



Report of Geotechnical Exploration
Single & Multi-Family Residential Development
FRMS Tract 1 – SD Highway 71
Hot Springs, South Dakota

AET Project No. P-0040382

Date:
March 6, 2025

Prepared for:
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Forensic • Environmental
Building Technology
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March 6, 2025

Towey Design Group, Inc.
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Attn: Mr. Mike Towey, PE
mtowey@toweydesigngroup.com

RE: Report of Geotechnical Exploration
Proposed Single & Multi-Family Residential Development
FRMS Tract 1 – SD Highway 71
Hot Springs, South Dakota
AET Project No. P-0040382

Dear Mike,

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the above referenced project to be constructed in Hot Springs, South Dakota. These services were performed in general accordance with our proposal to you dated January 22, 2025, and your written authorization to proceed provided on the same date, 2024. We are submitting one (1) electronic copy of the report to you.

Please contact me if you have any questions about the report. Our office can also be contacted to arrange observation and testing services during construction of the project.

Sincerely,
American Engineering Testing, Inc.

A handwritten signature in blue ink that reads 'Walt Feeger'.

Walt Feeger, PE
Principal Engineer – West Division
wfeeger@teamaet.com
Phone: (605) 388-0029

SIGNATURE PAGE

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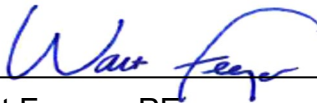
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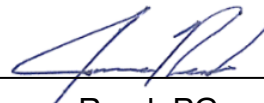
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1.0 INTRODUCTION

We understand a new single and multi-family housing development has been proposed in Hot Springs, South Dakota. Please refer to Figure 1: Site Location Map within Appendix A for the location of the proposed project. To assist with the planning and design of the streets and utilities within this development, American Engineering Testing, Inc. (AET) has been authorized to conduct a subsurface exploration program at the sites, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above services and provides our engineering recommendations based on this data.

2.0 SCOPE OF SERVICES

AET's services were performed in general accordance with our proposal dated January 22, 2025. The authorized scope consists of the following:

- Six (6) Standard Penetration Test (SPT) borings to proposed depths of about 15 feet below existing grade along the proposed roadway alignments.
- Soil laboratory testing.
- Geotechnical engineering analysis based on the gained data and preparation of this report.

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

3.0 PROJECT INFORMATION

Based on the information provided, we understand the project will consist of the construction of approximately $\pm 1,500$ lineal feet of new paved streets as part of a proposed single-family and multi-family residential development on the south side of SD Highway 71 in Hot Springs, South Dakota. Additionally, site infrastructure will include underground utilities.

The purpose of the geotechnical study was to determine the subsurface conditions at the site and to evaluate the suitability of the site soils for their use in constructing the proposed street alignments, and associated utilities. At this time limited information has been provided to us regarding the final grades of the street alignments. Additionally, this report does not include any recommendations with respect to the residential lots for this development.



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 six (6) standard penetration test (SPT) borings which were drilled on February 10, 2025. The borings were drilled at locations selected by AET personnel based on a conceptual site plan provided by TDG. The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic origins, and moisture condition. A density description or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

The surface elevations at the boring locations were approximated with our GIS field unit and GPS receiver. Please note that the geographic information system (GIS) location data we provide is strictly intended for general reference and informational purposes, and should not be relied upon as licensed survey data points. Our GPS receiver is accurate to approximately 2-5 feet vertical, and within 2 feet horizontal. As such, discrepancies in elevations may be noted when comparing site elevations to those recorded by the project surveyor-of-record.

4.2 Laboratory Testing

The laboratory test program included natural moisture content, Atterberg Limits, percent passing the No. 200 sieve, gradation (sieve) analysis, pH, resistivity, moisture-density relationship (Proctor), and California Bearing Ratio (CBR) tests. The test results appear in Appendix A on the individual boring logs adjacent to the samples upon which they were performed or on the data sheets following the logs in Appendix A.

The CBR test was remolded to approximately 95% of maximum dry density at the optimum moisture content for the specific boring/material. Results are summarized as follows:

Boring	Depth, ft	Soil Classification	Optimum Moisture Content, % ¹	Maximum Dry Density, pcf ¹	CBR Value ²
B-1	1-5	Silty Lean Clay (CL)	17.4	105.2	3.2
B-4	1-5	Silty Lean Clay (CL)	18.8	106.4	4.3

¹ Based on ASTM D698 (standard Proctor)

² Based on ASTM D 1883 (CBR)



It should be noted the bulk soil samples represent 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 and CBR data sheets may differ from the classifications of the individual soil layers identified on the respective Subsurface Boring Logs.

Two (2) laboratory pH and resistivity tests were performed on selected bulk samples obtained from the soil borings. The results are summarized below.

Boring	Depth, ft	Soil Type	pH	Resistivity, ohm-cm	Corrosion Potential
B-1	1-5	Silty Lean Clay (CL)	7.65	680	Severe
B-4	1-5	Silty Lean Clay (CL)	7.45	620	Severe

The corrosion potentials provided are based on information published in the Department of the Army’s Technical Manual TM 5-811-7 “Electrical Design, Cathodic Protection. Based on this information, the site soils have a severe corrosion potential towards iron and other buried metals. If corrosion of buried metal is critical, it should be protected using a non-corrosive backfill, wrapping, coating, sacrificial anodes, or a combination of these methods, as designed by a qualified corrosion engineer.

5.0 SITE CONDITIONS

5.1 Surface Observations

At the time of our field work, the site consisted of a vacant parcel of undulating property located on the south side of SD Highway 71, on the south side of Hot Springs. The site was vegetated by grasses, and weeds. In general, the overall site, between the boring locations, slopes downward to the southwest, with an elevation difference of about 22 feet noted between the boring locations.

5.2 Subsurface Soils/Geology

In general, underlying a layer of topsoil, the subsurface geology encountered within the borings consisted of alluvium overlying medium dense weathered sandstone and hard shale bedrock, associated with the Spearfish Formation, which extended to the total depths explored in Borings B-1 through B-3. Within Borings B-4 through B-6, the alluvial soils extended to the total depths explored. The alluvium consisted of stiff to very stiff silty lean clay, stiff to very stiff clayey silt, medium dense to dense silty gravel, loose to very dense silty sand, and firm to stiff silt/sandy silt.

Please note, determining the thickness of the “topsoil” layer 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.

The Subsurface Boring Logs included in Appendix A give a more detailed description of the soils encountered within the borings.

5.3 Groundwater

At the time of our field work, groundwater was not encountered within the borings drilled at the site. The lack of groundwater noted at the boring locations should not be taken as an accurate representation of the actual groundwater levels. Groundwater levels can fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors including local irrigation practices and levels of water in drainage areas or waterways adjacent to the borings. A long period of time may be required for groundwater to stabilize in the soils and bedrock present at the site; this period of time is generally not available during a typical subsurface exploration program.

6.0 RECOMMENDATIONS

6.1 Discussion

The following recommendations are based on the soil and groundwater conditions observed in the soil borings at the time of our exploration. However, the subsurface profile between the boring locations may differ significantly from those encountered at the boring locations. Further, changes in climatic conditions between the time of exploration and the time of construction may also affect soil conditions, particularly groundwater levels and the moisture content of the soils.

If possible, we highly recommend that construction take place during warmer weather months (typically May through October) which will aid in the proper processing and moisture conditioning of the excavated site soils for re-use as trench backfill and roadway embankment fill, where necessary. Frozen material should not be used as embankment fill or utility trench backfill material, and fill should not be placed over a frozen subgrade.

Even though groundwater was not encountered at the site, the earthwork contractor should anticipate de-watering during grading operations and excavations for underground utilities. If groundwater is encountered, an appropriate dewatering system should be provided that lowers and maintains the groundwater below the base of the excavations to facilitate proper placement of the utilities. Additionally, soft saturated soil conditions should be expected within low-lying (drainage) areas of the site. The earthwork contractor should anticipate these soil/groundwater conditions, and the bid documents should include a line item for subgrade remediation and dewatering.

Additionally, gypsum is a common material found in the Spearfish Formation and formation derived soils. Thin gypsum lenses (stringers) were encountered throughout the soils and shale bedrock encountered in the borings. While no massive gypsum layers were encountered within the borings, the material may be encountered during site grading work and utility placement. Once exposed, gypsum material can degrade which could cause future movement related distress, especially if water is introduced to the gypsum matrix. If massive gypsum is encountered at the base of any required site excavations, the geotechnical engineer should be allowed to observe the excavations and provide additional recommendations which typically involve over-excavation of the gypsum material to a specified depth and replacement with approved engineered fill material or lean concrete flowable fill.

6.2 Site Grading & Roadway Embankment Fill

At this time, we have not been provided with an overall site mass grading plan, which typically identifies anticipated cut and fill balances. Therefore, for purposes of our report, we have assumed that cut and fill balances required to establish the roadway embankment alignments will be on the order of 3 feet or less. Once the mass grading plan has been completed, AET should be allowed to review the information and provide additional recommendations as warranted.

We recommend that all topsoil, vegetation, man-made debris, and other unsuitable materials be removed in their entirety from within the proposed road alignments and all areas to receive overlot fill. Stripped materials consisting of vegetation/organic and unsuitable debris should be wasted from the site. Topsoil may be stockpiled on-site to re-vegetate disturbed/slope areas after completion of grading operations.

Where required, grading should continue to the design site elevations. The site soils are suitable for use as embankment and overlot fill to reach the desired site grade elevations. Prior to re-use, all excavated material should be cleaned of all topsoil, organics, unsuitable materials, and aggregate/rock greater than 3 inches in nominal size.

As noted, gypsum lenses (stringers) were encountered within several of the borings (B-3, B-4 and B-6) drilled at this site and therefore, some gypsum may be present in the site soils utilized as fill material. Gypsum easily degrades once exposed to the elements and moisture variations and can lead to undesirable movements within buried utilities and paved streets. We highly recommend that if encountered, and to the extent practical, the site soils be screened of all gypsum fragments greater than 1-inch in size and the fill material contain less than 15% by weight of gypsum fragments. Depending on the required cut and fill balances across the site, imported fill material may be required. The imported fill should be a non-expansive material and pre-approved for use by the geotechnical engineer prior to being hauled to the site.

It is our opinion that the site soils can be ripped and moved with large construction equipment such as dozers and scrapers. We recommend a shrinkage factor of at least 25% be used for calculating cut and fill balances across the site. Where applicable, areas to receive fill should be scarified to a depth of at least 8-inches, the moisture content of the scarified soils adjusted to near optimum moisture content and the soils recompacted to at least 95% of maximum standard Proctor dry density (ASTM D698). For grading purposes, the site soils should be processed and moisture conditioned to within $\pm 3\%$ of the optimum moisture content and placed in 8-inch maximum loose lift thicknesses prior to compactive efforts. The fill should be compacted to at least 95% of the maximum dry density (ASTM D698) for embankment fill less than 10 feet in height. For fill heights greater than 10 feet, we recommend the compaction requirement be increased to 98% of the maximum dry density (ASTM D698).

6.3 Permanent Cut and Fill Slopes

As noted, overall mass grading information (cut and fill balances) has not been provided at this time. However, proper subgrade preparation/remediation as well as strict moisture and density control during fill placement will be critical at this site. We highly recommend that fill sections be constructed as early as possible within the construction period to allow for settlements to occur before the placement of structures and paving.

Permanent cut and fill slopes along the proposed roadway alignments should not be constructed any steeper than 3H:1V. Where fill placement against existing slopes is required, the fill material should be placed starting at the toe of the slope. Subsequent fill should be benched into the exposed soils/bedrock.

Wherever existing slopes within the site soils are steeper than 4H:1V and will be covered by fill, the existing slope should be benched with a maximum bench height of 5 feet. Benches should be wide enough to accommodate compaction and earth moving equipment, and to allow placement of horizontal lifts of fill.

All fill slopes and benches should be constructed across the entire width of the slope and tied into the existing contours. Where the bedrock of the Spearfish Formation is exposed, benching should be performed regardless of existing slopes. Failure to properly bench the exposed bedrock prior to fill placement dramatically increases the potential of post-construction slope movement.

The constructed slopes should be re-vegetated once construction is complete to alleviate excessive erosion. Typically, we recommend the slope be seeded with a native seed mix and covered with a straw blanket or mat. Hydro-seeding may be utilized as well.

6.4 Utility Construction and Trench Excavation

We recommend that all utility lines be placed as noted herein and in accordance with any City of Hot Springs earthwork and utility construction documents, if applicable. Conventional construction equipment such as tracked excavators should be able to make the required trench excavations along the utility alignments. If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce side slope erosion or running which could require slope maintenance.

For trench excavations, it is our opinion the site alluvial soils should be classified as Type C with recommended slope laybacks of 1.5H:1V. The weathered sandstone and shale bedrock should be classified as Type B, with recommended slope laybacks of 1H:1V. These classifications should be considered preliminary and should be verified in the field on a daily basis by the contractor and/or geotechnical engineer. Excavations deeper than 20 feet and/or in saturated soils or below the groundwater table should be considered on an individual basis. Water levels, due to climatic conditions, should be evaluated at the time of construction. If the above trench layback recommendations are not feasible, due to space limitations or other factors, the OSHA rules should be consulted for alternative trench stabilization methods. Trench boxes or shoring in compliance with OSHA rules may be acceptable alternatives.

Based on the range of current moisture contents determined in our laboratory, the excavated soils will require processing and moisture conditioning to bring the trench spoils close to the optimum moisture content before reuse as trench backfill. It is anticipated the site soils will be mixed during earthwork and utility trenching operations. Therefore, we recommend the moisture content of the site soils used as backfill be adjusted to within $\pm 3\%$ of the optimum moisture content (ASTM D698).

Please note that means and methods of attaining the required moisture content and workability of the material should be left to the discretion of the earthwork contractor, but high moisture content site soils should not be deemed ‘unsuitable’ for use. Earthwork contractors should bid this project accordingly. We also recommend particular attention be paid to the compaction efforts around manholes to reduce the potential of future related settlements issues.

The trench backfill should be placed in 8-inch maximum loose lift thicknesses and compacted to at least 95% of maximum standard Proctor (ASTM D698) dry density. Additionally, we recommend the top 1-foot of the trench backfill zone be compacted to at least 98% of the maximum dry density to reduce the potential of future settlement related issues under paved areas. We also recommend particular attention be paid to the compaction efforts around manholes and service lines to reduce the potential of future related settlements issues.

Extensive proofrolling, as noted in the “Pavement Design Considerations” section of this report should be performed on all utility trenches within areas to receive pavement. Deficient areas noted by the geotechnical engineer during the proofrolling operations should be removed to the recommended depth and replaced as required.

6.5 Roadway Pavement Subgrade Preparation

Prior to placement of base course/new pavement, the exposed subgrade soils should be scarified to a depth of 8-inches, the moisture content of the scarified soils adjusted to near optimum moisture content and the material compacted to at least 95% of maximum standard Proctor dry density (ASTM D698).

To obtain a firm and unyielding subgrade, on which to construct the new pavement section, scarification and drying of the subgrade soils may be required. This scarification process may need to be repeated over several days in order to allow the soils to dry back to an acceptable moisture content. The earthwork contractor should be made aware of the soil conditions at the site and account for the anticipated subgrade preparation work.

If project schedules do not allow for sufficient time to dry the soil back to acceptable levels, use of a geo-textile stabilization/separation material can be incorporated in the design. The geo-textile should be placed on top of the graded subgrade and below the aggregate base course layer. Please note the pavement section, including base course thickness, may be subject to change if incorporating a geo-textile stabilization material into the design.



All prepared subgrades should be proof rolled with a loaded dump truck or similar weighted construction equipment to verify a firm and unyielding subgrade has been obtained prior to the placement aggregate base course materials. Any areas that "pump" under the loaded construction equipment should be evaluated by the engineer to determine whether additional excavation and replacement with a coarse, clean rock or the use of a geo-textile fabric should be used to stabilize the subgrade. Once the subgrade has been proof rolled and approved by the geotechnical engineer, base course may be placed.

6.6 Pavements

6.6.1 Considerations

The following pavement sections were designed based on the procedures as outlined in the 1993 AASHTO Empirical Equation for Flexible Pavements and Rigid Pavements.

We anticipate that the site soils will be used as grading material and will be relatively similar to those which we tested for subgrade suitability. Based on the soils encountered in the borings and our laboratory test results, an average California Bearing Ratio (CBR) value of 3.8 was used in the pavement design analysis. In addition, we have used the following design parameters for the construction of the new street alignments:

Design Criteria	Asphalt	Portland Cement Concrete
Overall Design Standard Deviation	0.45	0.35
Soil Resilient Modulus	CBR x 1500	150 pci
Initial Serviceability	4.2	4.5
Terminal Serviceability	2.0	2.5
Reliability, %	80	80
Drainage Coefficient	0.75 (no edge drains)	na

No traffic information was provided for use in our design analysis. However, based on the conceptual site plan provided by TDG, it is anticipated that the new street alignments will service the proposed new residential lots, and therefore, we utilized a Residential Street designation. An equivalent 20-year design 18-kip single axle load (ESAL) of 65,000 was used in our analysis.



The 20-year design period is considered to be the interval over which, with proper maintenance, the pavement will not require major repairs. A continuing regular maintenance program should be implemented to maintain satisfactory serviceability over the design life. The maintenance program should include sealing cracks and repairing minor deficiencies. Please notify us if any of the parameters used in the pavement design do not adequately define the anticipated conditions.

6.6.2 Aggregate Base Course

Aggregate base course gravel should be moisture conditioned to within $\pm 3\%$ of optimum and compacted to a minimum of 95% of maximum density as determined by the standard Proctor method (ASTM D698) and should meet the requirements as outlined in Section 882 “Aggregates for Granular Bases and Surfacing” of the SDDOT specifications, current edition.

6.6.3 Pavement Section Recommendations

Based on the above stated information and our analysis, we recommend the following pavement section be used for this project. Mix designs should be submitted prior to construction to verify their adequacy.

Recommended Pavement Section Thickness (inches)				
Traffic Area	Flexible (Asphalt), in.	Rigid (Portland Cement Concrete), in.	Aggregate Base Course, in.	Total, in.
FRMS Tract 1 Residential Streets	4	--	6	10
	5	--	4	9
	--	6	4*	10

*minimum recommended basecourse thickness for construction purposes

We recommend the asphalt be obtained from an approved mix design conforming to the South Dakota Department of Transportation (SDDOT) Specifications as defined in Sections 320 and 321 of the “Standard Specifications for Road and Bridges”, current edition.

Where rigid pavements are used, the concrete should be obtained from an approved mix design conforming to Section 380 “Portland Cement Concrete Pavement” and Section 460 “Structural Concrete” of the SDDOT Specifications, current edition.

Longitudinal and transverse joints should be provided as needed in concrete pavements for expansion/contraction and isolation. The location and extent of joints should be based upon the final pavement geometry. Sawed joints should be cut within 24-hours of concrete placement. All joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

6.7 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program.

Preventive maintenance activities are intended to slow the rate of pavement deterioration. Pavement maintenance consists of both localized maintenance (crack and joint sealing and patching) and global maintenance (surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance program, additional engineering input is recommended to determine the type and extent of preventive maintenance appropriate. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

7.1.1 Spearfish Formational Soils and Gypsum

Depending on the required excavations at this site, hard lean clay layers as well as the presence of hard gypsum will likely make excavating procedures somewhat more difficult than normal where they are encountered. The use of large tracked excavators (equipped with pneumatic hammers), dozers with ripping teeth, and minor controlled blasting will likely be required.

7.1.2 Soft Subgrade Soils

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

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 sections. The appropriate means of subgrade stabilization should be evaluated by the geotechnical engineer at the time of construction.

7.1.3 Runoff Water in Excavation

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 during construction. Based on the soils encountered, we anticipate the groundwater can be handled with conventional sump pumping.

7.1.4 Disturbance of Soils

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

7.2 Excavation Backsloping

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

7.3 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on the exposed subgrade and any 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, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, 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.”



Appendix A

Geotechnical Field Exploration and Testing
 Boring Log Notes
 Unified Soil Classification System
 Figure 1: Site Location Map
 Figure 2: Boring Location Map
 Subsurface Boring Logs
 Gradation Curves
Moisture-Density Relationship (Proctor) Test Reports
California Bearing Ratio (CBR) Test Reports

Appendix A

Geotechnical Field Exploration and Testing

AET Project No. P-0040382

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling standard penetration test (SPT) borings. The locations of the borings appear on Figure 2, preceding the Subsurface Boring Logs in this appendix.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} Values

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

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

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

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

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

A.2.3 Sampling Limitations

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

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

A.3 CLASSIFICATION METHODS

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

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

Appendix A

Geotechnical Field Exploration and Testing

AET Project No. P-0040382

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.5.4 Particle Size Analysis of Soils (with hydrometer)

Conducted per AET Procedure 01-LAB-050, which is performed in general accordance with ASTM: D422 and AASHTO: T88.

A.5.5 Unconfined Compressive Strength of Cohesive Soil

Conducted per AET Procedure 01-LAB-080, which is performed in general accordance with ASTM: D2166 and AASHTO: T208.

A.5.6 Laboratory Soil Resistivity using the Wenner Four-Electrode Method

Conducted per AET Procedure 01-LAB-090, which is performed using Soil Box apparatus in the laboratory in general accordance with ASTM: G57

A.6 TEST STANDARD LIMITATIONS

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

A.7 SAMPLE STORAGE

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

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

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

TEST SYMBOLS

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

STANDARD PENETRATION TEST NOTES

(Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N₆₀ values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

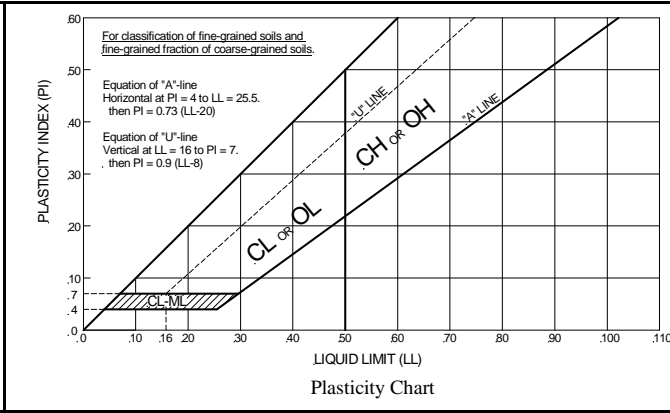
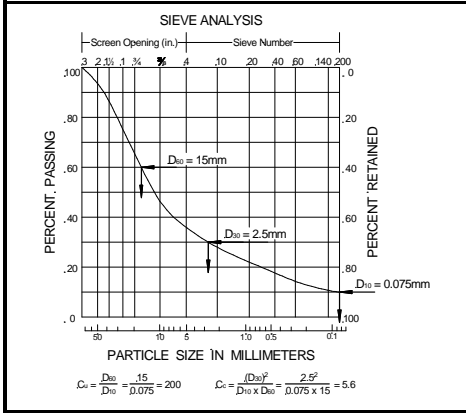
The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered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



UNIFIED SOIL CLASSIFICATION SYSTEM ASTM Designations: D 2487, D2488

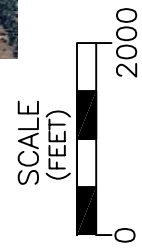
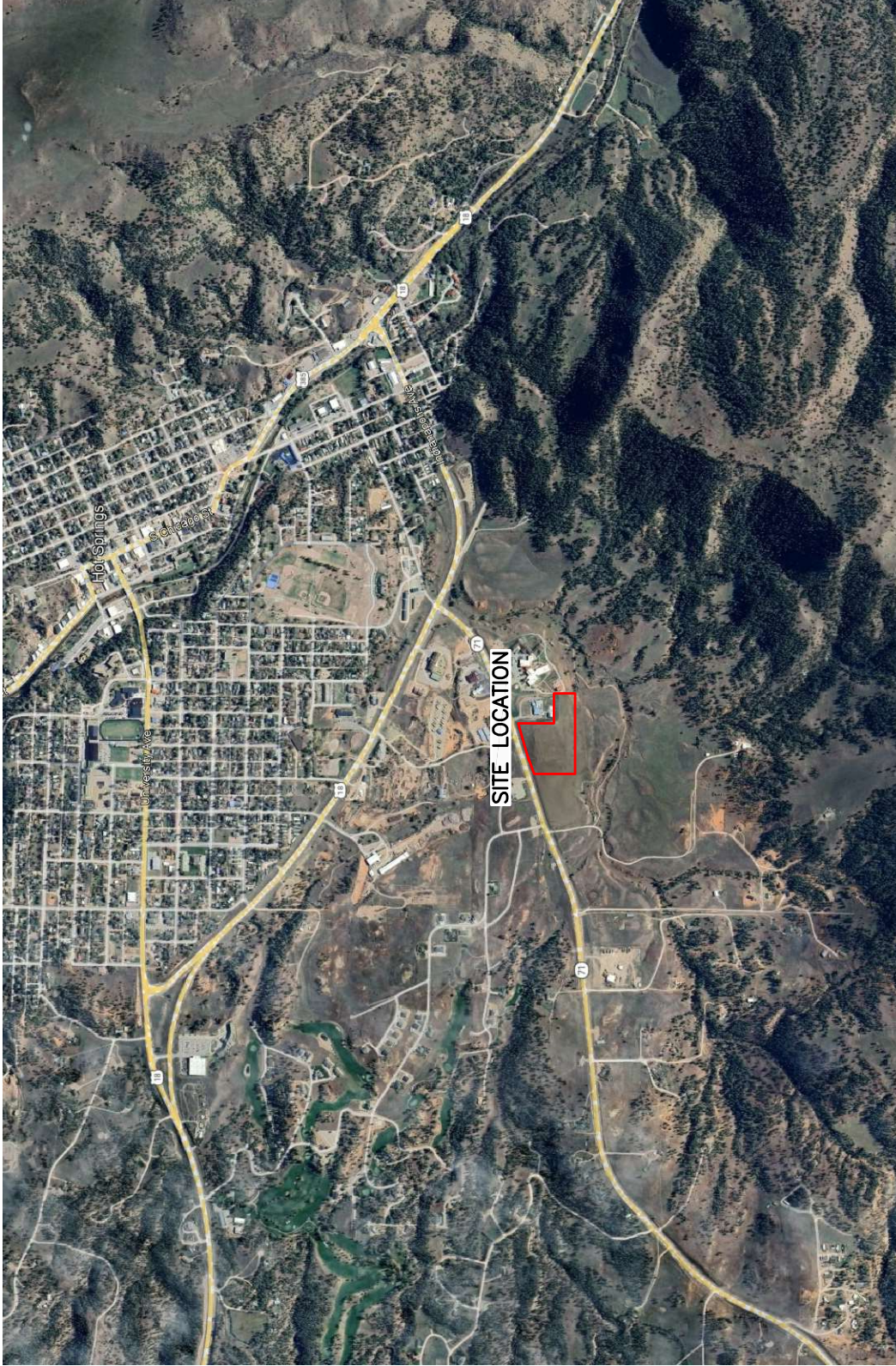
**AMERICAN
ENGINEERING TESTING,
INC.**

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A			Soil Classification		Notes		
			Group Symbol	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 $1 < Cc \leq 3^E$	GW	Well graded gravel ^F	^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 $Cu = D_{60}/D_{10}$, $Cc = (D_{30})^2/D_{10} \times D_{60}$ ^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name. ^M If soil contains $\geq 30\%$ 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. ^R Fiber Content description shown below.	
		Gravels with Fines more than 12% fines ^C	Fines classify as ML or MH	GM	Silty 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 $1 < Cc \leq 3^E$	SW	Well-graded sand ^I		
			$Cu < 6$ and $1 > Cc > 3^E$	SP	Poorly-graded sand ^I		
	Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Sils and Clays Liquid limit less than 50	inorganic	$PI > 7$ and plots on or above "A" line ^J	CL		Lean clay ^{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}
Sils and Clays Liquid limit 50 or more		inorganic	PI plots on or above "A" line	CH	Fat clay ^{K,L,M}		
		organic	Liquid limit—oven dried < 0.75 Liquid limit – not dried	MH	Elastic silt ^{K,L,M} 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			



ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

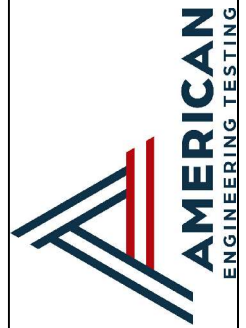
Grain Size		Gravel Percentages		Consistency of Plastic Soils		Relative Density of Non-Plastic Soils	
Term	Particle Size	Term	Percent	Term	N-Value, BPF	Term	N-Value, BPF
Boulders	Over 12"	A Little Gravel	3% - 14%	Very Soft	less than 2	Very Loose	0 - 4
Cobbles	3" to 12"	With Gravel	15% - 29%	Soft	2 - 4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



PROJECT: PROPOSED SINGLE & MULTI-FAMILY RESIDENTIAL DEVELOPMENT FRMS TRACT 1 - SD HIGHWAY 71, HOT SPRINGS, SOUTH DAKOTA		PROJECT NO. P-0040382
SUBJECT: FIGURE 1: SITE LOCATION MAP		DATE: FEBRUARY 11, 2025
SCALE: 1 INCH = 2000 FEET	DRAWN BY: KK	REVIEWED BY: WF



SCALE
(FEET)



PROJECT: PROPOSED SINGLE & MULTI-FAMILY RESIDENTIAL DEVELOPMENT
FRMS TRACT 1 - SD HIGHWAY 71, HOT SPRINGS, SOUTH DAKOTA

PROJECT NO. P-0040382

DATE:

FEBRUARY 11, 2025

SUBJECT: FIGURE 2: BORING LOCATION MAP

SCALE: 1 INCH = 150 FEET

DRAWN BY:

KK

REVIEWED BY:

WF



SUBSURFACE BORING LOG

AET No: **P-0040382**

Log of Boring No. **B-1 (p. 1 of 1)**

Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation <u>3481.0</u> MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , tan, stiff to very stiff, frost present, trace organics (roots) (CL)	TOPSOIL ALLUVIUM	27	F	SS	12					
2											
3			14	M	SS	11	9		40	17	
4											
5	CLAYEY SILT , tan, stiff to very stiff, trace sand present (ML)		12	M	SS	16	12				98
6											
7											
8			14	M	SS	15	11				
9											
10											
11	red silt lense present at 11'		20	M	SS	16	7				
12											
13	SILTY GRAVEL with SAND , tan to reddish brown, medium dense, sandstone fragments present (GM)		30	M	SS	11	3				27
14											
15	WEATHERED SANDSTONE , Silty Sand, reddish brown, medium dense (SM)	SPEARFISH FORMATION	14	M	SS	18	9				55
16											
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	2/10/25	09:45	16.5	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



SUBSURFACE BORING LOG

AET No: **P-0040382**

Log of Boring No. **B-2 (p. 1 of 1)**

Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation 3490.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , tan, very stiff, frost present, trace organics (roots) (CL)	TOPSOIL ALLUVIUM	18	F	SS	14					
2											
3											
4	SILTY GRAVEL with SAND , tannish-red, medium dense to dense, interbedded silty sand lenses present, cobbles present (GM)		23	M	SS	15	3				
5											
6											
7											
8											
9											
10											
11											
12											
13	SILTY SAND , reddish-tan, very dense, sandstone fragments present (SM)		52	M	SS	12	2				
14											
15											
16	WEATHERED SANDSTONE , Silty Sand, reddish brown, medium dense (SM)	SPEARFISH FORMATION	17	M	SS	16					30
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	2/10/25	08:48	16.5	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



SUBSURFACE BORING LOG

AET No: **P-0040382** Log of Boring No. **B-3 (p. 1 of 1)**
 Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation 3480.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , tan, very stiff, frost present, trace organics (roots) (CL)	TOPSOIL ALLUVIUM	21	F	SS	12					
2											
3	SILT , tan, firm, trace sand present (ML)		8	M	SS	12	8				
4											
5											
6			8	M	SS	12	12				96
7											
8											
9	SILTY SAND with GRAVEL , reddish brown, loose (SM)		8	M	SS	8	8				
10	SILTY GRAVEL with SAND , red, medium dense (GM)		21	M	SS	11	2				
11											
12											
13	SHALE , Silty Lean Clay, hard, gypsum present (CL)	SPEARFISH FORMATION	39	M	SS	16	12				
14											
15											
16			43	M	SS	16					
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH: 15.0	DRILLING METHOD: 3.25" HSA	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
		2/10/25	10:50	16.5	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



SUBSURFACE BORING LOG

AET No: **P-0040382**

Log of Boring No. **B-4 (p. 1 of 1)**

Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation 3474.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , reddish-brown, stiff to very stiff, frost present, trace organics (roots) (CL)	TOPSOIL ALLUVIUM	29	F	SS	13					
2											
3			14	M	SS	12	8		31	16	
4											
5	SANDY SILT , red, stiff, gypsum stringers present (ML)		12	M	SS	15	4				
6											
7											
8			13	M	SS	16	6				88
9											
10											
11			13	M	SS	18	7				
12											
13			12	M	SS	15	11				
14											
15											
16			14	M	SS	16					
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	2/10/25	14:01	16.5	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



SUBSURFACE BORING LOG

AET No: **P-0040382**

Log of Boring No. **B-5 (p. 1 of 1)**

Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation 3468.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , reddish-brown, stiff to very stiff, frost present, trace organics (roots) (CL)	TOPSOIL ALLUVIUM	29	F	SS	11					
2											
3			17	M	SS	10	9				
4											
5											
6			14	M	SS	14	7		30	15	
7											
8	SANDY SILT , red, stiff, silty lean clay seams present (ML)		9	M	SS	13	7				
9											
10											
11			14	M	SS	16	6				
12											
13			12	M	SS	16	7				
14											
15											
16			13	M	SS	16					
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	2/10/25	13:09	16.5	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



SUBSURFACE BORING LOG

AET No: **P-0040382**

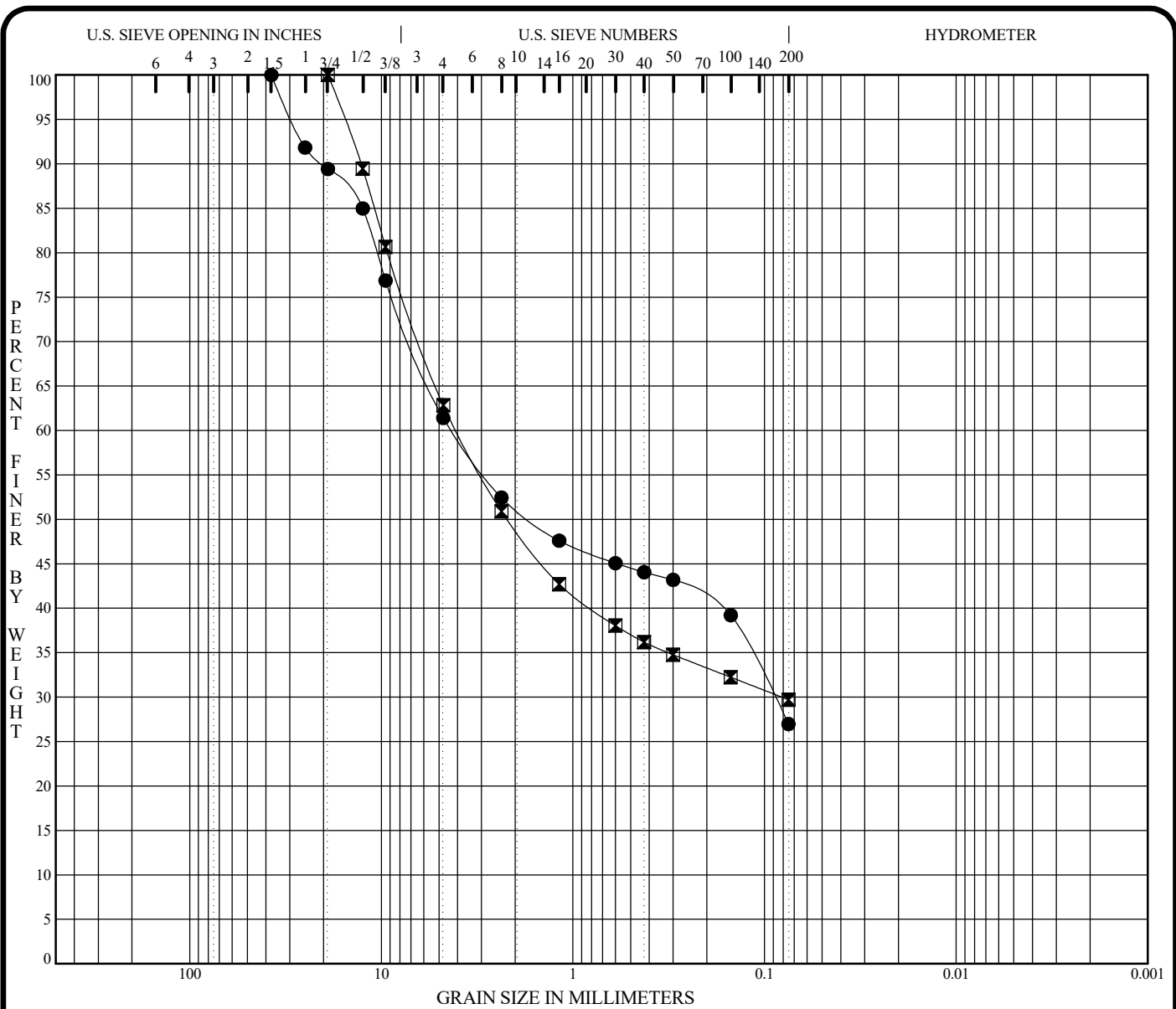
Log of Boring No. **B-6 (p. 1 of 1)**

Project: **FRMS Tract 1 Residential Development; Hot Springs, SD**

DEPTH IN FEET	Surface Elevation <u>3477.0</u> MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	TOPSOIL SILTY LEAN CLAY , reddish-brown, stiff to very stiff, frost present, organics present to 2.5' (CL)	TOPSOIL ALLUVIUM	29	F	SS	11					
2											
3			21	M	SS	14	6				
4											
5			10	M	SS	12	9		30	16	
6											
7											
8	clayey sand seams present from 7.5'		13	M	SS	14	8				83
9											
10	gypsum stringers present from 10'		18	M	SS	15	10				
11											
12											
13			16	M	SS	18	13				
14											
15											
16			12	M	SS	17					
Bottom of Boring											

AET_CORP P-0040382 FRMS TRACT 1.GPJ AET-CPT+WELL.GDT 3/5/25

DEPTH: 15.0	DRILLING METHOD: 3.25" HSA	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
		2/10/25	11:56	16.4	--	--	--	None	
BORING COMPLETED: 2/10/25									
DR: AA LG: KK Rig: 106									



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● B-1 12.5'	Silty Gravel with Sand (GM)	3					
☒ B-2 7.5'	Silty Gravel with Sand (GM)	2					

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-1 12.5'	37.50	4.25	0.089		38.6	34.5	27.0	
☒ B-2 7.5'	19.00	4.02	0.081		37.2	33.1	29.7	

PROJECT **FRMS Tract 1 Residential Development; Hot Springs, SD** AET JOB NO. **P-0040382**
DATE **2/10/25**



American Engineering Testing, Inc.
1745 Samco Rd
Rapid City, SD 57702

GRADATION CURVES



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 Rapid City
 1745 Samco Road
 Rapid City, SD 57702
 (605) 388-0029
 www.teamAET.com

Report No: PTR:AET-204742-S2

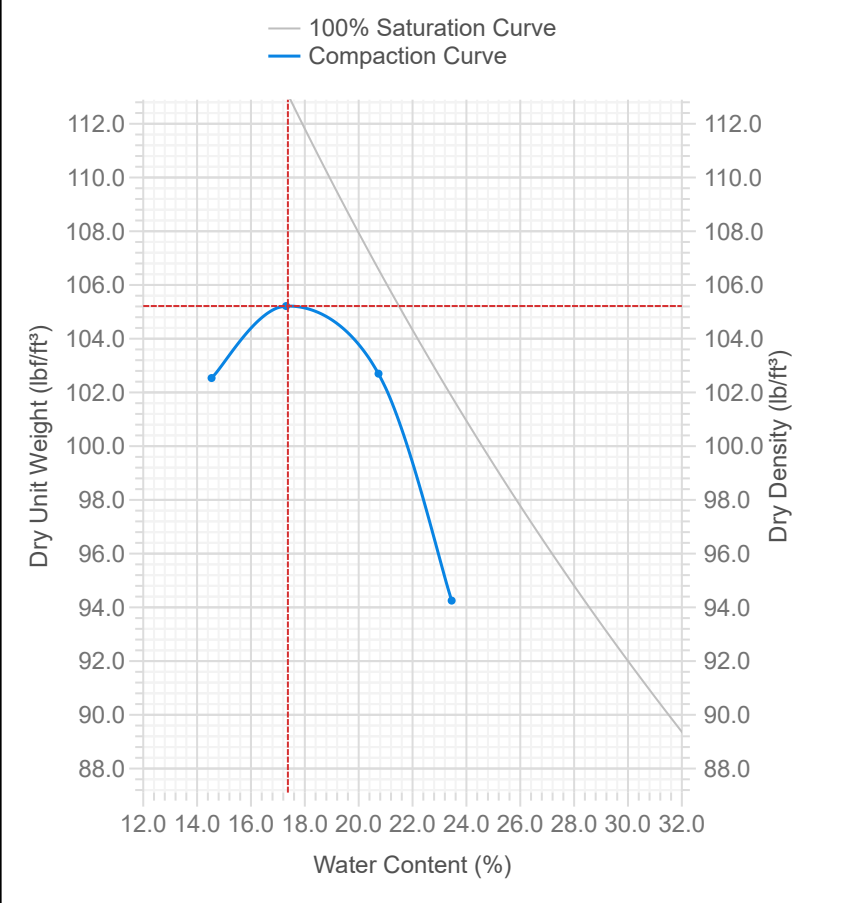
Proctor Report

Client: Towey Design Group, Inc.	CC:	Date of Issue: 2/14/2025
Project: FRMS Tract 1 Residential Development		
SD Highway 71 Hot Springs SD		
Job No: P-0040382		

Sample Details

Sample ID: AET-204742-S2	Field ID: Bulk B-1 1'-5'
Date Sampled: 2/10/2025	
Material: Silty Lean Clay (CL)	
Location: Boring B-1	
Sampled By: Kally Knutson	

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D698

Std. Maximum Dry Unit Weight (lb/ft³):	105.2
Std. Optimum Water Content (%):	17.4
Retained on 3/4" Sieve (%):	0
Passing 3/4" Sieve (%):	100
Cumulative Retained on 3/8" Sieve (%):	0
Retained on 3/8" Sieve (%):	0
Passing 3/8" Sieve (%):	100
Cumulative Retained on No.4 Sieve (%):	0
Retained on No.4 Sieve (%):	0
Passing No.4 Sieve (%):	100
Method:	A
Preparation Method:	Moist
Test Portion Specific Gravity:	2.65
Determined By:	Estimated
Tested By:	Christine Olson
Date Tested:	2/14/2025

Comments



American Engineering Testing, Inc.
 Rapid City
 1745 Samco Road
 Rapid City, SD 57702
 (605) 388-0029
 www.teamAET.com

Report No: PTR:AET-204742-S1

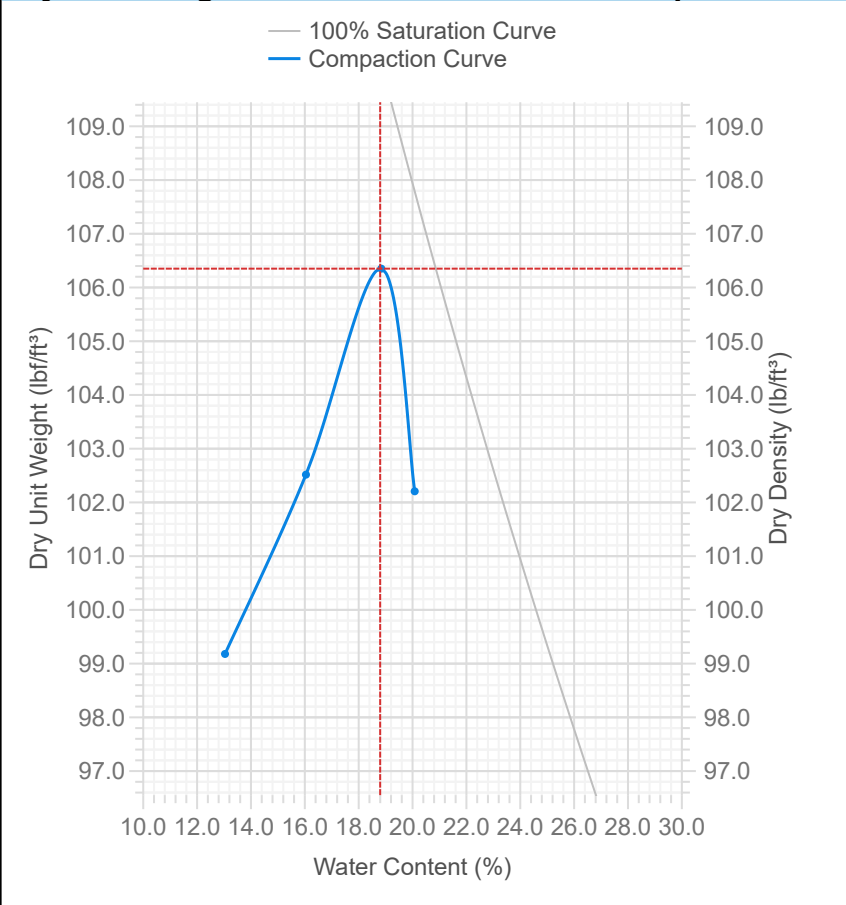
Proctor Report

Client: Towey Design Group, Inc.	CC:	Date of Issue: 2/14/2025
Project: FRMS Tract 1 Residential Development		
SD Highway 71 Hot Springs SD		
Job No: P-0040382		

Sample Details

Sample ID: AET-204742-S1	Field ID: Bulk B-4 1-5'
Date Sampled: 2/10/2025	
Material: Silty Lean Clay (CL)	
Location: Boring B-4	

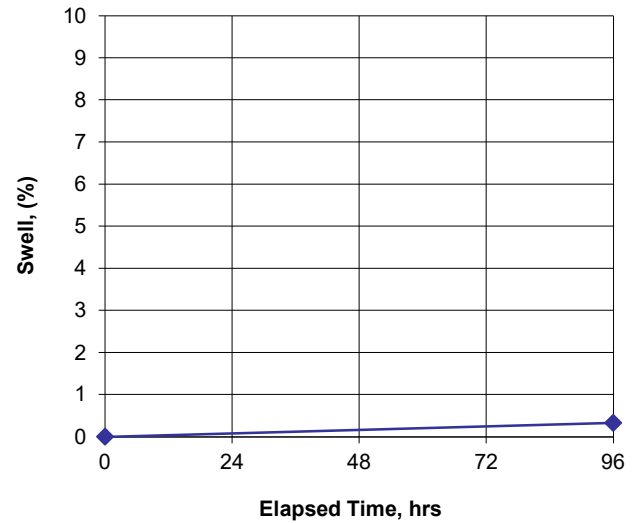
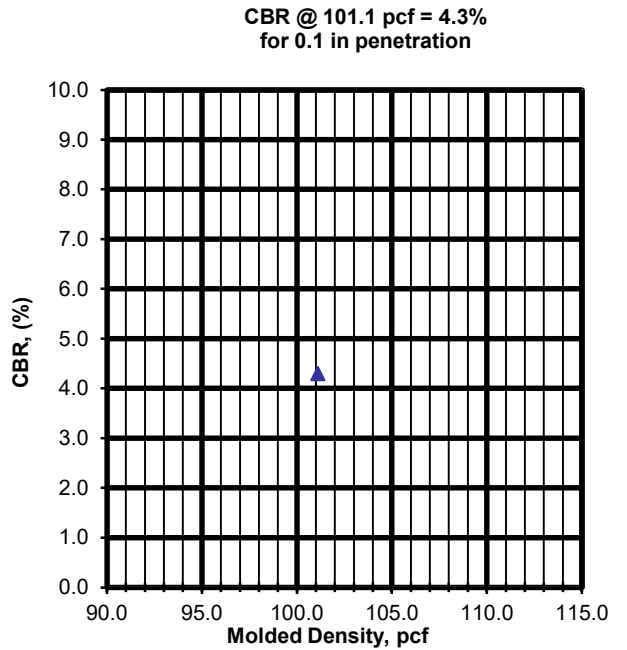
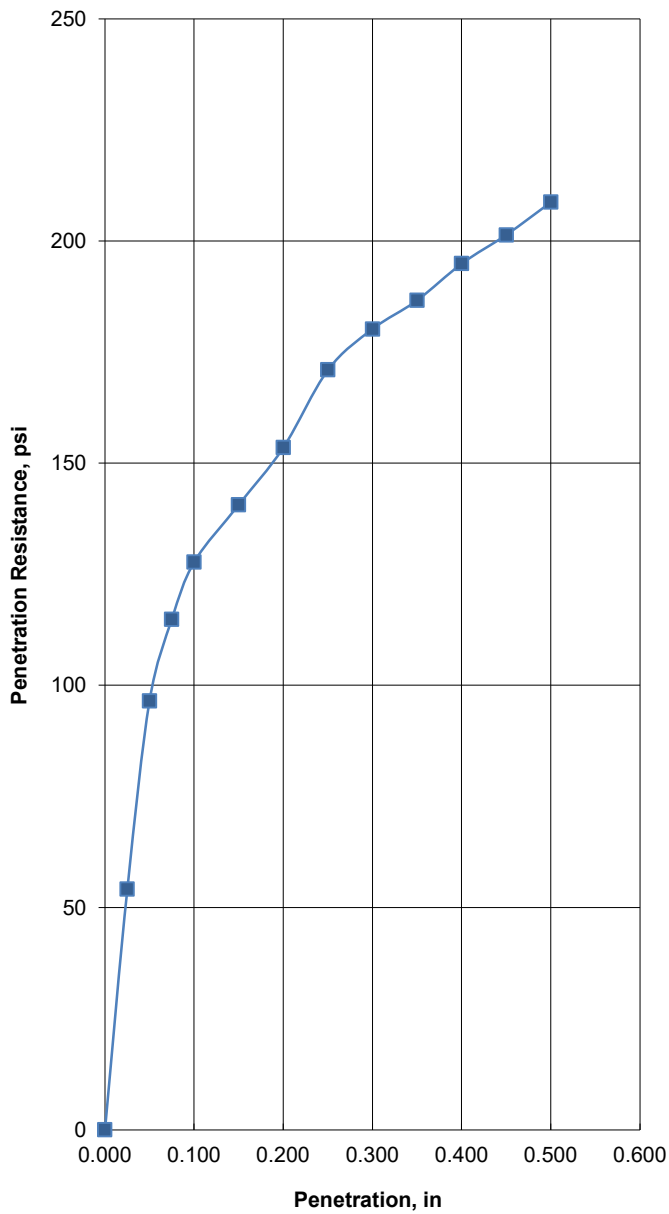
Dry Unit Weight - Water Content Relationship



Test Results

ASTM D698	
Std. Maximum Dry Unit Weight (lb/ft³):	106.4
Std. Optimum Water Content (%):	18.8
Method:	A
Preparation Method:	Moist
Rammer Type:	Manual
Test Portion Specific Gravity:	2.65
Determined By:	Estimated
Tested By:	Christine Olson
Date Tested:	2/14/2025

Comments



Molded			Soaked			CBR, (%)		Pen.	Swell
Dens.	% Max.	% Moisture	Dens.	% Max.	% Moisture	0.1 in	0.2 in	Surcharge	%
101.1	95.0	18.8	100.9	94.8	21.6	4.3	3.4	10lb	0.3
MATERIAL DESCRIPTION					USCS	Max. Dens.	Opt. Mois.	LL	PI
Silty Lean Clay					CL	106.4	18.8		

Project No: P-0040382	Bulk B-4 1-5'
Project: FRMS Tract 1 Residential Development Hot Springs, South Dakota	Test Descr. / Remarks
Date: 2/24/2025	CBR: ASTM: D1883 Proctor: ASTM: D698A



BEARING RATIO TEST REPORT

Report of Geotechnical Exploration
FRMS Tract 1 Residential Development – Rapid City, South Dakota
March 6, 2025
AET Project No. P-0040382



Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B

Geotechnical Report Limitations and Guidelines for Use

AET Project No. P-0040382

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by GBA¹, of which we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Understand the Geotechnical Engineering Services Provided for this Report

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

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

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

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

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

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

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

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

¹ Geoprofessional Business Association, 1300 Piccard Drive, LL14, Rockville, MD 20850
Telephone: 301/565-2733: www.geoprofessional.org, 2019

Appendix B

Geotechnical Report Limitations and Guidelines for Use

AET Project No. P-0040382

B.2.3 Read the Full Report

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

B.2.4 You Need to Inform Your Geotechnical Engineer About Change

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

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

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

B.2.5 Most of the “Findings” Related in This Report Are Professional Opinions

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

B.2.6 This Report's Recommendations Are Confirmation-Dependent

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

B.2.7 This Report Could Be Misinterpreted

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

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

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

Appendix B

Geotechnical Report Limitations and Guidelines for Use

AET Project No. P-0040382

B.2.8 Give Constructors a Complete Report and Guidance

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

B.2.9 Read Responsibility Provisions Closely

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

B.2.10 Geoenvironmental Concerns Are Not Covered

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

B.2.11 Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

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



March 2, 2026

Towey Design Group, Inc.
147 Chisholm Drive
Box Elder, South Dakota 57719

Attn: Mr. Mike Towey, PE
mtowey@toweydesigngroup.com

RE: Report of Geotechnical Exploration – Addendum 1
Proposed Single & Multi-Family Residential Development
FRMS Tract 1 – SD Highway 71
Hot Springs, South Dakota
AET Project No. P-0040382

Dear Mike,

Introduction

At the request of Mr. Jared Schippers (Albertson Engineering, Inc.), this letter transmits additional geotechnical recommendations with respect to the above referenced project to be constructed in Hot Springs, South Dakota. As you are aware, AET performed the geotechnical services for this project, and submitted our findings and recommendations in our report dated March 6, 2025.

Project Information

Based on the information provided, we understand site infrastructure will now include an approximate 285 lineal foot long Redi-Rock segmental block retaining wall on the order of about 7 feet in height (at its tallest point). The following recommendations should be considered for design and construction of the retaining wall.

Geotechnical Recommendations

Based on a review of the boring logs from our original study, silty lean clay soils will likely be present along the proposed retaining wall alignment. Therefore, to provide a uniform bearing surface on which to construct the new wall system, we recommend the new Redi-Rock segmental block wall be constructed on a leveling base consisting of at least 1-foot of compacted imported granular engineered fill over the reconditioned site soils. Where applicable, excavations should be laterally oversized at a 1H:1V ratio as necessary to accommodate placement of imported granular engineered fill material.



Prior to placement of the leveling base, the exposed subgrade should be scarified to a depth of at least 8-inches, the moisture content adjusted to near optimum, and the material compacted to at least 95% of the maximum dry density as determined by ASTM D698 (standard Proctor).

Please note that gypsum is a common material found in the Spearfish Formation and formational derived soils at the site. Thin gypsum lenses (stringers) were encountered throughout the soils and shale bedrock encountered in the borings. While no massive gypsum layers were encountered within the borings, the material may be encountered during site grading work. Once exposed, gypsum material can degrade which could cause future movement related distress, especially if water is introduced to the gypsum matrix. If massive gypsum is encountered at the base of the required excavations for the proposed retaining wall, a representative from AET should be allowed to observe the excavations and provide additional recommendations, which typically involve over-excavation of the gypsum material to a specified depth and replacement with approved engineered fill material or lean concrete flowable fill.

Once site grading has been completed along the wall alignment, imported granular engineered fill can then be placed. The granular engineered fill should be pre-approved by the geotechnical engineer prior to its use. The granular engineered fill should be a pit run or manufactured material (such as a crushed limestone aggregate base course) with a maximum size of 2-inches, 40% to 85% passing the #4 sieve, and no more than 15% passing the #200 sieve with a Liquid Limit less than 25. Engineered fill should be placed in 8-inch thick maximum loose lifts, the moisture content adjusted to within $\pm 3\%$ of optimum moisture content, and the individual lifts compacted to at least 95% of maximum standard Proctor (ASTM D698) dry density.

If placed on the zone of imported granular engineered fill over the prepared subgrade, 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.

To promote drainage, we recommend a clean granular backfill be used directly behind the walls 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 clean rock 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.



Cleaned and approved site soils or imported granular material may be used as the remainder of the backfill behind the wall. If the site clays are utilized, the material should be processed to the extent practical to remove any gypsum fragments greater than 1-inch in nominal size, if encountered. Prior to use, the moisture content of the material should be adjusted to within -1 to +3% of optimum, the material placed in 8-inch maximum loose lifts, and compacted to a minimum of 95% of the maximum dry density as determined by ASTM D698 (standard Proctor). If imported granular engineered fill material is used as backfill, it should be moisture conditioned to $\pm 3\%$ of optimum prior to use and compacted to a minimum of 95% (ASTM D698).

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 60 psf/ft
 - Imported granular fill 35 psf/ft
 - Clean granular fill 30 psf/ft

- Passive:
 - Site lean clay soils 220 psf/ft
 - Imported granular fill 500 psf/ft
 - Clean granular fill 645 psf/ft

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

- At Rest:
 - Site lean clay soils 80 psf/ft
 - Imported granular fill 55 psf/ft
 - Clean granular fill 50 psf/ft



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

- Coefficient of Friction (limestone aggregate base)..... 0.45
- Friction Angle (lean clay soils)..... 18°
- Friction Angle (imported granular).....36°
- Friction Angle (clean granular backfill)40°
- Cohesion (site lean clay soils)..... 200 psf
- Moist Unit Weight (site lean clay soils)..... 115 pcf
- Moist Unit Weight (imported granular)..... 130 pcf
- Dry Unit Weight (imported clean granular) 140 pcf

The lateral earth pressure values are based on a safety factor of 1.0, so an appropriate safety factor should be incorporated into the structural design of the wall(s).

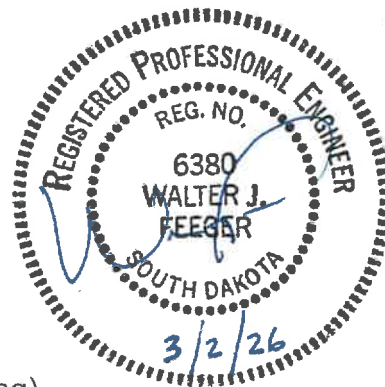
Closing

Please refer to the original geotechnical report for additional recommendations with respect to design and construction of the proposed project. If you have any questions or we can be of further service, please contact our office at (605) 388-0029.

Sincerely;
American Engineering Testing, Inc.

A handwritten signature in blue ink that reads 'Walt Feeger'.

Walt Feeger, PE
Manager/Principal Engineer – West Division



CC: Mr. Jared Schippers (Albertson Engineering)