AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
- GEOTECHNICAL
- MATERIALS
- ENVIRONMENTAL

December 10, 1998

City of St. Paul
Department of Planning and Economic Development
1300 City Hall Annex
25 West 4th Street
St. Paul, MN 55102-1362

Attn: Darold McMahan

RE: Geotechnical Exploration and Review
Cleveland Circle Ramp
St. Paul, Minnesota
AET #02-00838

Dear Mr. McMahan:

This report presents the results of a subsurface exploration program and geotechnical engineering review for the referenced project. We are submitting four (4) copies of the report to you, with an additional copy being sent as noted below.

Please call 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,

Steven D. Koenes, PE
Principal Engineer
Phone: (612) 659-1304
Fax: (612) 659-1379

SDK/ak

CC: 1 - SMMA
Attn: Dick Dufresne

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GEOTECHNICAL EXPLORATION AND REVIEW
FOR
CLEVELAND CIRCLE RAMP
ST. PAUL, MINNESOTA

AET #02-00838

SUMMARY

Purpose
You are proposing to construct parking ramps near the new River Center Arena in St. Paul, Minnesota. The purpose of our work on this project is to explore subsurface conditions and provide geotechnical engineering recommendations to assist you and the project team in planning, design, and construction.

Scope
To accomplish the above purpose, you have authorized our firm to drill nine(9) test borings at the site, conduct laboratory testing, and prepare this geotechnical engineering report.

Findings
The generalized soil and bedrock profile consists of 4½' to 10' of fill underlain by limestone to depths on the order of 15' to 21' below existing site grade and then about 3½' to 4' of Glenwood Shale. The shale is underlain by St. Peter Sandstone. The ground water level at this site is within the St. Peter Sandstone Formation at an estimated depth of greater than 75' below existing site grade.

Recommendations
These recommendations are condensed for your convenience. Study our entire report for detailed recommendations.

- The proposed parking ramps can be supported on foundations extending to the Platteville Limestone. The foundations can be proportioned for an allowable bearing capacity of 50 tsf on competent limestone.
- In areas where less than 3' of competent limestone remains above the Glenwood Shale, the allowable bearing capacity should be reduced to 20 tsf.

INTRODUCTION

This report presents the results of a subsurface exploration program and geotechnical engineering review for the proposed Cleveland Circle Ramp in St. Paul, Minnesota.

To protect you, American Engineering Testing, Inc. (AET), and the public, we authorize use of opinions and recommendations in this report only by you and your project team for this specific project. Contact us if other uses are intended. Even though this report is not intended to provide sufficient information to accurately determine quantities and location of particular materials, we recommend that your potential contractors be advised of the report availability.

Scope of Services

AET's work on this project was done in accordance with our proposal dated October 2, 1998, which you authorized on October 8, 1998. The authorized scope of services for this project consists of the following:

- Nine (9) standard penetration test borings to refusal on bedrock.
- Core each of the borings through the limestone and into the shale.
- Extend three (3) of the borings 10' into sandstone.
- Laboratory testing (water content, density, Atterberg Limits and swell).
- Geotechnical engineering analysis based on the above and preparation of this report.

The scope of our work is intended for geotechnical purposes only. This scope is not intended to explore for the presence or extent of environmental contamination at the site or provide opinions regarding the status of the site relative to "wetland" definitions.

PROJECT INFORMATION

The City of St. Paul is planning construction of two parking ramps in the block bounded by 5th/6th Street, Fort Road, Kellogg Boulevard and Interstate 35E. We understand one ramp will be located to the north of proposed new Smith Avenue and the other ramp will be constructed on the south side of proposed Smith Avenue. There will also be connecting links between the two ramps at various levels. We understand the north ramp is designated as a ramp for transit functions and the south ramp will service the adjacent River Center Arena and the retail area which is planned on the street level of the south ramp.

We understand both ramps will have three supported levels. Design information for the ramp is very preliminary at this time. You are currently contemplating that the ramps will have conventional bay spacings on the order of 60' x 30'.

Foundation Design Assumptions

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", and differential settlements over a 30' distance of up to ½".

The presented project 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 changes in our recommendations are appropriate.

SITE CONDITIONS

Surface Observations

The majority of the site is presently utilized for surface parking. There is an existing historic residential structure centrally located on the site. The extreme eastern portion of the property is a green area which also contains several small ash trees. There are retaining walls along the west and north sides of the site.

The surface elevations at the boring locations range from 94.1' at Boring #2 to 102.5' at Boring #8, indicating that the site slopes downward from the northwest to the southeast.

Subsurface Soils/Bedrock/Geology

Logs of the test borings are included in Appendix A. The logs contain information concerning soil layering, soil classification, geologic description, and moisture. Relative density or consistency is also noted, which is based on the standard penetration resistance (N-value).

Based on our interpretation of the available boring information, it is our judgment the generalized soil/bedrock profile consists of about 4½' to 10' of fill underlain by Platteville Limestone to depths of about 15' to 21' below grade, and then about 3½' to 4' of Glenwood Shale. The Glenwood Shale is underlain by St. Peter Sandstone. A few of the borings also encountered fine alluvium or swamp deposit between the fill and limestone.

The Platteville Formation consists of five (5) members: the Carimona, the Magnolia, the Hidden Falls, the Mifflin and the Pecatonica. From observation of the logs, it can be seen that the Carimona, the Magnolia and the Hidden Falls members have been eroded. Only the Mifflin and

Pecatonica members are present at this site. The entire Mifflin member is typically about 12½' thick, but some has been previously excavated or eroded. The Pecatonica member is about 1' to 1½' in thickness.

In evaluating the capability of the limestone, the quality of the rock is quantified by one of two methods. Typically, 5' increments are cored into the bedrock. The total length recovered (solid and fragmented) divided by the length of run, establishes the percent recovery, which is included on the logs under the REC column heading.

From an engineering standpoint, a more useful determination of the bedrock quality is based on the modified core recovery procedure. This method, known as the rock quality designation, or RQD, takes into account the number of fractures and soft zones within the bedrock, based on retrieved core samples. In calculating the modified core recovery, only those sections retrieved which are hard, solid and 4" or longer in length (ignoring breaks due to handling) are combined and expressed as a percentage of the total run length. The RQD value provides better indication of bedrock bearing capacity as soft layers/seams and highly jointed/fractured zones are taken into account in the determination. The RQD within the limestone varies from 68% to 100%. Typically, the upper few feet of limestone is more fractured and weathered, resulting in a lower RQD value. The lower portion of the limestone typically has RQD values of 90% or higher. The coring continued into the Glenwood Shale and in some cases into the St. Peter Sandstone Formations. RQD values within the Glenwood and St. Peter formations were not determined, since coring these formations typically results in low to extremely low values, just due to the nature of these materials.

In the project area, the St. Peter Sandstone should have a thickness of about 150'. It is poorly cemented but typically quite dense and competent. It is underlain by a sequence of Ordovician, Cambrian and pre-Cambrian rocks many of hundreds of feet thick. There are no known faults in the area that have been active in recent geologic times.

Tunnels are known to exist in the St. Peter Sandstone in portions of Downtown St. Paul. The main tunnels are generally located within the street right-of-ways. However, drifts were excavated into the building sites to allow the utilities to be hooked up to buildings. Known utility tunnels include US West tunnels, NSP tunnels, City Water tunnels, City Sewer tunnels and District Heating tunnels. Although invert elevation of these tunnels varies, the majority of the tunnels are located within the upper approximately 25' to 30' of the sandstone sequence.

It should be noted that the streets and the subject building areas are relatively new, associated with a revitalization of this area. Consequently, the network of subterranean tunnels is still in the configuration of the arrangement of the pre-existing streets. These pre-existing street right-of-ways are also portrayed on the attached boring location sketch. The base map for the boring location sketch was a tunnel survey prepared for American Engineering and Testing by Rehder and Associates, Inc., under a previous scope of work.

The existing fill is a mixture of granular and cohesive soil. Peat and organic soils are also present within the fill at some boring locations. Several of the borings also encountered miscellaneous materials such as concrete, brick, bituminous pavement, cinders and ashes within the fill materials. Much of the fill is black, dark brown and dark gray, suggesting at least a little organic content. The N-values recorded in the fill are also variable. Some of the N-values are very low, suggesting a low level of compaction.

A few of the borings encountered fine alluvium or swamp deposits between the fill and limestone. These soils typically consist of lean clay, organic clay and sapric peat.

The boring logs only indicate the subsurface conditions at the sampled locations. Variations often occur between and beyond borings.

Previous Boring Information

A previous Phase II Environmental Site Assessment was prepared by Huntington Engineering and Environmental, Inc., under project #4233 95-1041 on February 21, 1995. We were provided with a copy of the report. The Phase II exploration included 9 soil borings located generally in the southeast one half of the site. All but one of these borings encountered bedrock at depths of about 4½' to 7½' below existing site grade. Boring B-3 was an exception in that the first bedrock encountered was St. Peter Sandstone at a depth of about 20.5' below existing grade. It appears that the Platteville Limestone and Glenwood Shale have been excavated in this general area of the site. Previous boring B-3 was located in the area of the former Auto Repair and Service Building and after that the American Linen and Laundry Building. It is likely one of the previous structures in the area of Boring B-3 had a basement level which extended down to the sandstone.

Sanborn Map Review

The scope of our work also included reviewing the available Sanborn map information for the site in an effort to determine whether previous structures had basement and sub-basement levels. Information contained on the maps did not include lower floor elevations. The map legend suggest basements were noted with a B after the number of stories above grade. A basement could extend as little as 4' below grade per definition on the map legend. Based on the Sanborn map information, we feel that basement levels may have existed at three previous structures located on the site and also the existing house has a basement. These include the American Linen and Laundry Building (formerly the Auto Repair and Service Building), the Masonic Temple and the Knights of Columbus Building. Previous soil boring (B-3), located in the American Linen and Laundry Building, does suggest the limestone and shale were removed. Recent boring B-7 is located in the general area of the Knights of Columbus Building. This boring encountered construction debris in the existing fill, but the Platteville Limestone was present at a similar elevation as in other borings in this general area of the site. The recent preliminary exploration did not include soil borings within the footprint of the previous Masonic Temple Building. We recommend additional exploration at the site include drilling at least two borings in the portion of the site that was previously occupied by the Masonic Temple. We also suggest at least one additional boring in the foot print of the previous Knights of Columbus Building and one boring in the footprint of the previous American Laundry and Linen Building.

To aid you in your preliminary planning, we have included a sketch which denotes areas of the site where deeper basements may have previously existed.

Water Level Measurements

The boreholes were probed for the presence of ground water and water level measurements were taken. The measurements are recorded on the boring logs. A discussion of the water level measurement methods is presented in the **SUBSURFACE EXPLORATION** section of this report.

Measurable water levels were not observed in any of the borings at the time of our exploration. Drilling fluid was used during coring of the limestone and shale as well as drilling within the St. Peter Sandstone Formation. The presence of the drilling fluid did not allow water level readings to be taken. However, based on the appearance of the sandstone, it did not appear that the sandstone was waterbearing. Also, there are known tunnels within the St. Peter Sandstone which suggest ground water at a much lower elevation. Based on published data of the US Geological Survey, and our past experience on other Downtown St. Paul projects, it appears the water table is within the St. Peter Sandstone Formation. The water level is likely at about elevation 10' to 20' (City of St. Paul datum). This corresponds to a depth of about 75' to 85' below existing site grade.

Ground water levels usually fluctuate. Fluctuations occur due to varying seasonal and yearly rainfall and snow melt, as well as other factors.

GEOTECHNICAL CONSIDERATIONS

The following geotechnical considerations are the basis for the recommendations presented later in this report.

Review of Soil/Bedrock Properties

Fill

The existing fill is low to moderate strength material. The looser portions of the fill are judged to be compressible. The granular portions of the fill are moderate to better draining materials and the clayey fill materials are slow draining. The majority of the fill soils are judged to be at least moderately frost susceptible.

Fine Alluvium and Swamp Deposits

The fine alluvium and swamp deposits are low strength materials. The swamp deposits are highly compressible and the fine alluvium is judged to be moderately compressible. These soils are moderate to slow draining. The organic soils are highly frost susceptible if water is present and the lean clay fine alluvium is at least moderately frost susceptible.

Limestone

The limestone is a high strength material. The upper few feet of limestone is weathered at some boring locations and has a lower strength. The competent limestone is not judged to be compressible under anticipated structure loads. The limestone is slow draining. However, fractured and weathered zones within the limestone can allow rapid transmission of subsurface water. The non-weathered portion of the limestone is not judged to be significantly frost susceptible.

Shale

The Glenwood shale is high strength material and is not judged to be significantly compressible under anticipated building loads. The shale can undergo volume changes with changes in water content and due to elevated temperatures. The most common problem is associated with a gain in water content which results in swelling of the shale. Swelling of the shale has been a problem on some sites in the Downtown St. Paul Area. The swell is generally more severe where the overburden soils and limestone are removed. Crystal formation within the shale has been experienced in areas where temperatures and humidity levels are higher than normal. If the new structures utilize high temperature boilers for heat, then contact us for additional information. The shale is slow draining material and is at least moderately frost susceptible.

Sandstone

The sandstone is high strength material and is not judged to be significantly compressible under anticipated building loads. The sandstone is moderate to slow draining. The upper portion of the sandstone is generally slower draining because of its transitional shale content and also the upper several feet of sandstone is generally more cemented.

Geotechnical Overview

Currently there are no below grade levels planned. Therefore, the need for significant excavation and temporary retaining structures is not likely for this project. Review of the available boring information in conjunction with a review of the Sanborn maps for this area, suggests extensive excavation of the limestone on this site has not occurred. Therefore, we anticipate competent bedrock will be present at depths of about 5' to 10' below existing site grade on much of the site.

The existing fill and other overburden soils are not judged suitable for foundation support and are marginal with respect to supporting the floor slab. Our primary recommendation would be to remove all existing fill, swamp deposits and soft fine alluvial soils, exposing the underlying limestone. Foundations can then be supported directly on the limestone and higher quality fill material can be placed and compacted for support of the floor slab.

We realize that the site is currently utilized for surface parking and at least a portion of the existing pavement is subjected to significant bus traffic. In our opinion, supporting a concrete floor slab on the existing fill involves a risk to the owner that settlement of the slab could occur. This risk could be reduced by subcutting the existing fill soils 2' or 3' below floor elevation and placing higher quality fill material in the upper portion of the subgrade. Also, you could consider a flexible pavement design on the street level of the ramp. Although the flexible pavement may still undergo some settlement and distress, it would be easier to maintain a flexible bituminous surface than to replace a concrete floor slab.

The Glenwood shale is potentially expansive with an increase in water content. Heaving of basement floor slabs have occurred in the past in the Downtown St. Paul area. Typically, where heave problems occurred, overburden soils and much if not all of the Platteville limestone was removed from above the Glenwood shale. This resulted in a very low overburden pressure on the shale and subsequently the amount of swell was more dramatic. At this time, you are not considering constructing below grade levels. Therefore, the overburden pressure on the shale should be at least 1.2 tsf. Based on the recent swell pressure test and also previous tests performed on the Glenwood shale for Downtown St. Paul projects, it is our judgment significant expansion of the shale should not occur under a 1.2 tsf confining pressure.

The limestone encountered at the recent boring locations varied from about 8' to 17' in thickness. The core recovery values and the RQD values suggest that the limestone is relatively high quality bedrock. Many of the previous structures in this portion of Downtown St. Paul were supported directly on the bedrock which includes the limestone, shale and sandstone. Based on our understanding of the proposed construction and assumed moderate foundation loadings, it should be feasible to support the new parking ramps on the competent limestone. The foundations can be designed for an allowable bearing capacity of 50 tsf provided the foundation is bearing on at least 3' of competent limestone above the Glenwood shale. Where removal of the limestone has occurred and less than 3' of limestone remains above the shale, the foundation should be proportioned for an allowable bearing capacity of 20 tsf. Also, in areas where less than 3' of limestone remains, you must be concerned about the presence of tunnels within the underlying sandstone. Depending on the location and elevation of these tunnels, it may be necessary to extend a drilled pier foundation to a lower elevation to provide positive support for the new structure and protect the existing tunnel.

RECOMMENDATIONS

Ramp Grading

Excavation

We understand the existing historic building will be removed from the site to allow construction of the parking ramps. The amount of additional excavation that will be needed will be dependant on the level of risk that is assumed by the owner, relative to floor slab performance. To eliminate the risk of detrimental slab settlement, complete removal of the existing fill, swamp deposit and fine alluvium, exposing the underlying bedrock is recommended. Based on the recent borings, it appears excavation depths of up to 10' below grade will be needed. Based on the type of overburden soils encountered, we recommend excavation backslopes of 1½:1 (horizontal to vertical). If a proper oversizing space does not exist, it may be necessary to install some type of retention system. Retention systems are not being addressed in this report. Please contact us if recommendations for a retention system are needed.

Fill required to attain grade for floor slab support should be uniformly compacted in thin lifts to a minimum of 98% of Standard Proctor Density (ASTM:D698) in the upper 3' of subgrade and to a minimum compaction level of 95% of Standard Proctor Density below 3'.

It is our judgment the soils excavated from the site are not suitable for reuse as compacted fill.

If the owner is willing to accept a risk of higher than normal floor slab settlement and additional maintenance, you could consider excavating the site to a depth of 3' below planned bottom of floor slab elevation. The exposed fill soils should then be surface compacted with a heavy vibratory compactor. Areas which become unstable during the surface compaction should be subcut to more competent materials. In areas where highly organic soils are exposed, we also recommend additional subcutting be performed.

After subcutting and surface compaction of the exposed fill soils, the floor slab area can be filled to grade with compacted fill. We recommend granular soil which contains less than 12% passing the #200 sieve. The fill should be placed in relatively loose lifts and be compacted to a minimum of 98% of Standard Proctor Density. If a flexible pavement will be installed, this compaction level should be increased to 100% of Standard Proctor Density.

Foundations

It is our judgment the proposed parking ramp structures should be supported on foundations extending to limestone. It is our judgment most foundations can be designed for an allowable bearing capacity of 50 tsf on competent limestone. Where foundations are within 3' of the top of the shale, we recommend the foundation loadings be reduced to an allowable bearing capacity of 20 tsf. These loadings should allow for a factor of safety of about 3 against shear failure and result in total and differential foundation settlement of less than 1" and ½", respectively.

There are known utility tunnels within the St. Peter Sandstone. Where foundations bear on the limestone 3' or more above the Glenwood Shale, it is our judgment the presence of the tunnels should not be a significant concern. However, where foundations are within 3' of the Glenwood Shale, it may be necessary to extend drilled piers into the sandstone in known tunnel areas. The St. Peter Sandstone is also judged suitable for foundation loadings of up to 50 tsf. AET has performed a tunnel survey in the area. After the building foundations have been located, we should be contacted to review the foundation plan to further determine where deeper foundations may be needed. At that time, additional auger borings could be put down at each of the proposed column locations to determine bedrock elevations or the final determination could be made in the field at the time of construction based on rock contact elevations.

Prior to concrete placement, the exposed limestone in the bottom of footing excavation should be observed by a geotechnical engineer. The contractor should also drill a probehole to a depth of 5' at each foundation location.

Due to tunnels within the sandstone and areas where rock has been removed on the site, it is likely drilled piers will be needed at some foundation locations. Pier foundations should extend to a depth such that a 1:1 slope is maintained between the bottom outside edge of the foundation and the bottom outside edge of any tunnel invert. A temporary casing should be installed to retain the granular fill soils.

It is our judgment concrete placed in drilled pier excavations which do not contain water can be placed without utilizing pumping or tremie methods. Care should, however, be taken to avoid segregation of the concrete caused by concrete hitting the sides of the excavation or reinforcing steel during placement. If temporary casings are utilized, a positive head of concrete should be maintained within the casing during extraction.

Floor Slabs

Our primary recommendations is to remove the existing fill and overburden soils and place granular material as fill for floor slab support. Fill placed below the floor slab should be a granular material with less than 12% passing the #200 sieve. These soils should be uniformly compacted to a minimum of 95% of Standard Proctor Density to within 3' of bottom of slab elevation and to 98% of Standard Proctor Density in the upper 3' of subgrade.

If the owner is willing to accept a risk of higher than normal pavement or slab settlement, you could consider supporting the slab on the existing soil profile. As a minimum, we recommend subcutting the existing fill soils to a depth of 3' below planned top of subgrade elevation. The exposed soils should then be surface compacted with a heavy vibratory compactor and unstable areas should be further subcut. Any highly organic soils or soft clays should also be removed. We again recommend a granular fill with less than 12% passing the #200 sieve. The fill should be placed in relatively loose lifts and be uniformly compacted to 98% of Standard Proctor Density. The compaction level should be increased to 100% of Standard Proctor Density if a bituminous pavement is planned on the main floor level.

Slab settlement is likely more critical in the retail area of the south ramp. In this area we recommend complete removal of all overburden soils.

Sidewalk/Exterior Building Backfilling

Soils placed below exterior sidewalks should be compacted to a minimum of 95% of Standard Proctor density. Other recommendations relative to backfilling the structures and placing fill below exterior slabs appears on the standard data sheets at the end of this report. These sheets are entitled:

- Basement/Retaining Wall Backfill and Water Control (Page 23)
- Freezing Weather Effects on Building Construction (Page 24)

These sheets present information on preferred soil types, frost considerations, drainage, and lateral pressures. We recognize that basements are not planned for these ramps, although the first data sheet also provides information on lateral earth pressures for design of exterior retaining walls.

Pavement Subgrade Preparation

Preparation of the pavement subgrade areas should include improving the upper 3' of subgrade materials. The borings suggest compaction of the existing fill is variable and also miscellaneous debris such as concrete, brick, ashes and cinders are present within portions of the fill. Some of the fill contains or is underlain by organic materials and these organic soils may be within 3' of top of subgrade elevation, depending on final grades. Preparation of pavement areas should include excavating the existing fill soils to a depth of 3' below top of subgrade elevation. In areas where highly organic swamp deposits are exposed in the bottom of the excavation, the excavation should extend through the swamp deposits. The exposed fill soils in the bottom of excavation should be surface compacted with a heavy vibratory compactor. Areas which become unstable during the surface compaction should be subcut to more competent materials. Additional information regarding preparation of subgrade areas is provided on the attached sheet entitled "Bituminous Pavement Subgrade Preparation and Design". This sheet contains general information on pavement design, subgrade preparation and includes items such as test roll evaluation, subgrade drainage and compaction recommendations.

New fill soils should be placed and compacted per Mn/DOT Specification 2105.3F1 (Specified Density Method). Fill placed or reworked in the pavement areas should be compacted to a minimum of 100% of Standard proctor Density in the upper 3' of subgrade, and to 95% below the upper 3' zone. Soils placed in the upper 3' of subgrade should be granular. Granular soils which contain less than 12% passing the #200 sieve are preferred, but you could consider granular soils which contain up to 20% passing the #200 sieve. The thickness of pavement sections will depend on the type of material present within the upper portion of the subgrade. In this report, we are providing a design for a sand or silty sand subgrade which contains less than 20% by weight passing the #200 sieve. The recommended flexible pavement thickness design assumes a 20 year pavement life.

Silty Sand Subgrade (Less than 20% Passing the #200 Sieve)		
Material	**Section Thicknesses**	
	Car Only Areas	**Heavy Duty Areas**
Bituminous Wear (Type 41)	1½"	2"
Bituminous Base (Type 31)	1½"	2"
Class 5 Aggregate Base (Mn/DOT 3138)	6"	6"

CONSTRUCTION CONSIDERATIONS

Potential Difficulties

Runoff Water in Excavation

As pointed out earlier, the on-site soils are relatively poor draining. Because of this, surface water can be expected to "perch" in the excavation during times of wetter weather. To allow observation of the excavation bottom, to reduce the potential for soil disturbance, and to facilitate filling operations; we recommend water be removed from within the excavations during construction. Based on the soils encountered, we anticipate the ground water can be handled with conventional sump pumping.

Hard Rock Excavation

Depending on final lower floor elevation, it may be necessary to excavate limestone in foundation areas. We anticipate bedrock excavation will require hard rock excavating techniques.

Excavation Sidesloping/Retention

If unretained, the excavation should maintain sideslopes in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavation and Trenches." Even with the required OSHA sloping, ground water seepage can induce sideslope raveling or running which would require maintenance.

Observation and Testing

Observation and testing during various phases of construction is extremely important. We, therefore, recommend that a geotechnical engineering firm be retained to observed and perform the necessary testing during construction.

After the building locations and elevations are better established, we recommend an additional geotechnical exploration program be performed. This additional exploration should include the previously recommended borings in areas of the former Masonic Temple Building, Knights of Columbus Building and American Linen and Laundry Building. In addition, we recommend additional borings to supplement contact elevation for the Platteville Limestone in other areas of the site.

To reduce your exposure to damage claims on nearby structures, it is our judgment a preconstruction condition survey should be performed prior to the start of construction. We also recommend a vibration monitoring program be established prior to and during excavation or other construction procedures that result in significant vibration.

As previously recommended, we recommend a 5' deep probehole be drilled at each foundation location. The probehole should be drilled in the presence of a geotechnical engineer or geotechnical technician to document that unsuitable conditions within the limestone do not exist immediately beneath the foundations.

Moisture-density tests should also be taken in any controlled fill placed beneath the floor slabs, as perimeter backfill around the building and in pavement subgrade areas.

SUBSURFACE EXPLORATION

General

The subsurface exploration program consisted of nine (9) standard penetration test borings and rock coring. The field work was performed on October 26 through 30, 1998.

Approximate soil boring locations are shown on the attached sketch. The borings were staked and elevated by the project surveyors.

Drilling Methods

The borings were drilled with hollow stem augers and flight augers penetrating to the upper surface of the bedrock. Rock coring within the limestone and shale was then performed using wireline drilling techniques with an NQ or HQ diamond bit core barrel. Drilling within the St. Peter Sandstone was performed using tri-cone and drilling fluid rotary drilling methods. The boreholes were grouted in compliance with the Minnesota Department of Health Rules.

Sampling Methods

Split-Spoon Samples (SS)

Standard penetration (split-spoon) samples were collected in accordance with ASTM:D1586. This method consists of driving a 2" O.D. split-barrel sampler into the in situ soil with a 140-pound hammer dropped from a height of 30". The sampler is driven a total of 18" into the soil. After an initial set of 6", the number of hammer blows to drive the sampler the final 12" is known as the standard penetration resistance or N value.

Rock Cores

Rock coring was performed in general accordance with ASTM:D2113, using an NQ or HQ wireline system.

Disturbed Samples (DS)

Some of the samples taken within the upper portion of the profile were disturbed materials taken from the flights of the auger.

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. They may still be present in the ground even if they are not noted on the boring logs.

Classification Methods

Soil classifications 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 and Atterberg Limits) have been performed, classifications per ASTM:D2487 are possible. Otherwise, soil classifications shown on the boring logs are visual-manual judgments. We have attached charts (Appendix A) illustrating the USC system, the descriptive terminology, and the symbols used on the boring logs. The "Rock Description Terminology" is provided on the attached sheet in the appendix.

The boring logs include judgments of the geological depositional origin. This judgment is primarily based on observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

The results of the water content and Atterberg Limits tests are included on the boring logs in Appendix A, opposite the samples upon which the tests were run. The results of the Swell Pressure test are included on separate data sheets in Appendix A.

LIMITATIONS

The data derived through this sampling and observation program have been used to develop our opinions about the subsurface conditions at your site. However, because no exploration program can reveal totally what is in the subsurface, conditions between borings and between samples and at other times, may differ from conditions described in this report. The exploration we conducted identified subsurface conditions only at those points where we took samples or observed ground water conditions. Depending on the sampling methods and sampling frequency, every soil layer may not be observed, and some materials or layers which are present in the ground may not be noted on the boring logs.

If conditions encountered during construction differ from those indicated by our borings, it may be necessary to alter our conclusions and recommendations, or to modify construction procedures, and the cost of construction may be affected.

The extent and detail of information about the subsurface condition is directly related to the scope of the exploration. It should be understood, therefore, that information can be obtained by means of additional exploration.

STANDARD OF CARE

Our services for your project have been conducted to those standards considered normal for services of this type at this time and location. Other than this, no warranty, either express or implied, is intended.

SIGNATURES

Report Prepared by:	Report Reviewed by:
Steven D. Koenes, PE Principal Engineer MN Reg. No. 13180	Terry Swor, PG President MN Reg. No. 30008

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. 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. 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.

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)	30	45
Silty Sands (SM)	40	60
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.

BITUMINOUS PAVEMENT SUBGRADE PREPARATION AND DESIGN

GENERAL

Bituminous pavements are considered layered "flexible" systems. Dynamic wheel loads transmit high local stresses through the bituminous/base onto the subgrade. Because of this, the upper portion of the subgrade requires high strength/stability to reduce deflection and fatigue of the bituminous/base system. The wheel load intensity dissipates through the subgrade such that the high level of soil stability is usually not needed below about 2' 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 3149.2B.

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.

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 tap into storm sewer systems, or outlets into ditches. Where sand subbase layers include sufficient sloping, and water can migrate to lower areas, draintile lines can be limited to finger drains at the catch basins. Even if a sand layer is not placed, strategically placed draintile lines can aid in improving pavement performance. This would be most important in areas where adjacent non-paved areas slope towards the pavement. Perimeter edge drains can aid in intercepting water which may infiltrate below the pavement.

Appendix A

Boring Locations
Soil Boring Logs
Boring Log Notes
Classification of Soils for Engineering Purposes
General Terminology Notes

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838**　　LOG OF BORING NO. **1 (p. 1 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **94.3**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0	2" Bituminous pavement										
1	Fill, mixture of sand and silty sand with a little gravel and bituminous pavement and concrete, brown	FILL	18	M	SS	18					
3			8	M	SS	10					
4–6	Organic clay, a few pieces of limestone, black, soft (OH/PT) (may be fill)	SWAMP DEPOSIT OR FILL	8	M	SS	17					
7	Limestone, light gray and gray, crinkly bedded Weathering: Slightly weathered to fresh Fracturing: Moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER	50/.1	M	SS	1					
7					NQ	48	100	46	95		
11					NQ	68	100	59	98		
16	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*			NQ	46	100				
18–20	Shale, gray to about 19.5' then light gray sandy shale to shaley sandstone below about 19.5'	GLENWOOD FORMATION			NQ	38	100				
21	Sandstone, brown, light brown and white mottled to white, well cemented above about 22.5'	ST. PETER FORMATION									

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-6.2'	6" FA							
6.6-22.6'	NQ							
22.6-32.5'	RD w/DM ***							
BORING COMPLETED:	10/28/98							
CC: MC	CA: JS　Rig: 15R							

WATER LEVEL MEASUREMENTS

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

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838**

LOG OF BORING NO. **1 (p. 2 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	FIELD & LABORATORY TESTS REC %	RQD IN.	RQD %	PL	%-200
23			50/.1	M	SS	1					
24											
25											
26	Sandstone, brown, light brown and white mottled to white, well cemented above about 22.5'	ST. PETER FORMATION									
27											
28			50/.1	M	SS	1					
29											
30											
31											
32											
	END OF BORING		50/.0	M	SS	0					
	***Neat Cement Grout	*PECATONICA MEMBER									

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838**　　LOG OF BORING NO. **2 (p. 1 of 1)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

DEPTH IN FEET	SURFACE ELEVATION: 94.1 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
1	Fill, mixture of silty sand, fat clay and clayey sand with a little gravel and cinders, dark grayish brown and dark gray	FILL	18	M	SS	18					
2–4			5	M	SS	18					
5	Weathered limestone, light gray	PLATTEVILLE FORMATION MIFFLIN MEMBER	50/.2	M	SS	2					
6	Limestone, light gray and gray, crinkly bedded				NQ	21	94	16	68		
7			50/.1	M	SS	1					
8					NQ	40	100	40	100		
9–15	Weathering: Slightly weathered to fresh Fracturing: Very to moderately fractured Stratification: Very thinly bedded Hardness: Hard				NQ	60	100	60	100		
16–17	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*			NQ	38	100				
18	Shale, gray, sandy shale below about 18.5'	GLENWOOD FORMATION									
	END OF BORING	*PECATONICA MEMBER									

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS: DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-5.4'	6" FA							
5.4-18.8'	NQ							
Neat	Cement Grout							

BORING COMPLETED: **10/28/98**

CC: **MC** CA: **JS** Rig: **15R**

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

4/90

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **3 (p. 1 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

DEPTH IN FEET	SURFACE ELEVATION: 95.5 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0–10	Fill, mostly silty sand with a little gravel, some concrete below about 8', brown with a little black	FILL	14	M	SS	24					
			30	M	SS	16					
			3	M	SS	18					
			2	M	SS	18					
10–17	Limestone, light gray and gray, crinkly bedded Weathering: Slightly weathered to fresh Fracturing: Very to moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER	70/.4	M	SS	2					
					NQ	60	100	58	96		
					NQ	60	100	60	100		
17–19	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*									
19–21.5	Shale, gray to about 20.5' then light gray with a little brown sandy shale to shaley sandstone below about 20.5'	GLENWOOD FORMATION			NQ	23	100				

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-9.5'	6" FA							
10.6-22.5'	NQ							
22.5-32.2'	RD w/DM ***							
BORING COMPLETED: 10/28/98								
CC: MC CA: JS Rig: 15R								

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

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 02-00838   LOG OF BORING NO. 3 (p. 2 of 2)

PROJECT: Cleveland Circle Ramp; St. Paul, MN

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	FIELD & LABORATORY TESTS REC %	RQD IN.	RQD %	PL	%-200
			50/.0	M	SS	0					
23											
24											
25	Sandstone, brown, light brown and tan to white, well cemented above about 22.5'	ST. PETER FORMATION									
26											
27											
28			50/.1	M	SS	1					
29											
30											
31											
32											
	END OF BORING		50/.1	M	SS	0					
	***Neat Cement Grout	*PECATONICA MEMBER									

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **4 (p. 1 of 1)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **95.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0–0.5	6" Bituminous pavement										
1	Fill, mostly silty sand with brick, concrete and gravel, dark grayish brown	FILL	36	M	SS	18					
3			4	M	SS	8					
5	Lean clay, brown and light gray mottled, very soft (CL)	FINE*	52/.7	W	SS	13					
6	Limestone, light gray and gray, crinkly bedded Weathering: Slightly weathered to fresh Fracturing: Very to moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER			NQ	56	100	55	98		
11					NQ	60	100	60	100		
16					NQ	59	98	59	98		
17	Limestone, light gray Weathering: Fresh Fracturing: Slightly fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION**									
18–20	Shale, gray	GLENWOOD FORMATION									
	END OF BORING	*ALLUVIUM **PECATONICA MEMBER									

DEPTH:	DRILLING METHOD
0-5.7'	6" FA
5.9-20.6'	NQ
Neat	Cement Grout

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL

BORING COMPLETED: 10/27/98

CC: MC CA: JS Rig: 15R

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

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **5 (p. 1 of 1)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **94.8**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0–0.25	3" Bituminous pavement										
1	Fill, mixture of silty sand, sand and clayey sand with a little gravel, brown and dark brown	FILL	28	M	SS	18					
3			22	M	SS	18					
5			50/.2	M	SS	7					
6	Limestone, light gray and gray, crinkly bedded Weathering: Slightly weathered to about 6' then fresh Fracturing: Very to moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER			NQ	58	96	50	84		
11					NQ	60	100	60	100		
16					NQ	54	100	54	100		
17	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*									
19	Shale, gray	GLENWOOD FORMATION									
20	END OF BORING	*PECATONICA MEMBER									

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-5.2'	6" FA							
5.5-20'	NQ							
Neat	Cement Grout							

WATER LEVEL MEASUREMENTS

BORING COMPLETED: 10/29/98

CC: MC CA: JS Rig: 15R

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

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838**

LOG OF BORING NO. **6 (p. 1 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **96.9**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0–2	3.5" Bituminous pavement Fill, mostly silty sand with a little gravel, brown	FILL	9	M	SS	18					
2–5	Fill, mixture of silty sand and ashes with a little gravel, black and brownish gray		6	M	SS	18					
5–7.3	Fill, mixture of peat and silty sand with a little ashes, black and dark brown with a little gray		3	M	SS	18					
7.3			50/.5	M	SS	5					
7.3–18.2	Limestone, light gray and gray crinkley bedded Weathering: Slightly weathered to about 8' then fresh Fracturing: Very moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER			HQ	42	97	36	83		
11					HQ	59	98	59	98		
16					HQ	60	100	60	100		
18.2–20.5	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*									
20.5–	Shale, gray to about 21.8' then light gray sandy shale to shaley sandstone below about 21.8'	GLENWOOD FORMATION			HQ	22	90				

DEPTH:	DRILLING METHOD
0-7.3'	6" FA
7.3-22.9'	HQ
Neat	Cement Grout

BORING COMPLETED: 10/30/98

CC: MC CA: JS Rig: 15R

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL

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

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 02-00838 LOG OF BORING NO. 6 (p. 2 of 2)

PROJECT: Cleveland Circle Ramp; St. Paul, MN

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	FIELD & LABORATORY TESTS: REC %	RQD IN.	RQD %	PL	%-200
	END OF BORING										

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **7 (p. 1 of 1)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **95.2**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
	3.5" Bituminous pavement										
1	Fill, mixture of sand and silty sand, brown	FILL	15	M	SS	18					
2											
3	Fill, mostly lean clay, black and gray		7	M	SS	18					
4											
5–6	Fill, mixture of silty sand, brick and concrete, dark brown and brown		70/.7	M	SS	14					
7–17	Limestone, light gray and gray crinkly bedded Weathering: Slightly weathered to about 8' then fresh Fracturing: Very thinly bedded Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER			NQ	39	97	37	91		
					NQ	60	100	60	100		
					NQ	60	100	60	100		
17–18	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*									
18–20	Shale, gray	GLENWOOD FORMATION									
	END OF BORING	*PECATONICA MEMBER									

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-7.2'	6" FA							
7.2-20.6'	NQ							
Neat	Cement Grout							

WATER LEVEL MEASUREMENTS

BORING COMPLETED: 10/29/98

CC: MC CA: JS Rig: 15R

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

4/90

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 02-00838 LOG OF BORING NO. 8 (p. 1 of 2)

PROJECT: Cleveland Circle Ramp; St. Paul, MN

DEPTH IN FEET	SURFACE ELEVATION: 102.5 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0-8	Fill, mixture of silty sand, clayey sand and pieces of limestone and a little organic clay, dark brown, black and grayish brown	FILL	26	M	SS	22					
			24	M	SS	16					
			11	M	SS	10					
			54/.7	M	SS	13					
8-13	Limestone, light gray with lenses of brown to about 10.2' then gray with lenses of brown at about 12.4' then light gray and argillaceous from about 10.2' to 12.4' Weathering: Slightly weathered Fracturing: Very fractured Stratification: Thickly bedded Hardness: Hard to moderately hard	PLATTEVILLE FORMATION HIDDEN FALLS MEMBER	60/.1	M	SS	1					
					NQ	24	100	0	0		
					NQ	60	100	48	80		
13-21+	Limestone, light gray and gray, crinkly bedded Weathering: Fresh Fracturing: Moderately to slightly fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER			NQ	60	100	60	100		
					NQ	60	100	60	100		

DEPTH:	DRILLING METHOD
0-8.4'	3.25" HSA
8.5-30.5'	NQ
30.5-40.1'	RD w/DM ***

BORING COMPLETED: 10/26/98

CC: MC CA: JS Rig: 15R

WATER LEVEL MEASUREMENTS						
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL

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

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **8 (p. 2 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	FIELD & LABORATORY TESTS				
							REC %	RQD IN.	RQD %	PL	%-200
23–24	Limestone, light gray and gray, crinkly bedded Weathering: Fresh Fracturing: Moderately to slightly fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER									
25–26	Limestone, light gray Weathering: Fresh Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard	PLATTEVILLE FORMATION*			NQ	60	100				
27–29	Shale, gray to about 28' then light gray sandy shale to shaley sandstone below about 27.3'	GLENWOOD FORMATION									
30–40	Sandstone, light brown and brown, cemented to 30.5'	ST. PETER FORMATION	50/.1	M	SS	0					
35			100/.1	M	SS	0					
40	**END OF BORING**		100/.1	M	SS	0					

*PECATONICA MEMBER

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **02-00838** LOG OF BORING NO. **9 (p. 1 of 2)**

PROJECT: **Cleveland Circle Ramp; St. Paul, MN**

SURFACE ELEVATION: **98.8**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	REC %	RQD IN.	RQD %	PL	%-200
0–5	Fill, mixture of silty sand and clayey sand with a little gravel, brown	FILL	3	M	SS	24					
			24	M	SS	18					
5–6.5	Sapric peat, black, moist (PT)	SWAMP DEPOSIT	3	M	SS	18					
6.5–9.5	Lean clay, gray, soft (CL)	FINE ALLUVIUM	2	M	SS	18					
9.5–21	Limestone, light gray and gray, crinkly bedded Weathering: Moderately to about 9.8' then fresh Fracturing: Very to moderately fractured Stratification: Very thinly bedded Hardness: Hard	PLATTEVILLE FORMATION MIFFLIN MEMBER	50/.0	M	SS HQ	12	83	12	83		
					HQ	60	100	60	100		
					HQ	60	100	60	100		
21–	Limestone, light gray Weathering: Fresh	PLATTEVILLE FORMATION*			HQ	60	100				

DEPTH:	DRILLING METHOD
0-9.8'	6" FA
9.8-26'	HQ
Neat	Cement Grout

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL

BORING COMPLETED: **10/30/98**

CC: **MC** CA: **JS** Rig: **15R**

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

4/90

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 02-00838 LOG OF BORING NO. 9 (p. 2 of 2)

PROJECT: Cleveland Circle Ramp; St. Paul, MN

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC. IN.	FIELD & LABORATORY TESTS REC %	RQD IN.	RQD %	PL	%-200
23 24 25	Fracturing: Moderately fractured Stratification: Thinly bedded Hardness: Hard Shale, gray to about 24.5' then light gray, sandy shale to shaley sandstone below about 24.5'	GLENWOOD FORMATION									
26	Sandstone, light brown, cemented	ST.**									
	END OF BORING										

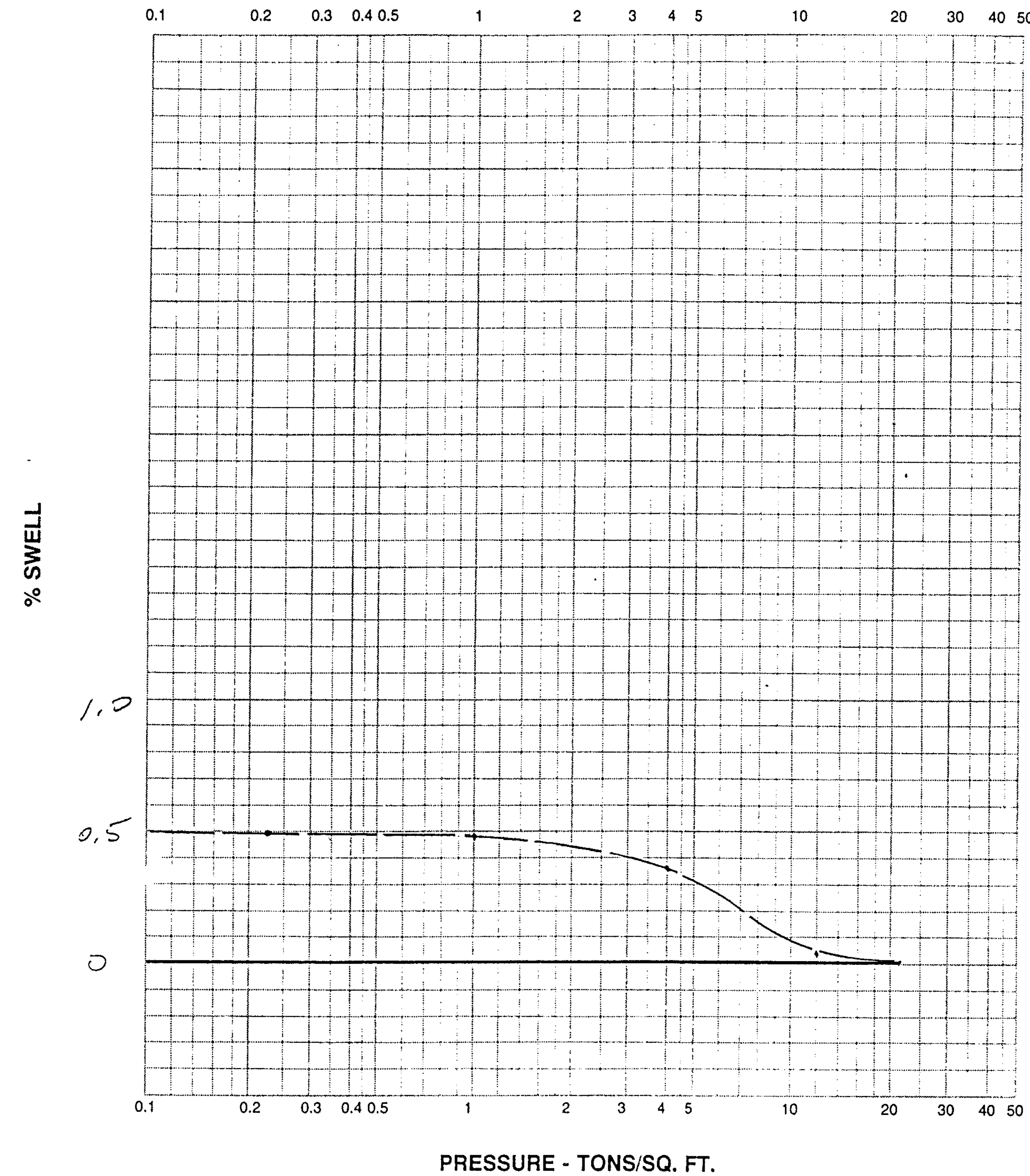
*PECATONICA MEMBER

**PETER FORMATION

***Neat Cement Grout

SWELL TEST

% SWELL VS. LOG OF PRESSURE



Project CLEVELAND CIRCLE RAMP - ST. PAUL, MN. - AET # 02-00838

Date 11-6-98 Job No. 3411 Boring No. 9 Sample No. ______ Depth (ft.) @ 23½

Soil Type GLENWOOD SHALE -- FAT CLAY (CH)

Initial Water Content (%) 7.0 Dry Density (pcf) 139.9 Liquid Limit 58.3 Plastic Limit 15.9 Plasticity Index 42.4

Specific Gravity ______ Organic Content (%) ______ Initial Specimen Height (in.) 0.911 Diameter 2.499

Preconsolidation Pressure (Pc) ______ Compression Index (Cc) ______ Recompression Index (Cr) ______

Remarks: MAXIMUM SWELL PRESSURE = 22.0 tsF
% SWELL @ 150 psF = 0.50

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
B,H,N:	Size of flush-joint casing
BX:	BX double tube core barrel
AC:	At completion of boring
CA:	Crew assistant
CAS:	Pipe casing, number indicates nominal diameter in inches
CC:	Crew chief
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
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
JW:	Jetting water
MC:	Column used to describe moisture condition of samples and for the ground water level symbol
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
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
WAT:	Water
WH:	Sampler advanced by static weight of drill rod and 140-pound hammer
WR:	Sampler advanced by static weight of drill rod
94 mm:	94 millimeter wireline core barrel
▼:	Water level indicated in boring

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
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic limit, %
q_p:	Pocket penetrometer strength, tsf
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical resistivity, ohm-cms
RQD:	Rock Quality Designator 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
VS:	Vane shear strength (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES

The standard penetration test consists of driving the sampler with a 140-pound hammer 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 tenth of a foot 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").

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487
(Based on Unified Soil Classification System)

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[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	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	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	CL	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	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

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

[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 in hatched area, soil 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 to group name.

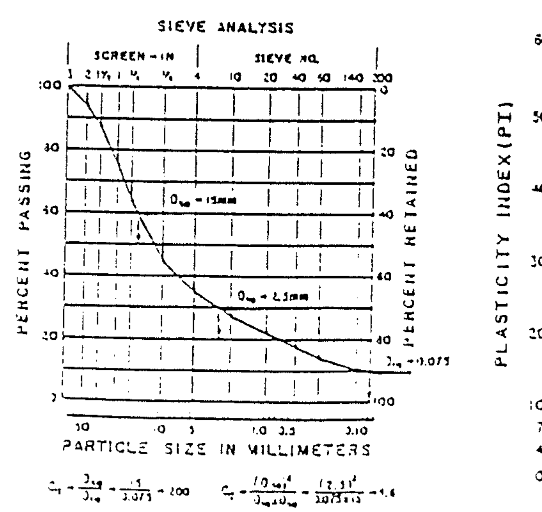
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

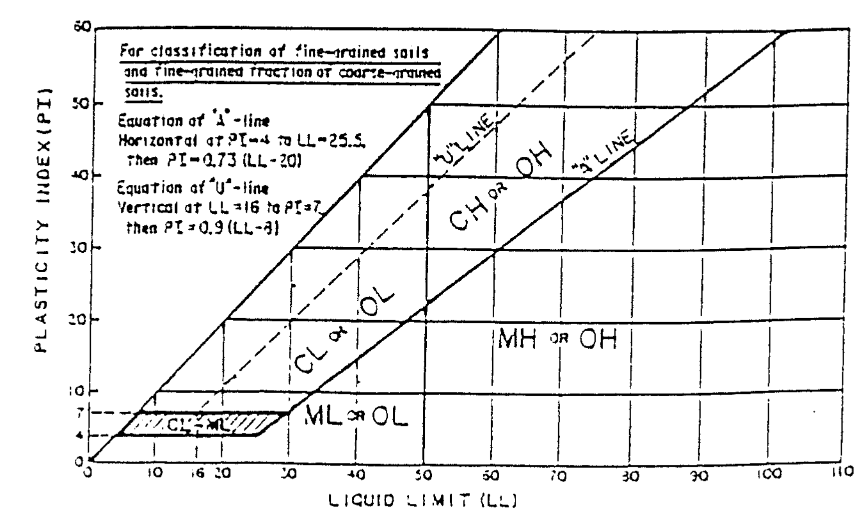
[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.





GENERAL TERMINOLOGY NOTES FOR SOIL IDENTIFICATION AND DESCRIPTION

GRAIN SIZE

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

GRAVEL PERCENTAGES

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

CONSISTENCY OF PLASTIC SOILS

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

RELATIVE DENSITY OF NON-PLASTIC SOILS

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

MOISTURE/FROST CONDITION
(MC Column)

D (Dry): Absence 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.

F (Frozen): Soil frozen.

LAYERING NOTES

Laminations: Layers less than ½" thick of differing material or color

Lenses: Pockets or layers greater than ½" thick of differing material or color

FIBER CONTENT OF PEAT

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

ORGANIC DESCRIPTION

Non-peat soils are described as organic, if soil is judged to have sufficient organic content to influence the soil properties.

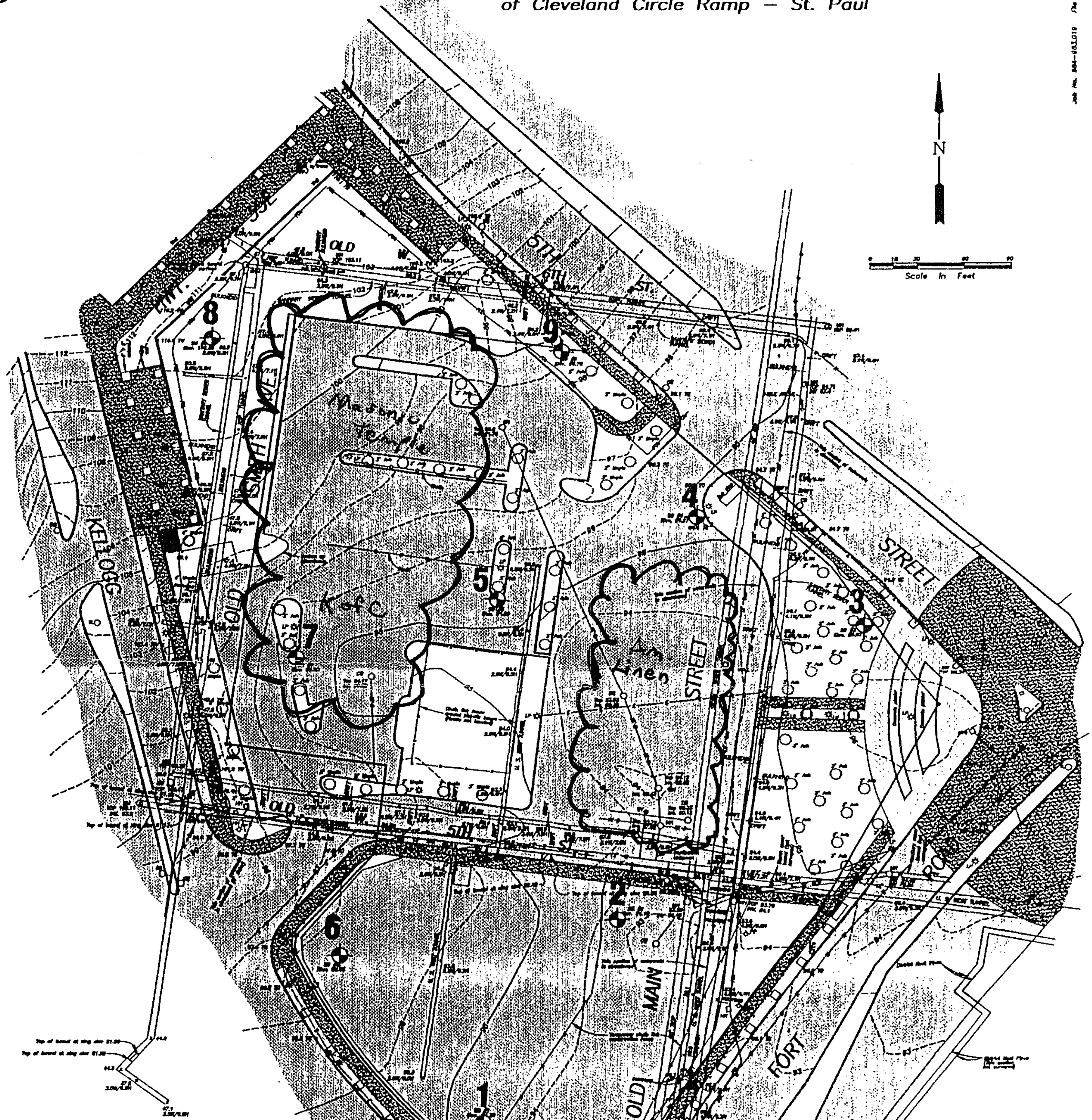
Survey for:

AMERICAN ENGINEERING & TESTING

of Cleveland Circle Ramp – St. Paul

– Possible Basement Areas

Job No. 884-053,019 File No. 98-145



NOTES

- Boundary shown is taken from survey by Curt Leavitt dated dated October 14, 1992.
- Utilities shown are from information furnished by the City of St. Paul, Northern States Power Company and U. S. West and are verified where possible.
- Contact Gopher State 1 for utility locations before any construction shall begin. Phone 454-0002.
- Bench Mark: Top of hydrant at the southwest corner of the intersection of Fort Road and 5th Street. Elevation = 98.99 feet (City of St. Paul Datum).

UTILITY STATEMENT

The underground utilities shown have been located from field survey information and existing drawings. The surveyor makes no guarantee that the underground utilities shown comprise all such utilities in the area, either in service or abandoned. The surveyor further does not warrant that the underground utilities shown are in the exact location indicated, although he does certify that they are located as accurately as possible from information available. The surveyor has not physically located the underground utilities.

I hereby certify that this survey was prepared by me or under my direct supervision and that I am a duly Registered Land Surveyor under the laws of the State of Minnesota.

Dated this 9th day of September, 1998.

REHDER AND ASSOCIATES, INC.

By:______________________

Alvin R. Rehder, Land Surveyor
Minnesota Registration No. 13295
Revised: October 30th, 1998 — Update survey
Revised: November 3rd, 1998 — Update survey

LEGEND

- Denotes sanitary tunnel
- Denotes storm sewer tunnel
- Denotes U. S. West tunnel
- Denotes N.S.P. tunnel
- Denotes width/height
- Denotes spot elevation
- Denotes spot elevation on top of curb
- Denotes invert
- Denotes top of retaining wall
- Denotes manhole
- Denotes catch basin
- Denotes fire hydrant
- Denotes light pole
- Denotes monitoring well
- Denotes water valve
- Denotes drill hole found
- Denotes iron monument found
- —W— Denotes water line
- —E— Denotes electric line
- —FOI— Denotes fiber optics line
- —Gas— Denotes gas line
- —ST-S— Denotes storm sewer line
- Denotes power pole
- Denotes gas valve
- Denotes hand hole

Rehder and Associates, Inc.

CIVIL ENGINEERS AND LAND SURVEYORS

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