AMERICAN ENGINEERING TESTING, Inc.

CONSULTANTS
- GEOTECHNICAL
- MATERIALS
- ENVIRONMENTAL
- FORENSICS

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# REPORT OF GEOTECHNICAL EXPLORATION AND REVIEW

PROPOSED WOODLAND DRIVE RETAINING WALL
WOODLAND DRIVE
STURGIS, SOUTH DAKOTA

AET Project No. 17-03278

**Date:**

March 12, 2018

**Prepared for:**

City of Sturgis
1040 Harley-Davidson Way
Sturgis, South Dakota 57785

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March 12, 2018

City of Sturgis
1040 Harley-Davidson Way
Stugis, South Dakota 57785

Atttn: Ms. Liz Wunderlich, P.E.
LWunderlich@SturgisGov.com

RE: Geotechnical Exploration and Review
Proposed Woodland Drive Retaining Wall
Woodland Drive
Sturgis, South Dakota
AET No. 17-03278

Dear Liz,

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the proposed retaining wall along Woodland Drive in Sturgis, South Dakota. This work was performed in general accordance with AET's proposal dated February 8, 2018 and your written authorization to proceed on February 9, 2018. One electronic copy of this report is being sent to you.

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 expressed or implied, is intended. Important information regarding risk management and proper use of this report is given in the Appendix entitled "Geotechnical Report Limitations and Guidelines for Use".

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

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

Kristen R. Yates, P.E.
Rapid City Manager
Phone: (605) 388-0029
Fax: (605) 388-0064
kyates@amengtest.com



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# Signature Page

Prepared for:

City of Sturgis
1040 Harley-Davidson Way
Sturgis, South Dakota 57785

Attn: Ms. Liz Wunderlich, P.E.

Prepared by:

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Kristen R. Yates, P.E.
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Robert Temme, P.E.
Vice President – Western Region

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## 1.0 INTRODUCTION

We understand the construction of a new retaining wall on the north side of Woodland Drive in Sturgis, South Dakota. Please refer to the Site Location Map included in Appendix A of this report. To assist in planning and design, American Engineering Testing, Inc. (AET) was authorized to conduct a geotechnical study, including standard penetration test borings at the site, soil laboratory testing, and 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 in general accordance with our proposal dated February 8, 2017, approved on February 9, 2018. The authorized scope consists of the following:

- Drill one (1) standard penetration test (SPT) boring to a depth of about 15 feet below grade near the proposed location of the retaining wall.
- Soil laboratory testing.
- Geotechnical engineering analysis based on the gained data and preparation of this report.

These services are intended for geotechnical purposes. The scope is not intended to explore for the presence or extent of environmental contamination.

## 3.0 PROJECT INFORMATION

We understand the project will consist of the construction of a new retaining wall set approximately 30 feet from the north side of Woodland Drive. The wall will be approximately 80 to 85 feet in length and approximately 10 feet tall at the maximum height. We anticipate the wall will be constructed of segmented block stacked to the final design height, and a spread footing for the entire length of the wall.

The previously 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 one (1) SPT boring drilled on March 2, 2018. The boring location was staked in the field by AET personnel and approved by Sturgis Public Works personnel.

The approximate location of the boring is shown on the Boring Location Map in Appendix A. The elevation at the boring location was referenced to a Temporary Benchmark (TBM). The TBM selected for this project was the sanitary sewer manhole east of the boring within the sidewalk. For the purposes of our report, an assumed elevation of 100.0 feet was given to the TBM.

The subsurface boring logs at these locations and the methods used are presented in Appendix A. The 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).

## 4.2 Laboratory Testing

The laboratory test program included natural moisture content, dry density, percent passing the #200 sieve, and a moisture-density relationship (standard Proctor). The laboratory test results for the moisture content, dry density, and the percent passing #200 sieve appear on the individual boring logs adjacent to the samples upon which they were performed in Appendix A. The results of the standard Proctor test is on a separate sheet behind the soil boring logs in Appendix A.

It should also be noted the bulk soil sample represents a mixture of the soils encountered within the upper 5 foot interval of the borehole. As such, the soil classification as presented on the Moisture-Density Relationship may differ from the classifications of the individual soil layers identified on the respective Subsurface Boring Logs.

## 5.0 SITE CONDITIONS

### 5.1 Surface Observations

The project site is located on the north side of Woodland Drive near the intersection with 7th Street in Sturgis, South Dakota. At the time of our field work the area was mostly covered with planted grasses. In general, the overall site drainage appears to be to the southeast.

### 5.2 Subsurface Soils/Geology

Our boring encountered approximately 6 inches of lean clay topsoil over lean clay alluvium to approximately 8.5 feet below grade. The soils were frozen up to 1 foot below grade. Below the lean clay, a thin layer (6-inches) of sandy silt with a little gravel was encountered over dense to very dense sandy gravel with silt, cobbles and possible boulders to the final depth sampled at 15 feet below grade. The subsurface boring log is attached in Appendix A, which provides detailed information about the general soil layering and classifications at the boring location.

### 5.3 Groundwater

At the time of the field activities, subsurface water was not measured in the boring. The lack of subsurface water should not be taken as an accurate representation of the actual subsurface water levels. A long period of time may be required for groundwater to stabilize in the soils present at the site. This period of time is generally not available during a typical subsurface exploration program.

## 6.0 RECOMMENDATIONS

### 6.1 Discussion

At this time, finished grad elevations have not been provided for the new retaining wall. However, it is anticipated that only minor grading (cuts and fills on the order of 1 foot or less) will be required along the retaining wall.

### 6.2 Site Preparation

Once the topsoil has been striped and where required, site excavations should continue to the desired construction elevations. The excavated material, cleaned of all man-made debris, organics/deleterious material, and any aggregate or bedrock fragments greater than 2-inches in nominal size, should be stockpiled on-site for re-use as wall backfill material.

It is our opinion the new retaining wall should be constructed on a leveling base consisting of at least 12-inches of compacted aggregate base course material over the reconditioned site lean clay soils. Prior to placement of the leveling course, the exposed subgrade should be scarified to a depth of at least 8-inches, the moisture content adjusted to within ±3% of optimum, and the material compacted to at least 95% of the maximum dry density as determined by ASTM D698 (standard Proctor). All exposed surfaces should be free of mounds and depressions which could prevent uniform compaction.

Groundwater was not encountered during our site work, and we do not anticipate groundwater will be encountered in the footing or utility excavations; however, be aware that temporary dewatering of these excavations may be necessary if groundwater is encountered.

### 6.3 Retaining Wall Recommendations

The wall system may be designed for an allowable bearing capacity of 2,000 pounds per square foot (psf). As designed, loadings should provide a theoretical safety factor of three or more with respect to a general shear or base failure of the footings.

Provided the structure is properly constructed, the total movement is estimated to be on the order of 1-inch with differential movements on the order of ½-inch. Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design, during construction and for the life of the project.

### 6.4 Wall Backfill Considerations

To promote drainage, we recommend a clean granular backfill be used directly behind the wall that extends at least 1 foot out from the back face of the wall. This gravel backfill should have a maximum aggregate size of 1½ inches with less than 5% passing the #200 sieve. We also recommend a perforated drain tile be placed at the bottom inside edge of the layer of granular backfill behind the wall system. The drain tile should be placed with a minimum slope sufficient to route collected water to the end(s) of the wall and/or points where it can be discharged through gravity flow. Weep holes may considered in design and construction of the wall system.

Cleaned and approved site soils may be used as the remainder of the backfill behind the wall. The material should be processed to the extent practical to provide a moisture content within ±3% of optimum as determined by ASTM D698 (standard Proctor) and compacted to a minimum of 95% of the maximum dry density. Compaction of the backfill should be accomplished with hand-operated tampers or other lightweight compactors. Over-compaction may cause excessive lateral earth pressures which could result in unexpected wall movements.

For soils above any free water surface, recommended equivalent fluid pressures for unrestrained foundation elements are:

- Active:
  Site lean clay soils........................................................50 psf/ft
  Imported granular fill...................................................35 psf/ft

- Passive:
  Site lean clay soils......................................................205 psf/ft
  Imported granular fill.................................................480 psf/ft

Where the design includes restrained elements, the following equivalent fluid pressures are recommended:

- At Rest:
  Site lean clay soils........................................................65 psf/ft
  Imported granular fill...................................................55 psf/ft

The lateral earth pressures outlined above are not applicable for submerged soils/hydrostatic loading and do not include the influence of surcharge, equipment or roadway loading, which should be added, where applicable.

The following soil parameters should be considered in the design and construction of site retaining wall:

- Coefficient of Friction (aggregate base course)................................... 0.45
- Friction Angle (site lean clay soils) .......................................................20°
- Friction Angle (imported granular).........................................................34°
- Unit Weight (site lean clay soils)...................................................... 90 pcf
- Unit Weight (imported granular) .................................................... 135 pcf

## 7.0 CONSTRUCTION CONSIDERATIONS

### 7.1 Potential Difficulties

Depending on the time of year in which construction takes place, unstable subgrade soils could be encountered during the site and grading operations. If encountered, additional conditioning of the soils may be required to obtain moisture contents which allow for firm and unyielding subgrade and/or compaction.

Typically, scarification and drying of the subgrade soils can be accomplished over a relatively short period of time provided the work is completed during warm/hot and dry weather. Localized areas of soft wet subgrades can be remedied with additional excavation to expose firmer soils, placement of coarse rock to provide a solid base on which to place additional fill and/or the use of geotextiles between the soft soils and the overlying fill and/or pavement sections. The appropriate means of subgrade stabilization should be evaluated by the geotechnical engineer at the time of construction.

### 7.2 Runoff Water in Excavations

Water can be expected to collect in the excavation bottom during times of inclement weather or snow melt. 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 excavation as soon as possible during construction.

### 7.3 Disturbance of Soils

The on-site soils can become disturbed under construction traffic, especially if the soils are wet.

If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut soils can then be dried and recompacted back into place, or they should be removed and replaced with drier imported fill.

### 7.4 Observation and Testing

The preliminary recommendations in this report are based on the subsurface conditions found at our test boring locations. Once final building locations, sizes, and grades are finalized, AET's geotechnical engineer should be allowed to review the design data and determine if and where additional borings are warranted. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied.

## 8.0 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 expressed 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".

# STANDARD SHEETS

# EXCAVATION AND REFILLING FOR STRUCTURAL SUPPORT

## EXCAVATION

Excavations for structural support at soil boring locations should be taken to depths recommended in the geotechnical report. Since conditions can vary, recommended excavation depths between and beyond the boring location should be evaluated by geotechnical field personnel. If groundwater is present, the excavation should be dewatered to avoid the risk of unobservable poor soils being left in-place. Excavation base soils may become disturbed due to construction traffic, groundwater or other reasons. Such soils should be subcut to underlying undisturbed soils. Where the excavation base slopes steeper than 4:1, the excavation bottom should be benched across the slope parallel to the excavation contour.

Soil stresses under footings spread out with depth. Therefore, the excavation bottom and subsequent fill system should be laterally oversized beyond footing edges to support the footing stresses. A lateral oversize equal to the depth of fill below the footing (i.e., 1:1 oversize) is usually recommended. The lateral oversize is usually increased to 1.5:1 where compressible organic soils are exposed on the excavation sides. Variations in oversize requirements may be recommended in the geotechnical report or can be evaluated by the geotechnical field personnel.

Unless the excavation is retained, the backslopes should be maintained in accordance with OSHA Regulations (Standards-29 CFR), Part 1926, Subpart P, "Excavations" (found on www.osha.gov). Even with the required OSHA sloping, groundwater can induce sideslope raveling or running which could require that flatter slopes or other approaches be used.

## FILLING

Filling should proceed only after the excavation bottom has been approved by the geotechnical engineer/technician. Approved fill material should be uniformly compacted in thin lifts to the compaction levels specified in the geotechnical report. The lift thickness should be thin enough to achieve specified compaction through the full lift thickness with the compaction equipment utilized. Fine grained soils are moisture sensitive and are often wet (water content exceeds the "optimum moisture content" defined by a Proctor test). In this case, the soils should be scarified and dried to achieve a water content suitable for compaction. This drying process can be time consuming, labor intensive, and requires favorable weather.

Filling operations for structural support should be closely monitored for fill type and compaction by a geotechnical technician. Monitoring should be on a full-time basis in cases where vertical fill placement is rapid; during freezing weather conditions; where groundwater is present; or where sensitive bottom conditions are present.

## EXCAVATION/REFILLING DURING FREEZING TEMPERATURES

Soils that freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density loss depends on the soil type and moisture condition; and is most pronounced in clays and silts. Foundations, slabs, and other improvements should be protected from frost intrusion during freezing weather. For earthwork during freezing weather, the areas to be filled should be stripped of frozen soil, snow and ice prior to new fill placement. In addition, new fill should not be allowed to freeze during or after placement. For this reason, it may be preferable to do earthwork operations in small plan areas so grade can be quickly attained instead of large areas where much frost stripping may be needed.

# 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.

## 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 large 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.

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 include 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 large 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.

# Appendix A

AET Project No. 17-03278

Geotechnical Field Exploration and Testing
Unified Soil Classification System
Site Location Map
Boring Location Map
Subsurface Boring Logs
Standard Proctor Results

## A.1 FIELD EXPLORATION

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

## A.2 SAMPLING METHODS

### A.2.1 Ring-lined barrel Samples - Calibrated to $N_{60}$ Values

Standard penetration (ring-lined barrel) samples were collected in general accordance with ASTM: D3550. The ASTM test method consists of driving a 2.5-inch O.D. thick-walled, split-barrel sampler lined with brass rings 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.

### 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.

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

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

## A.4 WATER LEVEL MEASUREMENTS

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

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

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

## A.5 LABORATORY TEST METHODS

### A.5.1 Water Content Tests

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

### A.5.2 Atterberg Limits Tests

Conducted per AET Procedure 01-LAB-030, which is performed in general accordance with ASTM: D4318 and AASHTO: T89, T90.

### A.5.3 Sieve Analysis of Soils (thru #200 Sieve)

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

## A.6 TEST STANDARD LIMITATIONS

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

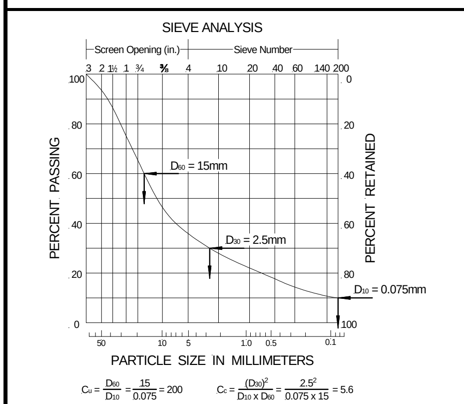
## A.7 SAMPLE STORAGE

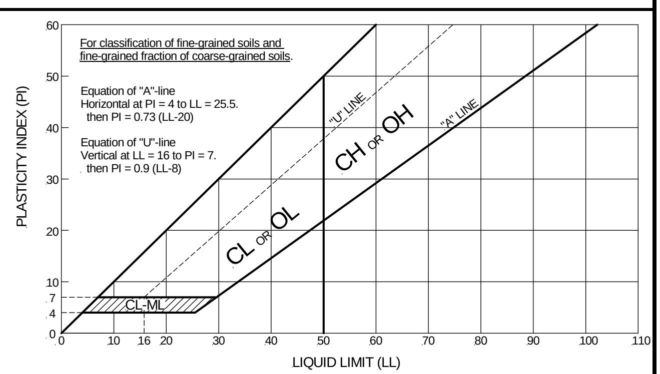
Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

# 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 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** <0.75 / Liquid limit – not dried | 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** <0.75 / Liquid limit – not dried | 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] |



Plasticity Chart

## Notes

[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.

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

### Grain Size

| 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 |

**Gravel Percentages**

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

**Consistency of Plastic Soils**

| 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 |

**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. Waterbearing usually relates to sands and sand with silt.
- 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.

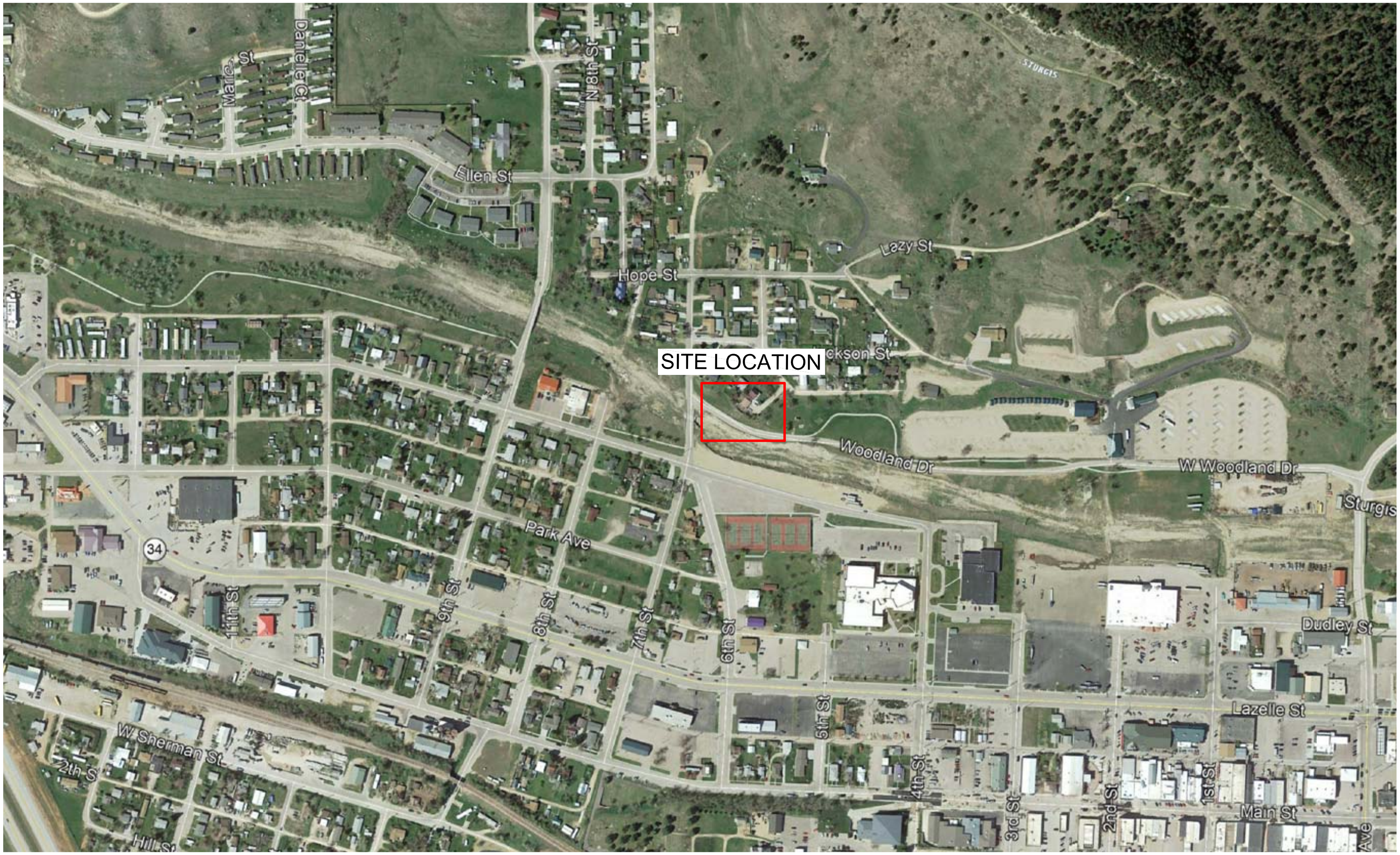
**Fiber Content of Peat**

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

**Organic/Roots Description (if no lab tests)**

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

- 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.





SCALE (FEET)

0 600

| | | |
|---|---|---|
| PROJECT: PROPOSED WOODLAND DRIVE RETAINING WALL<br>STURGIS, SOUTH DAKOTA | | PROJECT NO. 17-03278 |
| SUBJECT: SITE LOCATION MAP | | DATE: MARCH 6, 2018 |
| SCALE: 1 INCH = 600 FEET | DRAWN BY: JR | REVIEWED BY: WF |

AMERICAN ENGINEERING TESTING, INC.


| | | |
|---|---|---|
| AMERICAN ENGINEERING TESTING, INC. | PROJECT: PROPOSED WOODLAND DRIVE RETAINING WALL<br>STURGIS, SOUTH DAKOTA | PROJECT NO.<br>17–03278 |
| | SUBJECT: BORING LOCATION MAP | DATE:<br>MARCH 6, 2018 |
| | SCALE: 1 INCH = 80 FEET — DRAWN BY: JR | REVIEWED BY: KY |

AMERICAN ENGINEERING TESTING, INC.

# SUBSURFACE BORING LOG

AET JOB NO: **17-03278** LOG OF BORING NO. **B-1 (p. 1 of 1)**

PROJECT: **Proposed Woodland Drive Retaining Wall; Sturgis, South Dakota**

SURFACE ELEVATION: **101.4**

| DEPTH IN FEET | MATERIAL DESCRIPTION | GEOLOGY | N | MC | SAMPLE TYPE | REC IN. | WC | DEN | LL | PL | %-#200 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–1.0 | **TOPSOIL**, Lean Clay with sand and organics, dark brown, frozen to 1.0' | TOPSOIL | | | | | | | | | |
| 1.0–8.5 | **LEAN CLAY** with sand and trace organics, brown, very stiff (CL) | ALLUVIUM | | | | | | | | | |
| 3 | | | 21 | M | MC | 18 | 14 | 79 | | | |
| 5.5 | | | 29 | M | MC | 18 | | | | | |
| 8 | | | 21 | M | MC | 18 | 15 | | | | |
| 8.5–9.0 | **SANDY SILT** with trace gravel and trace organics, brown, very stiff (ML) | | | | | | | | | | |
| 9.0–15.3 | **SANDY GRAVEL** with silt, cobbles and boulders, light brown to brown, dense to very dense (GP) | | | | | | | | | | |
| 11 | | | 45 | M | MC | 18 | 3 | 105 | | | 7 |
| 13.5 | | | 50/.4 | M | MC | 11 | | | | | |
| 15 | | | 50/.3 | M | MC | 4 | | | | | |
| | Bottom of Boring | | | | | | | | | | |

| DEPTH: | DRILLING METHOD |
|---|---|
| 15.0 | 3.25" HSA |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | DRILLING FLUID LEVEL | WATER LEVEL |
|---|---|---|---|---|---|---|
| **3/2/18** | **14:10** | **15.3** | **15.0** | **NA** | **NA** | **None** |

BORING COMPLETED: **3/2/18**

DR: **BT** LG: **ES** Rig: **RC-1**

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

Job No. **17-03278** Date **3/12/18**

Project **Proposed Woodland Drive Retaining Wall**
**Sturgis, South Dakota**

Source of Material **Boring #1 - 5.0'**

Description of Material **Sandy Lean Clay (CL)**

Test Method **ASTM:D698 - Method A**

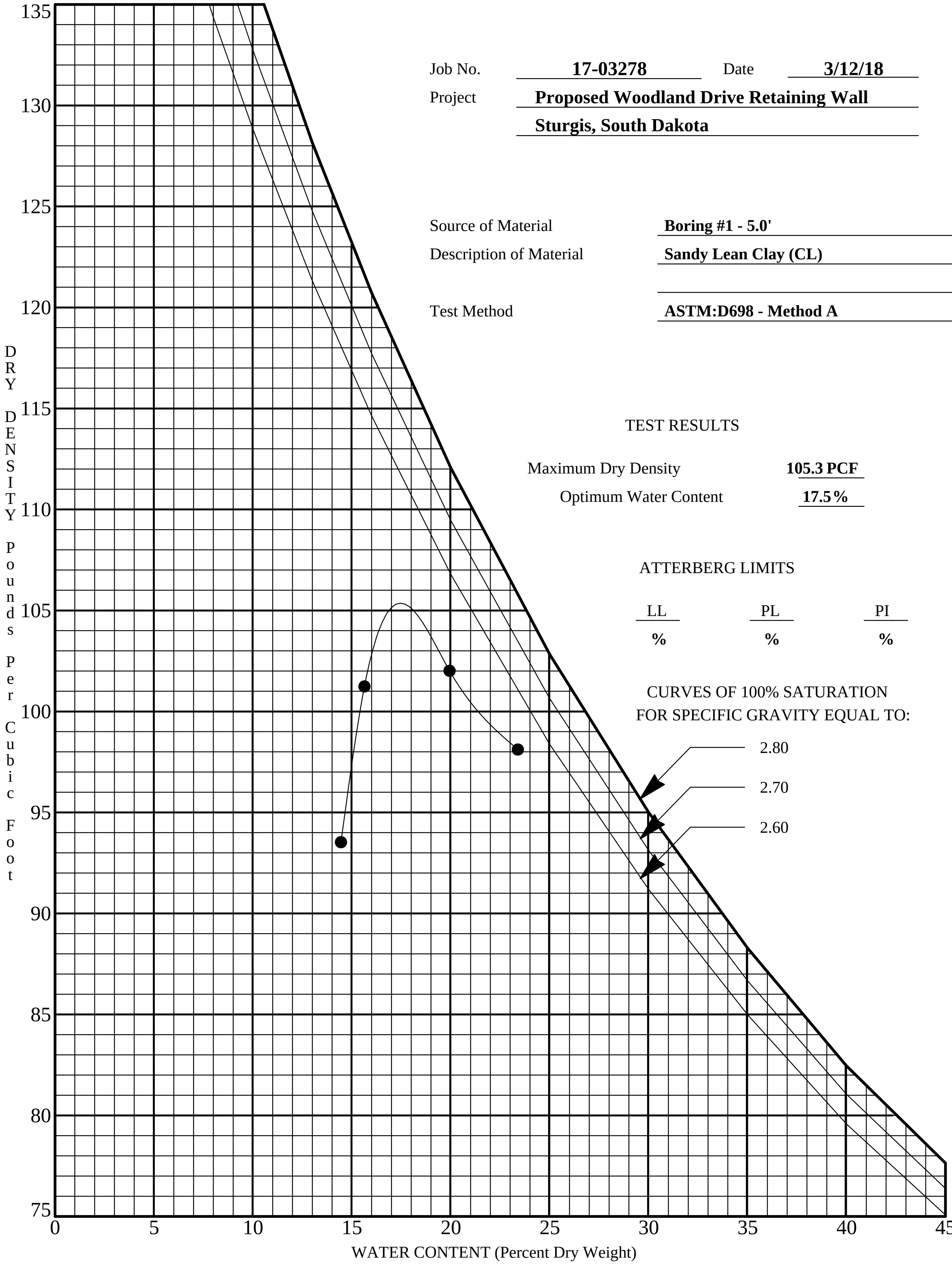
TEST RESULTS

Maximum Dry Density **105.3 PCF**

Optimum Water Content **17.5 %**

ATTERBERG LIMITS

| LL | PL | PI |
|---|---|---|
| % | % | % |

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# MOISTURE-DENSITY RELATIONSHIP

# Appendix B

Geotechnical Report Limitations and Guidelines for Use

**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.

**RISK MANAGEMENT INFORMATION**

**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. No one, not even you, should apply the report for any purpose or project except the one originally contemplated.

**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.

**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.

**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

**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.

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

**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.

**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 recognize that separating logs from the report can elevate risk.

**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.

**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.

**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.