab restraint and the associated random cracking.

If a membrane is to be used in conjunction with a granular layer, the approach recommended depends on slab usage and the construction schedule. The vapor membrane should be placed above the granular layer when:

- Vapor sensitive floor covering systems are used or vapor sensitive items will be directly placed on the slab.
- The area will be humidity controlled, but the slab will be placed before the building is enclosed and sealed from rain.
- Required by a floor covering manufacturer's system warranty.

The vapor membrane should be placed below the granular layer when:

- Used in humidity controlled areas (without vapor sensitive coverings/stored items), with the roof membrane in place, and the building enclosed to the point where precipitation will not intrude into the slab area. Consideration should be given to slight sloping of the membrane to edges where draintile or other disposal methods can alleviate potential water sources, such as pipe or roof leaks, foundation wall damp proofing failure, fire sprinkler system activation, etc.

There may be cases where membrane placement may have a detrimental effect on the subgrade support system (e.g., expansive soils). In these cases, your decision will need to weigh the cost of subgrade options and the performance risks.

BASEMENT/RETAINING WALL BACKFILL AND WATER CONTROL

DRAINAGE

Below grade basements should include a perimeter backfill drainage system on the exterior side of the wall. The exception may be where basements lie within free draining sands where water will not perch in the backfill. Drainage systems should consist of perforated or slotted PVC drainage pipes located at the bottom of the backfill trench, lower than the interior floor grade. The drain pipe should be surrounded by properly graded filter rock. A filter fabric should then envelope the filter rock. The drain pipe should be connected to a suitable means of disposal, such as a sump basket or a gravity outfall. A storm sewer gravity outfall would be preferred over exterior daylighting, as the latter may freeze during winter. For non-building, exterior retaining walls, weep holes at the base of the wall can be substituted for a drain pipe.

BACKFILLING

Prior to backfilling, damp/water proofing should be applied on perimeter basement walls. The backfill materials placed against basement walls will exert lateral loadings. To reduce this loading by allowing for drainage, we recommend using free draining sands for backfill. The zone of sand backfill should extend outward from the wall at least 2', and then upward and outward from the wall at a 30° or greater angle from vertical. As a minimum, the sands should contain no greater than 12% by weight passing the #200 sieve, which would include (SP) and (SP-SM) soils. The sand backfill should be placed in lifts and compacted with portable compaction equipment. This compaction should be to the specified levels if slabs or pavements are placed above. Where slab/pavements are not above, we recommend capping the sand backfill with a layer of clayey soil to minimize surface water infiltration. Positive surface drainage away from the building should also be maintained. If surface capping or positive surface drainage cannot be maintained, then the trench should be filled with more permeable soils, such as the Fine Filter or Coarse Filter Aggregates defined in MnDOT Specification 3149. You should recognize that if the backfill soils are not properly compacted, settlements may occur which may affect surface drainage away from the building.

Backfilling with silty or clayey soil is possible but not preferred. These soils can build-up water which increases lateral pressures and results in wet wall conditions and possible water infiltration into the basement. If you elect to place silty or clayey soils as backfill, we recommend you place a prefabricated drainage composite against the wall which is hydraulically connected to a drainage pipe at the base of the backfill trench. High plasticity clays should be avoided as backfill due to their swelling potential.

LATERAL PRESSURES

Lateral earth pressures on below grade walls vary, depending on backfill soil classification, backfill compaction and slope of the backfill surface. Static or dynamic surcharge loads near the wall will also increase lateral wall pressure. For design, we recommend the following ultimate lateral earth pressure values (given in equivalent fluid pressure values) for a drained soil compacted to 95% of the Standard Proctor density and a level ground surface.

	Equivalent Fluid Density	
Soil Type	**Active (pcf)**	**At-Rest (pcf)**
Sands (SP or SP-SM)	35	50
Silty Sands (SM)	45	65
Fine Grained Soils (SC, CL or ML)	70	90

Basement walls are normally restrained at the top which restricts movement. In this case, the design lateral pressures should be the "at-rest" pressure situation. Retaining walls which are free to rotate or deflect should be designed using the active case. Lateral earth pressures will be significantly higher than that shown if the backfill soils are not drained and become saturated.

FREEZING WEATHER EFFECTS ON BUILDING CONSTRUCTION

GENERAL

Because water expands upon freezing and soils contain water, soils which are allowed to freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density/ strength loss depends on the soil type and moisture condition. Heave is greater in soils with higher percentages of fines (silts/clays). High silt content soils are most susceptible, due to their high capillary rise potential which can create ice lenses. Fine grained soils generally heave about 1/4" to 3/8" for each foot of frost penetration. This can translate to 1" to 2" of total frost heave. This total amount can be significantly greater if ice lensing occurs.

DESIGN CONSIDERATIONS

Clayey and silty soils can be used as perimeter backfill, although the effect of their poor drainage and frost properties should be considered. Basement areas will have special drainage and lateral load requirements which are not discussed here. Frost heave may be critical in doorway areas. Stoops or sidewalks adjacent to doorways could be designed as structural slabs supported on frost footings with void spaces below. With this design, movements may then occur between the structural slab and the adjacent on-grade slabs. Non-frost susceptible sands (with less than 12% passing a #200 sieve) can be used below such areas. Depending on the function of surrounding areas, the sand layer may need a thickness transition away from the area where movement is critical. With sand placement over slower draining soils, subsurface drainage would be needed for the sand layer. High density extruded insulation could be used within the sand to reduce frost penetration, thereby reducing the sand thickness needed. We caution that insulation placed near the surface can increase the potential for ice glazing of the surface.

The possible effects of adfreezing should be considered if clayey or silty soils are used as backfill. Adfreezing occurs when backfill adheres to rough surfaced foundation walls and lifts the wall as it freezes and heaves. This occurrence is most common with masonry block walls, unheated or poorly heated building situations and clay backfill. The potential is also increased where backfill soils are poorly compacted and become saturated. The risk of adfreezing can be decreased by placing a low friction separating layer between the wall and backfill.

Adfreezing can occur on exterior piers (such as deck, fence or other similar pier footings), even if a smooth surface is provided. This is more likely in poor drainage situations where soils become saturated. Additional footing embedment and/or widened footings below the frost zones (which includes tensile reinforcement) can be used to resist uplift forces. Specific designs would require individual analysis.

CONSTRUCTION CONSIDERATIONS

Foundations, slabs and other improvements which may be affected by frost movements should be insulated from frost penetration during freezing weather. If filling takes place during freezing weather, all frozen soils, snow and ice should be stripped from areas to be filled prior to new fill placement. The new fill should not be allowed to freeze during transit, placement or compaction. This should be considered in the project scheduling, budgeting and quantity estimating. It is usually beneficial to perform cold weather earthwork operations in small areas where grade can be attained quickly rather than working larger areas where a greater amount of frost stripping may be needed. If slab subgrade areas freeze, we recommend the subgrade be thawed prior to floor slab placement. The frost action may also require reworking and recompaction of the thawed subgrade.

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 better draining excess water in the base/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.

GRANULAR BORROW
Soils meeting Mn/DOT Specification 3149.2B1. 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 BORROW
Soils meeting Mn/DOT Specification 3149.2B2. This refers to granular soils which, of the portion passing the 1" sieve, contain less than 12% by weight passing the #200 sieve.

MODIFIED SELECT GRANULAR BORROW
Clean, medium grained sands which, of the portion passing the 1" sieve, contain less than 5% by weight passing the #200 sieve and less than 40% by weight passing the #40 sieve.

GEOTEXTILE STABILIZATION FABRIC
Geotextile meeting Type V requirements defined in Mn/DOT Specification 3733. When using fabric, installation should also meet the requirements outlined in Mn/DOT Specification 3733.

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 and recompacted per the Specified Density Method (Mn/DOT Specification 2105.3F1).

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 equipment used, soil conditions present, and/or pavement performance expectations.

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 engineering properties/stability are affected. These soils are usually black to dark brown in color.

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' to 4' (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' subgrade zone are unstable, attempts to properly compact the upper 3' zone to the 100% level may be difficult or not possible. Therefore, control of moisture just below the 3' 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 "popouts," 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 2½' deep for "auto only" areas and 3' 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 and 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' 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.

BEDDING/FOUNDATION SUPPORT OF BURIED PIPE

GENERAL

This page addresses soil bedding and foundation support of rigid pipe, such as reinforced concrete, and flexible pipe, such as steel and plastic. This does not address selection of pipe based on loads and allowable deflections, but rather addresses the geotechnical/soil aspects of uniform pipe support. Bedding/foundation support needs relate to local conditions directly beneath and to the sides of the pipe zone, which may be influenced by soft in-situ ground conditions or by soil disturbance due to soil sensitivity or ground water. Bedding relates to granular materials placed directly beneath the bottom of the pipe (usually 4" to 6" thick), which is intended to provide increased support uniformity. We refer to foundation soils as thicker layers of sands and/or gravels (beneath the bedding zone) intended to provide increased foundation strength support, usually needed due to soft, unstable and/or waterbearing conditions.

GRANULAR BEDDING

With circular pipes, high local loads (approaching point loads) develop if pipes are placed on hard surfaces. Load distribution is improved by placing granular bedding materials beneath the pipe, which are either shaped to match the pipe bottom or are placed without compaction to allow "settling in." The bedding should be placed in such a manner that the pipe will be at the proper elevation and slope when the pipe is laid on the bedding. Common bedding material is defined in Mn/DOT Specification 3149.2F, Granular Bedding. Published documents recommend rigid pipes having a diameter of 12" to 54" be placed on a bedding thickness of 4", which increases to 6" of bedding for pipe diameters ranging from 54" to 72". Beyond a 72" diameter, the bedding thickness can be equal to the pipe outside diameter divided by 12. Typically, the need for bedding under small diameter pipes (less than 12") depends on the pipe designer's specific needs, although in obvious point loads situations (bedrock, cobbles, significant coarse gravel content), bedding is recommended. Note that bedding should also account for larger diameter bells at joints.

FOUNDATION FILL

Positive uniform strength is usually compromised in soft or unstable trench bottom conditions. In this case, deeper subcuts and foundation fill placement is needed beneath the pipe. In moderate instability conditions, improvement can likely be accomplished with a thicker bedding layer. However, in more significant instability situations, particularly where ground water is present, coarser materials may be needed to provide a stronger foundation. Thicker gravel layers can also be a favorable media from which to dewater. The following materials would be appropriate for stability improvement, with the coarser materials being appropriate for higher instability/ground water cases.

- Fine Filter Aggregate - Mn/DOT Specification 3149.2J
- Coarse Filter Aggregate - Mn/DOT Specification 3149.2H

When using a coarser material which includes significant void space, we highly recommend enveloping the entire gravel layer within a geotextile fabric. The gravel material includes open void space, and the fabric acts as a separator which minimizes the intrusion of fines into the open void space. If an additional granular bedding sand is used above foundation gravel, the fabric would also prevent downward infiltration of bedding sand into the rock void space.

Although it is preferred to not highly compact thin granular bedding zones directly beneath the pipe center, it is desirable to compact the foundation materials to prevent more significant pipe settlement. We recommend foundation fill be compacted to a minimum of 95% of the Standard Proctor density (ASTM:D698). It is not possible to test coarse rock fill, although this material should still be well compacted/ tamped.

Often, pipes entering structures such as catch basins, lift stations, etc., enter the structure at a higher elevation than the structure bottom, and are therefore placed on the structure backfill. Fill beneath these pipes should be considered foundation fill. Depending on the flexibility of the connection design, it may be necessary to increase the minimum compaction level to reduce differential settlements, particularly with thicker fills.

SIDE FILL SUPPORT

If the pipe designer requires support from the side fill, granular bedding should also be placed along the sides of the pipe. In poor soil conditions, the sand fill may need to be placed laterally up to two pipe diameters on both sides of the pipe. With rigid pipe, compacted sand placement up to the spring line (within the haunch area) is usually sufficient. With flexible pipe, side fill should be placed and compacted at least to the top of the pipe. For positive support, it is very important to properly compact the sands within the haunch area.

STANDARD RECOMMENDATIONS FOR UTILITY TRENCH BACKFILLING

GENERAL

Clayey and silty soils are often difficult to compact, as they may be naturally wet or may become wet due to ground water or surface/rain water during construction. Soils will need to be placed within a certain range of water (moisture) content to attain desired compaction levels. Moisture conditioning to within this range can be time consuming, labor intensive, and requires favorable weather.

The degree of compaction and the soil type used for backfill within open cut utility trenches depends on the function of the overlying land surface. Details are as follows:

ROADWAYS

Where trenches are located below roadways, we recommend using inorganic fill and compacting these soils per Mn/DOT Specification 2105.3F1 (Specified Density Method). This specification requires 100% of the Standard Proctor density in the upper one meter subgrade zone, and 95% below this. Note that this specification includes moisture content range requirements which are important for proper subgrade stability.

Where available soils are wet or of poor quality, it may be possible to use the "Quality Compaction Method" (Mn/DOT Specification 2105.3F2) for soils below the upper one meter subgrade zone if you can tolerate some subsidence. However, a high level of stability is still important within the upper subgrade zone and recommend that the "Specified Density Method" be used in this upper subgrade area. We caution that if backfill soils in the lower trench area are significantly unstable, it may be difficult or even impossible to properly compact soils within the upper one meter subgrade zone. In this case, placing a geotextile fabric directly over the unstable soils can aid in offsetting the instability.

STRUCTURAL AREAS

If fill is placed beneath or within the significant zone of influence of a structure (typically a 1:1 lateral oversize zone), the soil type and minimum compaction level will need to be evaluated on an individual basis. Because trenches result in variable fill depths over a short lateral distance, higher than normal compaction levels and/or more favorable (sandy) soil fill types may be needed. If this situation exists, it is important that special geotechnical engineering review be performed.

NON-STRUCTURAL AREAS

In grass/ditch areas, backfill soils should be placed in reasonable lift thicknesses and compacted to a minimum of 90% of the Standard Proctor density (ASTM:D698) and/or per the Mn/DOT "Quality Compaction Method." If lower compaction levels are attained, more noticeable subsidence at the surface can occur. Steep or high slopes require special consideration.

Appendix A

AET Project No. 28-00333

Geotechnical Field Exploration and Testing
Boring Log Notes
Unified Soil Classification System
Figure 1 – Boring Locations
Subsurface Boring Logs
Percent Swell/Void Ratio vs. Log of Pressure

Appendix A
Geotechnical Field Exploration and Testing
AET Project No. 28-00333

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling 14 standard penetration test borings and advancing 1 NQ bedrock core. The locations of the borings appear on Figure 1, preceding the Subsurface Boring Logs in this appendix.

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 newest 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 are able to 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 actually 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.

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.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
B, H, N:	Size of flush-joint casing
CA:	Crew Assistant (initials)
CAS:	Pipe casing, number indicates nominal diameter in inches
CC:	Crew Chief (initials)
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
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
RD:	Rotary drilling with fluid and roller or drag bit
REC:	In split-spoon (see notes) 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.
REV:	Revert drilling fluid
SS:	Standard split-spoon sampler (steel; 1⅜" 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_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	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_{60} 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

AMERICAN ENGINEERING TESTING, INC.

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

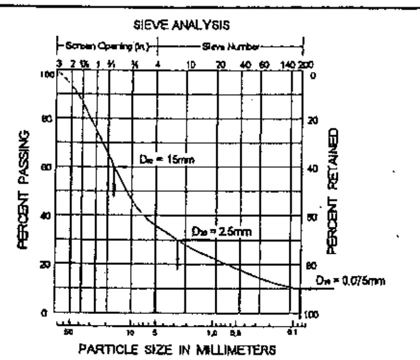
<u>Notes</u>

[A]Based on the material passing the 3-in (75-mm) sieve.
[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name
[C]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

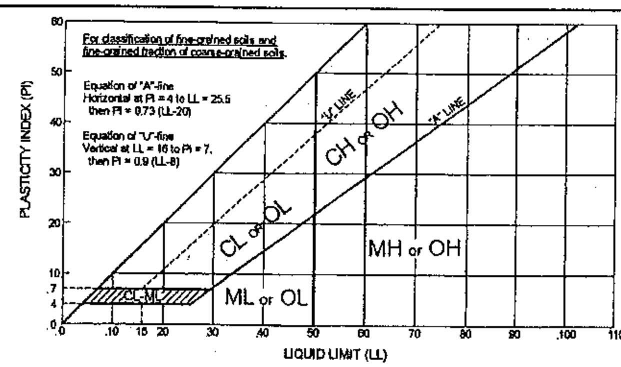
[D]Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

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

[F]If soil contains ≥15% sand, add "with sand" to group name.
[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H]If fines are organic, add "with organic fines" to group name.
[I]If soil contains ≥15% gravel, add "with gravel" to group name.
[J]If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.
[K]If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.
[L]If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M]If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N]PI≥4 and plots on or above "A" line.
[O]PI<4 or plots below "A" line.
[P]PI plots on or above "A" line.
[Q]PI plots below "A" line.
[R]Fiber Content description shown below.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $\quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{2.5^2}{0.075 \times 15} = 5.6$



Plasticity Chart

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

<u>Grain Size</u>

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

<u>Gravel Percentages</u>

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

<u>Consistency of Plastic Soils</u>

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

<u>Relative Density of Non-Plastic Soils</u>

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

<u>Moisture/Frost Condition</u> (MC Column)

D (Dry):	Absense of moisture, dusty, dry to touch.
M (Moist):	Damp, although free water not visible. Soil may still have a high water content (over "optimum").
W (Wet/ Waterbearing):	Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
F (Frozen):	Soil frozen

<u>Layering Notes</u>

Laminations:	Layers less than ½" thick of differing material or color.
Lenses:	Pockets or layers greater than ½" thick of differing material or color.

<u>Peat Description</u>

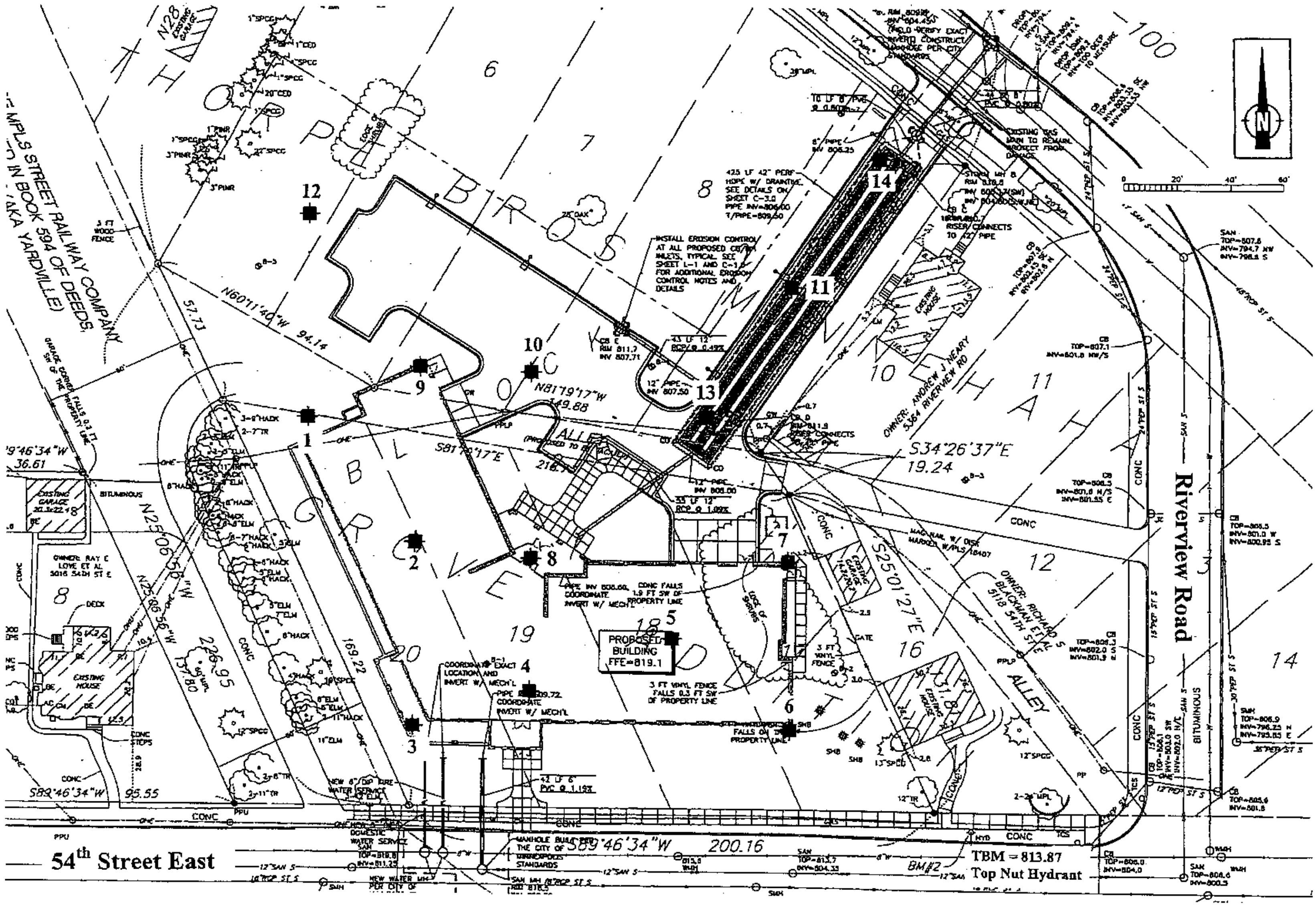
Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

<u>Organic Description (if no lab tests)</u>

Soils are described as *<u>organic</u>*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *<u>Slightly organic</u>* used for borderline cases.

<u>Root Inclusions</u>

With roots:	Judged to have sufficient quantity of roots to influence the soil properties.
Trace roots:	Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.



AMERCAN ENGINEERING TESTING, INC.	**PROJECT** Proposed Riverview Apartments, 54th Street and Riverview Road, Minneapolis, Minnesota		**AET NO.** 28-00333
	SUBJECT Boring Locations		**DATE** February 18, 2011
	SCALE See Above	**DRAWN BY** MJLH / **CHECKED BY** --		**FIGURE 1**

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **1 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **819.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly clayey sand with organic fines, trace roots, dark brown, frozen to about 1'	FILL		F/M	SS	14	22				
2–4	FILL, mostly lean clay with sand, a little clayey sand with organic fines, brown, a little dark brown		11	M	SS	12	32				
4–9	FILL, mostly sand, a little lean clay with sand, light brown, a little brown		10	M	SS	12					
			24		SS	0					
9–11.5	FAT CLAY WITH SAND AND GRAVEL, gray and brown, very stiff (CH) (possible redeposited shale)	TILL	29	M	SS	12	18				
11.5–14	GRAVEL WITH CLAY AND SAND, gray, waterbearing, dense (GP-GC)		49	W	SS	12					
14–16.6	WEATHERED SHALE, gray	DECORAH FORMATION	32	W	SS	14					

END OF BORING
HSA obstructed at 16.6'

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-16.6'	3.25" HSA							
		1/12/11	1:10	16.0	14.5	16.0		14.7
		1/12/11	1:30	16.0	16.6	16.6		11.7

BORING COMPLETED: **1/12/11**

DR: **DTS** LG: **TM** Rig: **69C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **2 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **819.5**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly clayey sand with organic fines and gravel, trace roots, dark brown, a little brown, frozen to about 1'	FILL		F/M	SS	14	10				
2–4	LEAN CLAY, trace roots, brown, firm (CL)	FINE ALLUVIUM	8	M	SS	6	25				
4–6.5	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	14	M	SS	12					
6.5–9	SAND, a little gravel, fine to medium grained, brown, moist, loose (SP)		9	M	SS	12					
9–11.5	SANDY LEAN CLAY WITH GRAVEL, brown and gray mottled, hard, laminations of silty sand and fat clay (CL)	TILL	31	M	SS	6	17				
11.5–14	SILTY SAND WITH GRAVEL, brown, a little light gray, dense, laminations of silt (SM)		35	M	SS	12					
14–17.4	WEATHERED SHALE, gray	DECORAH FORMATION	32	M	SS	14					
			50/.1	M	SS	1					

END OF BORING
HSA obstructed at 17.3'
SS obstructed at 17.4'

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-17.3'	3.25" HSA	1/12/11	2:25	16.0	14.5	16.0		14.3

BORING COMPLETED: 1/12/11

DR: DTS LG: TM Rig: 69C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **3 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **820.1**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mostly clayey sand with organic fines, a little gravel, trace roots, dark brown, frozen	FILL									
1–4	FILL, mostly sand, a little gravel and clayey sand with organic fines, frozen to about 2'			F	SS	12	17				
			7	M	SS	6					
4–6.5	FILL, mixture of gravel and clayey sand with organic fines, trace roots, dark brown		9	M	SS	6					
6.5–11.5	FILL, mixture of sandy lean clay, sand with silt, a little gravel, lean clay and clayey sand, trace roots, brown and dark brown		10	M	SS	6	19				
			10	M	SS	6					
11.5–15.5	CLAYEY SAND WITH GRAVEL, gray and brown mottled to gray, hard, laminations of fine silty sand (SC)	TILL	25/.5	▼ M	SS	12	15				
					TW	0					
			34	W	SS	6					
15.5–18	WEATHERED SHALE, gray	DECORAH FORMATION			TW	17					
18	**END OF BORING** HSA obstructed at 18'										

DEPTH:	DRILLING METHOD
0-18'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/13/11	1:55	16.0	14.5	16.0		12.3

BORING COMPLETED: **1/13/11**

DR: **DTS** LG: **TM** Rig: **69C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 28-00333 LOG OF BORING NO. 4 (p. 1 of 1)

PROJECT: Riverview Apartments; Minneapolis, MN

SURFACE ELEVATION: 818.4

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	REC %	RQD IN.	RQD %	%-#200
0-2	FILL, mostly silty sand, a little clayey sand with roots, dark brown	FILL	13	M	SS	6					
2-7	FILL, mostly clayey sand with organic fines, a little silty sand with organic fines, trace roots, dark brown		14	M	SS	12	19				
			4	M	SS	6	19				
7-9.5	SAND WITH SILT, a little gravel, fine to medium grained, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	13	M	SS	6					
9.5-13.5	CLAYEY SAND, a little gravel, brown, firm to hard, laminations of silty and (SC)	TILL	7	M	SS	6	17				
			100/.3	M	SS	2	18				
13.5-17.5	WEATHERED SHALE, gray SS obstructed at 15.5' HSA obstructed at 17'	DECORAH FORMATION	100/.5	M	SS	8					
17.5-22.5	SHALE, gray LIMESTONE, light gray and gray, lenses of brown Weathering: Moderately to slightly weathered Fracturing: Very to moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION CARIMONA MEMBER			NQ	47.5		99	39	81	
22.5-26	LIMESTONE, light gray Weathering: Slightly weathered Fracturing: Very to moderately fractured Stratification: Thickly bedded Hardness: Hard	PLATTEVILLE FORMATION MAGNOLIA MEMBER			NQ	58.5		97	53.5	89	
26	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-17'	3.25" HSA
17-26'	NQ Core

BORING COMPLETED: 1/14/11

DR: DTS LG: TM Rig: 69C

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/14/11	3:00	15.5	14.5	15.5		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 28-00333 LOG OF BORING NO. 5 (p. 1 of 1)

PROJECT: Riverview Apartments; Minneapolis, MN

SURFACE ELEVATION: 816.3

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–6.5	FILL, mostly clayey sand with organic fines, a little gravel and lean clay, pieces of floor tile, trace roots, dark brown, black and brown, frozen to about 2'	FILL		F	SS	12	18				
			16	M	SS	12	13				
			53/.5	M	SS	6	29				
6.5–9	CLAYEY SAND, brown, firm, laminations of fine sand (SC)	TILL	7	M	SS	2	17				
9–10.2	GRAVELLY SANDY LEAN CLAY, gray, a little brown, hard, laminations of fine silty sand (CL)		50/.4	M	SS	2	22				

END OF BORING
SS obstructed at 9.9'
HSA obstructed at 10.2'

DEPTH:	DRILLING METHOD							
0-10.2'	3.25" HSA							

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/13/11	11:10	9.9	10.2	10.2		None

BORING COMPLETED: 1/13/11

DR: DTS LG: TM Rig: 69C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **6 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

DEPTH IN FEET	SURFACE ELEVATION: 814.3 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	FILL, mostly clayey sand with organic fines, a little gravel, pieces of concrete, trace roots, dark brown	FILL									
1			10	M	SS	12	15				
3			2.5	M	SS	2	22				
5			14	M	SS	6					
7	CLAYEY SAND, a little gravel, brown, firm, laminations of wet silty sand (SC)	TILL									
8			5	M/W	SS	16	16				
9	CLAYEY SAND, a little gravel, grayish brown, stiff (SC)										
10			10	M	SS	16	15				
	END OF BORING HSA obstructed at 11.5'										

DEPTH:	DRILLING METHOD
0-11½'	3.25" HSA

BORING COMPLETED: 1/13/11

DR: DTS LG: TM Rig: 69C

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/13/11	11:45	11.0	11.5	11.4		10.2

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **7 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **813.8**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–3	FILL, mostly sandy lean clay with organic fines, trace roots, dark brown	FILL	6	M	SS	6	38				
			9	M	SS	12	19				
3–4.5	FILL, mostly clayey sand, brown										
4.5–7	CLAYEY SAND, a little gravel, grayish brown, firm (SC/SM)	TILL	8	M	SS	12	14				
7–7.7	CLAYEY SAND, a little gravel, brown and gray mottled, hard, laminations of silty sand (SC)		50/.3	M	SS	2	15				

END OF BORING
SS obstructed at 7.3'
HSA obstructed at 7.7'

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-7.7'	3.25" HSA	1/14/11	1:15	7.3	7.7	7.7		None

BORING COMPLETED: **1/14/11**

DR: **DTS** LG: **TM** Rig: **69C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **8 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **819.1**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	FILL, mixture of clayey sand with organic fines, silty sand and sand with silt, a little gravel, pieces of brick, frozen to about 2'	FILL		F	SS	14	16				
			7	M	SS	12					
4–9	FILL, mixture of sand with silt and a little gravel and clayey sand, light brown and brown		9	M	SS	14					
			9	M	SS	12					
9–12.3	CLAYEY SAND WITH GRAVEL, grayish brown, stiff (SC)	TILL	9	M	SS	14	14				
12.3–12.7	WEATHERED SHALE, gray	DECORAH FORMATION	50/.1	M	TW SS	2 1					

END OF BORING
SS obstructed at 12.3'
HSA obstructed at 12.7'

DEPTH:	DRILLING METHOD
0-12.7'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/13/11	9:50	12.3	12.7	12.7		None

BORING COMPLETED: 1/13/11

DR: DTS LG: TM Rig: 69C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **9 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **818.7**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mostly clayey sand with organic fines, a little gravel, trace roots, black, frozen	FILL		F	SS	18	21				
1–2	SANDY LEAN CLAY, trace roots, brown, stiff (CL) (possible fill)	TILL OR FILL					28				
2–4.5	SAND WITH SILT, fine grained, light brown, a little grayish brown, moist, loose, lenses of lean clay (SP-SM)	COARSE ALLUVIUM	7	M	SS	16					
4.5–6.5	SAND, a little gravel, fine to medium grained, light brown, a little brown, moist, loose, laminations of lean clay (SP)		7	M	SS	12					
6.5–9	SAND WITH SILT, a little gravel, medium to fine grained, brown, a little dark brown, moist, medium dense, laminations of lean clay (SP-SM)		11	M	SS	6					
9–11.5	GRAVEL WITH CLAY AND SAND, brown, a little dark brown and light gray, moist, dense, laminations of silt (GP-GC)	TILL	44	▼	SS	12					
11.5–14	GRAVEL WITH SILT AND SAND, gray, waterbearing, very dense (GP-GM)		72	W	SS	14					
14–16.3	WEATHERED SHALE, gray	DECORAH FORMATION	68	M	SS	16					

END OF BORING
HSA obstructed at 16.3'

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-16.3'	3.25" HSA							
		1/12/11	11:40	13.5	12.0	13.1		10.6
		1/12/11	12:15	16.0	16.3	16.3		11.8

BORING COMPLETED: 1/12/11

DR: **DTS** LG: **TM** Rig: **69C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **10 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **817.4**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mixture of lean clay with sand, and silty sand with organic fines, trace roots, brown and dark brown	FILL	8	M	SS	12	19				
2–7	SAND WITH SILT, fine to medium grained, brown, moist, loose (SP-SM) (possible fill)	COARSE ALLUVIUM OR FILL	10	M	SS	14					
			5	M	SS	12					
7–9	GRAVELLY SILTY SAND, medium to fine grained, brown, moist, very dense (SM)	TILL OR COARSE ALLUVIUM	51	M	SS	12					
9–11	CLAYEY SAND, a little gravel, grayish brown to gray, stiff (SC)	TILL	11	M	SS	6	14				
11	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-9½'	3.25" HSA	1/14/11	10:45	11.0	9.5	11.0		None

BORING COMPLETED: **1/14/11**

DR: **DTS** LG: **TM** Rig: **69C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

06/04

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **11 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

DEPTH IN FEET	SURFACE ELEVATION: 813.7 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4.5	FILL, mostly clayey sand with organic fines, trace roots, dark brown	FILL	17	M	SS	6	21				
			9	M	SS	12	23				
4.5–7	CLAYEY SAND, a little gravel, brown, firm (SC)	TILL	8	M	SS	12	14				
7–9	SANDY LEAN CLAY, a little gravel, apparent cobble or boulder from 7.4' to 9', brown, hard, laminations of silty sand (CL)		50/.4	M	SS	5	11				
9–10.9	WEATHERED SHALE, gray	DECORAH FORMATION	84/.9	M	SS	12					
	END OF BORING SS obstructed at 10.9'										

DEPTH:	DRILLING METHOD
0-9½'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/14/11	10:00	10.9	9.5	10.9		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

BORING COMPLETED: 1/14/11

DR: **DTS** LG: **TM** Rig: **69C**

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **12 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

DEPTH IN FEET	SURFACE ELEVATION: 819.2 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mixture of silty sand with organic fines and clayey sand with organic fines, a little gravel, trace roots, dark brown	FILL	9	M	SS	6	16				
2–4	FILL, mixture of lean clay and sand with silt, brown and light brown		12	M	SS	12	39				
4–6	SAND WITH SILT, fine to medium grained, brown, moist, loose (SP-SM)	COARSE ALLUVIUM	10	M	SS	12					
6–8	SAND, a little gravel, medium to fine grained, brown, moist, loose (SP)		8	M	SS	12					
8–10	SAND WITH SILT, a little gravel, medium to fine grained, brown, moist, medium dense (SP-SM)		19	M	SS	12					
10–12.5	GRAVELLY CLAYEY SAND, brown, very stiff, laminations of silty sand and sandy lean clay (SC)	TILL	26	M	SS	16	11				
				▼	TW	0					
12.5–14	GRAVEL WITH SAND, brown, waterbearing, dense (GP)		39	W	SS	6					
14–16.8	WEATHERED SHALE, gray	DECORAH FORMATION			TW	14	20	104	50	22	
			70/.8	M	SS	12					

END OF BORING
SS obstructed at 16.8'

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-15½'	**3.25" HSA**							
		1/14/11	**9:15**	**14.0**	**12.6**	**14.0**		**11.8**
		1/14/11	**10:00**	**16.8**	**15.5**	**16.8**		**None**
BORING COMPLETED: **1/14/11**								
DR: **DTS** LG: **TM** Rig: **69C**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **13 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **814.1**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mostly clayey sand with organic fines, trace roots, black, frozen	FILL		F	SS	15	28				
1–3	FILL, mostly silty sand with organic fines, dark brown										
3–4	FILL, mostly clayey sand, dark gray		7	M	SS	16	12				
4–5	FILL, mostly clayey sand, a little gravel, trace roots, dark brown						27				
5–6	FILL, mostly silty sand, a little gravel, brownish gray	TILL	8	M	SS	16	15				
6–8	CLAYEY SAND, trace roots, brown and gray mottled, firm to stiff (SC)		16	M	SS	16	17				
							14				
8	LIMESTONE, gray (possible stringer)	DECORAH FORMATION	100/.1	M	SS	1					
	END OF BORING SS obstructed at 8.1'										

DEPTH:	DRILLING METHOD
0-8'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/20/11	10:05	8.1	8.0	8.1		None

BORING COMPLETED: **1/20/11**

DR: **JM** LG: **JK** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **28-00333** LOG OF BORING NO. **14 (p. 1 of 1)**

PROJECT: **Riverview Apartments; Minneapolis, MN**

SURFACE ELEVATION: **812.1**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly lean clay with sand, slightly organic, a little silty sand, trace roots, dark brown and brown, frozen	FILL		F	SS	6	41				
2–4	FILL, mostly sandy lean clay, slightly organic, with gravel, trace roots, dark brown and brown		10	M	SS	4	34 22				
4–5	FILL, mostly sand with silt and gravel, brown		9	M	SS	9					
5–6	FILL, mostly sandy lean clay, a little gravel and silty sand, brown, gray and dark brown						19				
6–6.5	SANDY LEAN CLAY, a little gravel, brown and gray mottled, stiff (CL)	TILL	50/.5	M	SS	2	20				
6.5–9	GRAVEL WITH SAND, grayish brown, moist, very dense (GP) (possible bedrock)	TILL OR BEDROCK									
9–10.2	WEATHERED SHALE, gray	DECORAH FORMATION	83	M	SS	0					
10.2			100/.2	M	SS	1					

END OF BORING
SS obstructed at 10.2'

DEPTH:	DRILLING METHOD
0-10.2'	3.25" HSA

WATER LEVEL MEASUREMENTS

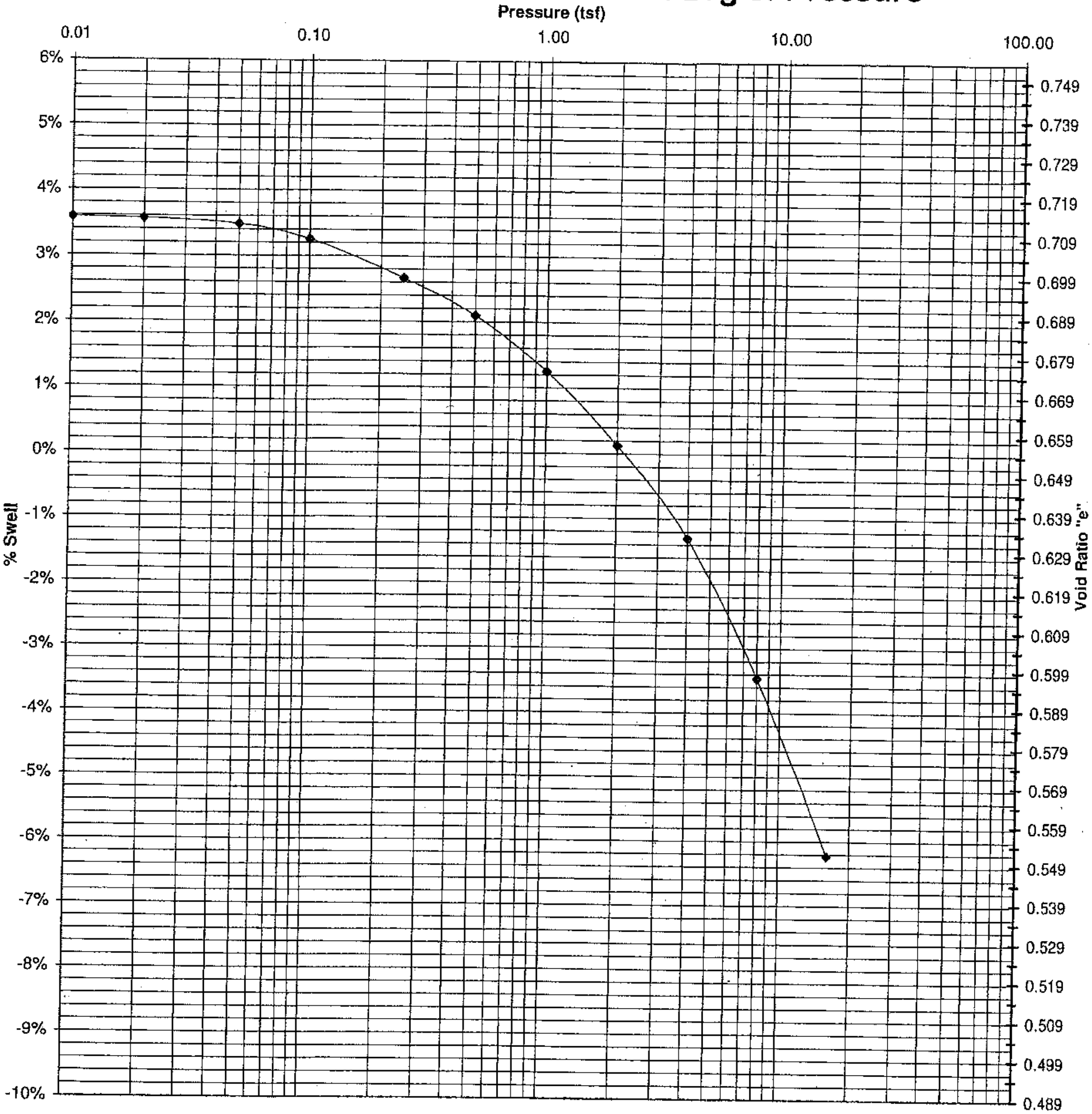
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/20/11	11:40	10.2	10.0	10.2		None

BORING COMPLETED: **1/20/11**

DR: **JM** LG: **JK** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

Percent Swell / Void Ratio vs. Log of Pressure



Project: 54th & Riverview - #28-00333 | Date: 2/8/11

Sample #: | Type: 3T | Boring #: B-12 | Depth ft: 14-15.5 | Job #: 7809

Soil Type: Weathered Shale, Lean Clay (CL/CH)

W.C. (%): 20.2 | γ dry (pcf): 103.8 | e_o: 0.713 | LL: 49.5 PL: 21.8 PI: 27.7 | LI: -0.06 | Gs: 2.75 (Assumed) | O.C.(%):

Specimen Ht (in): 0.652 Dia. (in): 2.503 | P_c: | C_c: 0.156 | C_s: | Max. Swell Pressure (tsf): 2.1 tsf

Remarks:

9301 Bryant Ave. South Suite 107 — Soil Engineering Testing, Inc. — Bloomington, Minnesota 55420-3436

Appendix B

AET Project No. 28-00333

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
AET Project No. 28-00333

B.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.

B.2 RISK MANAGEMENT INFORMATION

B.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. An no one, not even you, should apply the report for any purpose or project except the one originally contemplated.

B.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.

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

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typically factors include: the client's 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 general 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.

B.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

B.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.

B.2.6 A Report's Recommendations Are Not Final
Do not overrely 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.

B.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.

B.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.

B.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 to prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position 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.

B.2.10 Read Responsibility Provisions Closely
Some clients, 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.

B.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.