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Geotechnical Evaluation Report

Proposed Rolling Hills Water Tank

Vicinity of Drennan Road and Mockingbird Lane

El Paso County, Colorado

VIVID Project No.: D20-2-282

VIVID Engineering Group

Revised: January 7, 2021

Report prepared for:

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GEOTECHNICAL EVALUATION REPORT
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1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of a geotechnical investigation performed for a proposed water tank (i.e. subject tank) in a vacant field southwest of the intersection of Drennan Road and Mockingbird Lane in El Paso County, Colorado. An additional boring was also requested for each of the two proposed future water tanks, located adjacent to the subject tank site. An attached Vicinity Map (Figure 1) shows the general location of the project. Our investigation was performed for JDS-Hydro Consultants Inc. and was authorized by Ms. Gwen Dall. **This report represents revision 2 of the original report. Revision 1 reflected adjustments in anticipated tank foundation and slab elevations relative to the existing ground and bedrock surface elevations. In summary, both the foundations and slab are anticipated to bear directly on the bedrock materials, and no fill will be required below these tank structural elements.**

Revision 2 reflects the drilling and sampling of the requested four additional borings in the area of the proposed water pipeline and drainage basin in order to determine subsurface conditions anticipated during excavation. The revision includes data obtained from the drilling and sampling of the additional borings and lab testing. Additional design recommendations were not included in the scope.

This report includes our recommendations relating to the geotechnical aspects of project design and construction. The conclusions and recommendations stated in this report are based upon the subsurface conditions found at the locations of our exploratory borings at the time our exploration was performed. They also are subject to the provisions stated in the report section titled **Additional Services & Limitations**. Our findings, conclusions, and recommendations should not be extrapolated to other areas or used for other projects without our prior review. Furthermore, they should not be used if the site has been altered, or if a prolonged period has elapsed since the date of the report, without VIVID's prior review to determine if they remain valid.

1.2 PROJECT DESCRIPTION

We understand the proposed project consists of the construction of a 98.5-foot diameter, 2.0 MG above ground, post-tensioned, concrete storage tank located southwest of Drennan Road and Mockingbird Lane in El Paso County, Colorado. We understand the finished floor elevation of the tank is proposed to be at 5972 feet. Two future tanks are also proposed to be constructed northeast of the 2.0 MG tank. Geotechnical design and construction recommendations for the two future tanks are not included in this report. The proposed site layout is shown on Figure 2, attached to this report.

We understand a 24" water pipeline is to be constructed from the proposed tank and connecting to the existing WWSD water system located southwest of the proposed tanks. A drainage basin is also planned to be constructed northeast of the proposed tank. The bottom of the drainage basin is proposed to be approximately 4.5 feet below the existing ground surface.

According to approximate borehole surface elevations estimated from topographic mapping and our understanding of proposed grading plans, we believe that, in general, planned site grading to achieve

finished site grades will likely include on the order of 2 to 4 feet of cut required to bring the tank finish floor to the proposed grade. Our recommendations are based on the slab and foundation bearing on the sandstone bedrock.

No structural loads were provided at the time this report was written. We understand the tank is to be constructed with a reinforced concrete floor slab and circumferential spread footing with 6 to 12 inches of crushed stone or granular base materials below the slab. Other construction related activities are anticipated to include the connection of the inflow and outflow pipelines, site grading, and installation of utilities. If the type of construction or actual building loads vary significantly from those assumed above, VIVID should be notified in order to revise our recommendations, if required.

1.3 PURPOSE AND SCOPE

The purpose of our investigation was to explore and evaluate subsurface conditions within or near the footprint of the proposed water tank on the site and, based upon the conditions found, to develop recommendations relating to the geotechnical aspects of project design and construction. Two additional borings were requested by JDS-Hydro within or near the approximate center of the two future tanks in order to evaluate subsurface conditions only. An additional four borings were requested in the area of the proposed water pipeline and drainage basin for subsurface data only. Our conclusions and recommendations for the subject tank site in this report are based upon analysis of the data from our field exploration, laboratory tests, and our experience with similar soil and geologic conditions in the area.

VIVID's scope of services included:

- A visual reconnaissance to observe surface and geologic conditions at the project site and locating the exploratory borings;
- Notification of the Utility Notification Center of Colorado (UNCC)/Colorado 811 one-call service to identify underground utility lines at the boring locations prior to our drilling;
- The drilling of 5 exploratory borings at the perimeter and center of the subject circular water storage tank, and 2 exploratory borings within the future tank footprints, all of which were staked by JDS-Hydro based upon DN Tanks requirements, and access to the site;
- The drilling of 3 additional exploratory borings at locations selected by JDS-Hydro within the proposed water pipeline alignment and 1 additional boring within the proposed drainage basin;
- Performance of a plate load test within the subject tank footprint to determine Modulus of Subgrade Reaction, based on a 12-inch square plate;
- Laboratory testing of selected samples obtained during the field exploration to evaluate relevant physical and engineering properties of the soil;
- Evaluation and engineering analysis of the field and laboratory data collected to develop our geotechnical conclusions and recommendations; and
- Preparation of this report, which includes a description of the proposed project, a description of the surface and subsurface site conditions found during our investigation, our conclusions and recommendations as to foundation and floor slab design and construction, and other related geotechnical issues, and appendices which summarize our field and laboratory investigations.

2.0 FIELD EXPLORATION AND LABORATORY TESTING

2.1 FIELD EXPLORATION

A field exploration performed on January 30, 2020 included drilling 7 exploratory borings at the approximate locations specified by JDS-Hydro and indicated on the Boring Location Plan (Figure 2). Borings B-1, B-2, B-4 and B-5 were drilled within/near the perimeter of the proposed subject tank and were advanced to approximate depths of 29 feet below the ground surface. Boring B-3 was drilled at the approximate center of the subject tank and was advanced to a depth of approximately 45 feet, at which depth drilling advancement was terminated due to refusal on a highly cemented layer of sandstone bedrock. Borings B-6 and B-7 were drilled near the approximate center of the two future water tanks and were advanced to depths of approximately 29 feet.

An additional field exploration performed on December 23, 2020 included drilling 4 exploratory borings at the approximate locations specified by JDS-Hydro on Figure 3 and Figure 4 of this report. Borings B-8 through B-10 were drilled within the proposed water pipeline alignment and were advanced to depths of approximately 14 to 15 feet below the existing ground surface. Boring B-11 was drilled at the approximate center of the proposed drainage basin and was advanced to a depth of approximately 15.5 feet.

The initial 7 borings were advanced using a truck-mounted CME-55 drill rig equipped with 4-inch diameter, continuous-flight, solid-stem auger. The 4 additional borings were advanced using a truck-mounted Diedrich 90 drill rig equipped with 4-inch diameter continuous-flight, solid-stem auger. Samples were taken with a standard split-spoon (SPT) sampler and California-type sampler (2.0-inch I.D./2.5-inch O.D.) and by bulk methods. Penetration tests were obtained at the various sample depths as well.

Appendix A to this report includes logs describing the subsurface conditions. The lines defining boundaries between soil and rock types on the logs are based upon drill behavior and interpolation between samples and are therefore approximate. Transition between soil and rock types may be abrupt or may be gradual.

2.2 GEOTECHNICAL LABORATORY TESTING

Laboratory tests were performed on selected soil samples to estimate their relative engineering properties. Tests were performed in general accordance with the following methods of ASTM or other recognized standards-setting bodies, and local practice:

- Description and Identification of Soils (Visual-Manual Procedure)
- Classification of Soils for Engineering Purposes
- Moisture Content and Unit Weight of Soils
- Sieve Analysis
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- Swell/Settlement Test

Results of the geotechnical laboratory tests are presented in the report text, where applicable, and included in Appendix B of this report. Selected test results are also shown on the boring logs in Appendix A.

2.3 ANALYTICAL LABORATORY TESTING

Analytical testing for soil corrosivity was performed on two select samples and included the following tests:

- pH
- Resistivity
- Redox Potential
- Water-soluble Chloride Content
- Sulfides
- Water-soluble Sulfate Content

Results of the analytical laboratory tests are included in Appendix C of this report. Selected test results are also shown on the boring logs in Appendix A

3.0 SITE CONDITIONS

3.1 SURFACE

At the time of our exploration, the subject site was a vacant property southwest of the intersection of Drennan Road and Mockingbird Lane in El Paso County, Colorado. The Pikes Peak National Cemetery (PPNC) is located west of the proposed project site as well as a major utility easement located between the PPNC and the project site. The ground surface consisted of gently rolling topography and was covered predominately with grasses and yucca plants. Prairie dog holes were scattered across the property. Outcroppings of sandstone bedrock were present at various locations in areas adjacent to the site. Groundwater seeps were not observed on the site.

3.2 GEOLOGY

Prior to drilling, the site geology was evaluated by reviewing available geologic information including the USGS Geologic Map of the Coral Bluffs Quadrangle, El Paso County, Colorado (Soister, P.E. 1968). Mapping indicates the surficial soils in the general area of the project site comprise predominately of Piney Creek Alluvium deposits of mostly clayey and silty sand underlain by interbedded sandstone, claystone and shale bedrock of the Pierre Shale Formation. The mapping is generally consistent with our explorations.

3.3 SEISMICITY

Based upon the geologic setting, subsurface soil conditions, and low seismic activity in this region, liquefaction is not expected to be a hazard at the site. Based on correlation of blow count data (N-values) from the borings advanced during this evaluation, the subsurface soil profiles correspond with Site Class C of the 2015 International Building Code (IBC). The intermediate design acceleration values from IBC are presented below.

Table 1
Design Acceleration for Short Periods

S_S	F_a
0.167	1.2

S_S = The mapped spectral accelerations for short periods (SEAOC/OSHPD Seismic Design Maps Tool, 2020)

F_a = Site coefficient (SEAOC/OSHPD Seismic Design Maps Tool, 2020)

Table 2
Design Acceleration for 1-Second Period

S_1	F_V
0.059	1.7

S_1 = The mapped spectral accelerations for 1 second period (SEAOC/OSHPD Seismic Design Maps Tool, 2020)

F_v = Site coefficient SEAOC/OSHPD Seismic Design Maps Tool, 2020

3.4 SUBSURFACE

VIVID explored the subsurface conditions by drilling, logging and sampling 7 exploratory borings within or near the general area to be occupied by the proposed subject tank and future tanks as shown on Figure

2. These borings were drilled to depths ranging from approximately 29 to 45 feet below the existing ground surface. In addition, 3 exploratory borings were performed at select locations within the area of the proposed water pipeline and 1 boring within the proposed drainage basin. The additional borings were drilled to depths ranging from approximately 14 to 15.5 feet below the existing ground surface. The general profile encountered in our borings consisted of:

Sand (Alluvium)

This unit comprised mainly of clayey sand with thin layers of silty sand and was encountered at the ground surface in the two borings in the locations of the future water tanks and extended to depths of approximately 3.5 to 6 feet below the existing ground surface. A thin layer, approximately 1-foot thick, of silty sand was encountered overlying the weathered bedrock in one of the water pipelines borings (Boring B-10). Silty sand extended the full depth of the boring located in the area of the drainage basin (B-11). The sand soils were generally olive and yellowish-brown in color and slightly moist. Field penetration testing (blow counts) and drill rig observations indicated the sand soils were medium dense to loose.

Bedrock

A layer of weathered sandstone bedrock was encountered at the ground surface in all 5 of the borings located within or near the footprint of the proposed 2.0 MG tank. A thin layer of weathered sandstone, approximately 1.5 feet thick, was encountered below the surficial soils in boring B-7. A weathered sandstone layer was encountered at the ground surface or below the sand in all 3 of the borings located within the proposed water pipeline alignment. The weathered sandstone was medium hard to hard based on field penetration resistance testing and drill rig observations. The weathered layer extended to depths of 2 to 5 feet below the existing ground surface, was dry to slightly moist and was generally olive, olive-brown, light brown and yellowish-brown.

Interbedded sandstone and claystone bedrock of the Pierre Shale Formation was encountered underlying the units described above and extended to depths between approximately 15 and 29 feet below the ground surface. The sandstone and claystone bedrock materials were predominantly olive, olive-brown, yellowish-brown and reddish-brown in color, slightly moist to moist, and hard to very hard as indicated by the field penetration test (blow counts). Well-cemented layers of bedrock were encountered at various depths within this unit.

The interbedded sandstone and claystone bedrock was underlain by shale bedrock of the Pierre Shale Formation and extended to the maximum depths explored of approximately 29 to 45 feet below the ground surface. The shale was generally dark gray in color, slightly moist to moist, and very hard with a highly-cemented layer encountered at a depth of approximately 45 feet in boring B-3.

The boring logs in Appendix A should be reviewed for more detailed descriptions of the subsurface conditions at each of the boring locations explored.

3.4.1 Groundwater

Groundwater was not encountered in any of the borings at the time of drilling or when checked one day after completion of drilling. Groundwater is not anticipated to be a significant factor for construction. Soil

moisture levels and groundwater levels commonly vary over time and space depending on seasonal precipitation, irrigation practices, land use, and runoff conditions. These conditions and the variations that they create often are not apparent at the time of field investigation. Accordingly, the soil moisture and groundwater data in this report pertain only to the locations and times at which exploration was performed. They can be extrapolated to other locations and times only with caution. It should also be noted that VIVID has not performed a hydrologic study to verify the seasonal high-water level.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 GEOTECHNICAL FEASIBILITY OF PROPOSED CONSTRUCTION

VIVID found no subsurface conditions during this investigation that would preclude development of the site essentially as planned, provided the recommendations in this report are incorporated into the design and construction of the project. Our recommendations for earthwork, foundations, and slabs are discussed further in the following sections of the report.

Based on a finished floor elevation of 5972 feet and our understanding of the existing topography, we anticipate the slab and foundation will be bearing on sandstone bedrock. Foundation system recommendations are described in more detail in Section 4.3.1. Slab-on-grade recommendations are described in more detail in Section 4.5. This includes subgrade preparation prior to placement of the 6 to 12-inch crushed stone or granular base material below the slab, as required by DN Tanks, per Section 4.2.2.

4.2 CONSTRUCTION CONSIDERATIONS

4.2.1 General

All site preparation and earthwork operations should be performed in accordance with applicable codes, safety regulations and other local, State or Federal guidelines.

4.2.2 Site Preparation and Grading

Initial site work should consist of completely removing all organic material and other deleterious materials from all areas to be filled and areas to be cut. All material should be removed for offsite disposal in accordance with local laws and regulations or, if appropriate, stockpiled in proposed non-structural areas for future use. Areas to receive fill should be evaluated by the geotechnical engineer prior to the placement of any fill materials.

After performing the required excavations and prior to the placement of the granular base material as required by DN Tanks, processing of the subgrade should be performed. This should include scraping the bedrock clean and relatively flat (undisturbed bedrock should not be scarified). If loose material is present at the bottom of the excavation, the loose material should be compacted as specified in Section 4.2.6 of this report. All fill materials should be placed on a horizontal plane and placed in loose lifts not to exceed 8 inches in thickness, unless otherwise accepted by the geotechnical engineer.

4.2.3 Excavation Characteristics

Based on our discussion and the topographic map provided to us, we understand the desired finished floor elevation is 5972 feet. We anticipate cuts up to approximately 7 feet will be required to achieve footing elevations.

If deep excavations for utility placement are required, hard to very hard bedrock will be encountered. Excavation in the upper portions of bedrock should not present significant challenges for standard heavy-duty excavation equipment. The unweathered bedrock can be very hard and very much intact, making ripping of the bedrock extremely difficult. Excavation equipment such as heavy-duty backhoes/trackhoes suitable for rock excavation, hoe rams, dozers equipped with rock excavating teeth/rippers and similar

equipment will be required to excavate into the very hard bedrock materials. We anticipate excavation in the harder materials could be relatively slow depending on the depth of excavation, the type of bedrock encountered, the type and site of equipment used, as well as the contractor's experience with similar excavation.

All excavations must comply with applicable local, State and Federal safety regulations, and particularly with the excavation standards of the Occupational Safety and Health Administration (OSHA). Construction site safety, including excavation safety, is the sole responsibility of the Contractor as part of its overall responsibility for the means, methods and sequencing of construction operations. VIVID's recommendations for excavation support are intended for the Client's use in planning the project, and in no way relieve the Contractor of its responsibility to construct, support and maintain safe slopes. Under no circumstances should the following recommendations be interpreted to mean that VIVID is assuming responsibility for either construction site safety or the Contractor's activities.

We believe that the sand overburden soils on this site will classify as Type C materials and the sandstone and claystone bedrock will classify as Type B materials using OSHA criteria. OSHA requires that unsupported cuts be laid back to ratios no steeper than 1½:1 (horizontal to vertical) for Type C materials and no steeper than 1:1 for Type B materials. In general, we believe that these slope ratios for the soils provided above will be temporarily stable under unsaturated conditions. If groundwater seepage was to occur, flatter slopes may be appropriate. Please note that the actual determination of soil type and allowable sloping must be made in the field by an OSHA-qualified "competent person."

4.2.4 Structural Fill

If the foundation is to be backfilled on one side, structural fill must be used. If the on-site materials are used as structural fill, the bedrock must be broken down into "soil-like" material with no particles greater than 2 inches. Imported structural fill should consist of a CDOT Class 1 Structure Backfill. A sample of any imported fill material should be submitted to our office for approval and testing at least 1 week prior to stockpiling at the site.

Structural fill should be moisture-treated and compacted according to the recommendations in Section 4.2.6 of this report.

4.2.5 Utility Trench Backfill

Backfill material should be essentially free of plant matter, organic soil, debris, trash, other deleterious matter and rock particles larger than 4 inches. However, backfill material in the "pipe zone" (from the trench floor to 1 foot above the top of pipe) should not contain rock particles larger than 1 inch. Strictly observe any requirements specified by the utility agency for bedding and pipe-zone fill. In general, backfill above the pipe zone in utility trenches should be placed in lifts of 6 to 8 inches, and compacted using power equipment designed for trench work. Backfill in the pipe zone should be placed in lifts of 8 inches or less and compacted with hand-held equipment. Compact trench backfill as recommended in Section 4.2.6 of this report. If utilities are placed below tank footings or slab, the trench must be backfilled with flow fill as specified in CDOT Standard Specifications Section 206.02. This will provide support more consistent with the bedrock materials and minimize potential differential settlement.

4.2.6 Compaction Requirements

Fill materials should be placed in horizontal lifts compatible with the type of compaction equipment being used, moisture conditioned, and compacted in accordance with the following criteria:

Table 3
Compaction Specifications

FILL LOCATION [1]	MATERIAL TYPE	PERCENT COMPACTION[2] (ASTM D 1557)	MOISTURE CONTENT
Subgrade Preparation (after clearing, grubbing, excavation, and prior to placement of new fill and/or structural elements)	On-site Soils, not including undisturbed sandstone bedrock	92 minimum	± 2 % of optimum
Exterior Wall Backfill	Imported Granular Soils or On-site Soils (CDOT Class 1 Structural Backfill)	92 minimum	± 2 % of optimum
Utility Trenches (outside tank perimeter)	On-site Soils	92 minimum	± 2 % of optimum

1) Where two or more "Fill Locations" coincide, the more stringent specification should be used.
2) In non-structural or landscaped areas, the compaction specification may be reduced to 90 percent.

Structural fill should be placed in level lifts not exceeding 8-inches in loose thickness and compacted to the specified percent compaction to produce a firm and unyielding surface. If field density tests indicate the required percent compaction has not been obtained, the fill material should be reconditioned as necessary and re-compacted to the required percent compaction before placing any additional material.

4.2.7 Construction in Wet or Cold Weather

During construction, grade the site such that surface water can drain readily away from the building areas. Promptly pump out or otherwise remove any water that may accumulate in excavations or on subgrade surfaces and allow these areas to dry before resuming construction. The use of berms, ditches and similar means may be used to prevent stormwater from entering the work area and to convey any water off site efficiently.

If earthwork is performed during the winter months when freezing is a factor, no grading fill, structural fill or other fill should be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. A good practice is to cover the compacted fill with a "blanket" of loose fill to help prevent the compacted fill from freezing.

If the structures are erected during cold weather, foundations, concrete slabs-on-grade, or other concrete elements should not be constructed on frozen soil. Frozen soil should be completely removed from

beneath the concrete elements, or thawed, scarified and recompacted. The amount of time passing between excavation or subgrade preparation and placing concrete should be minimized during freezing conditions to prevent the prepared soils from freezing. The use of blankets, soil cover or heating as required may be utilized to prevent the subgrade from freezing.

4.2.8 Construction Testing and Observation

Testing and construction observation should take place under the direction of VIVID to support that engineer's professional opinion as to whether the earthwork does or does not substantially conform to the recommendations in this report. Furthermore, the opinions and conclusions of a geotechnical report are based upon the interpretation of a limited amount of information obtained from the field exploration. It is therefore not uncommon to find that actual site conditions differ somewhat from those indicated in the report. The geotechnical engineer should remain involved throughout the project to evaluate such differing conditions as they appear, and to modify or add to the geotechnical recommendations as necessary.

4.2.9 Surface Drainage and Landscaping

Positive drainage away from the tank is essential to the performance of foundations and slabs and should be provided during the life of the structure. Non-paved areas within 10-feet of the structure should slope away at a minimum of 8 percent. Areas where pavements or slabs are constructed adjacent to the structure should slope away at a minimum grade of 2 percent. All downspouts from roof drains should be tight-lined to an on-site stormwater system or, at a minimum, cross all backfilled areas such that they discharge all water away from the backfill zone and the structure. Drainage should be created such that water is diverted off the site and away from backfill areas of adjacent structures.

4.2.10 Permanent Cut and Fill Slopes

If required, permanent cut and fill slopes exposing the materials encountered in our borings are anticipated to be stable at slope ratios as steep as 3:1 (horizontal to vertical) under dry conditions. We believe that slope ratios of 4:1 or flatter are more reliable if subjected to wetting, and present less of a maintenance problem. New slopes should be revegetated as soon as possible after completion to reduce erosion problems.

4.3 SHALLOW FOUNDATIONS

Provided the following recommendations are complied with, the proposed storage tank may be supported on shallow foundations. Our subsurface investigation indicates excavation for construction of shallow foundations for the proposed structure will expose sandstone bedrock materials. To provide uniform support and to limit differential settlement, all footings shall extend to bedrock.

4.3.1 Shallow Foundation

Foundation elevations were not provided to our office prior to this investigation. Based on the existing topography and our understanding of desired finished floor elevations, we anticipate the foundation will bear directly on sandstone bedrock.

- Foundations should be constructed directly on the sandstone bedrock, as discussed above.

- Foundations bearing upon sandstone bedrock should be designed for a maximum allowable soil bearing capacity of 4,000 psf. A one-third increase in bearing capacity is allowable for transient loads. Foundations should be proportioned as much as practicable to minimize differential settlement.
- If utilities are placed below tank footings or slab, the trench must be backfilled with flow fill as specified in CDOT Standard Specifications Section 206.02. This will provide support more consistent with the bedrock materials and minimize potential differential settlement.
- Foundation sizes should be determined by a structural engineer based on actual structural loading. However, as a minimum, continuous footings should have a minimum width of 18 inches. The actual footing sizes should be determined by a qualified structural engineer based on the soil bearing capacity and actual structural loads.
- Exterior foundations must be protected from frost action. We recommend footings be protected with at least 30 inches of soil cover or that which is required by local building codes. Foundation components must not be placed on frozen soils.
- A representative of VIVID should observe all foundation excavations prior to placement of concrete.

4.4 LATERAL EARTH PRESSURES

If foundations or walls are partially backfilled with soil on one side, they will therefore be subjected to lateral earth pressures. The design and construction criteria presented below should be observed for earth retention systems on this site with flat back slopes. Active and at-rest lateral earth pressures apply to the structural fill soils that are "retained" by the foundation walls. Passive lateral earth pressure applies to soils placed adjacent the inside edge of the tank footing/wall beneath the floor slab. The sliding coefficient applies to the friction between the base of the foundation and the underlying soil. The following values were estimated assuming a moist unit weight of 125 pounds per cubic foot and an internal friction angle of 32 degrees for imported granular structural fill materials. A moist unit weight of 120 pounds per cubic foot and internal friction angle of 28 degrees for on-site soils and sandstone bedrock.

Table 4
Lateral Earth Pressure Parameter Summary

Lateral Earth Pressure Parameter	Values for Imported Granular Structural Fill (ultimate values)	Values for On-site Soils (ultimate values)
At-Rest[1]	58 pcf	63 pcf
Active[2]	38 pcf	43 pcf
Passive[3]	406 pcf	332 pcf
Unfactored Coefficient of Sliding Friction[3]	0.62	0.53

Notes: 1. Retaining walls that are laterally supported (structurally restrained from rotation) can be expected to undergo only a slight amount of deflection. These walls should be designed for an "at-rest" lateral earth pressure.

2. Retaining structures which can deflect sufficiently to mobilize the full “active” earth pressure condition should be designed for an “active” lateral earth pressure.

3. Lateral loads may be resisted using these coefficients of friction for sliding and unfactored passive earth pressures. Due to the relatively large movements required to mobilize the passive pressure, we recommend a minimum factor of safety of 1.5 be utilized.

4. It should be noted that the above lateral earth pressures assume drained conditions behind the wall and a horizontal backfill surface without surcharges.

4.5 SLABS-ON-GRADE

Based on the plans provided to us and the desired slab elevation of 5972 feet, we anticipate the slab section will bear on sandstone bedrock. The slab section includes the slab and the 6 to 12 inches of granular base as required by DN Tanks. Subgrade preparation as described above for the interior slab shall be applied to exterior flatwork that is constructed adjacent the building structure as well.

The criteria presented below should be observed for design and construction of slabs on this site. The construction details should be considered when preparing the project documents.

- Considering the results obtained from a plate load test performed using a 12” square plate according to (ASTM D 1196), we recommend designing the slab utilizing a modulus of subgrade reaction of **300** pounds per cubic inch (pci) when bearing on sandstone bedrock.
- If utilities are placed below the slab, the trench must be backfilled with flow fill as specified in CDOT Standard Specifications Section 206.02. This will provide support more consistent with the bedrock materials and minimize potential differential settlement.

4.6 CORROSIVITY AND CONCRETE

4.6.1 Corrosion Potential

Laboratory testing was completed to provide data regarding corrosivity of onsite soils. Our scope of services does not include corrosion engineering and, therefore, a detailed analysis of the corrosion test results is not included. A qualified corrosion engineer should be retained to review the test results and design protective systems that may be required.

Laboratory chloride concentration, sulfate concentration, sulfide concentration, pH, oxidation reduction potential, and electrical resistivity tests were performed on a sample of onsite materials obtained during our field investigation. The results of the tests are included in Appendix C to this report and are summarized below in Table 5.

Table 5
Summary of Laboratory Soil Corrosivity Testing

Boring No.	Sample Depth (ft)	Water Soluble Chloride (%)	pH	Redox Potential (mV)	Resistivity (ohm-cm)	Water Soluble Sulfate (%)	Sulfide Content
B-4	2.0	0.0006	4.2	455.2	1,656	0.029	Negative
B-6	4.0	0.0097	7.3	369.6	490	0.271	Negative

Metal and concrete elements in contact with soil, whether part of a foundation system or part of a supported structure, are subject to degradation due to corrosion or chemical attack. Therefore, buried metal and concrete elements should be designed to resist corrosion and degradation based on accepted practices.

Based on the "10-point" method developed by the American Water Works Association (AWWA) in standard AWWA C105/A21.5, the corrosivity test results indicate that the onsite surficial clayey sand soils encountered in the area of the future tanks have corrosive potential. The test results of the soil located in the area of the subject tank indicate low corrosive potential. We recommend that a corrosion engineer be consulted to recommend appropriate protective measures, if required.

4.6.2 Chemical Sulfate Susceptibility and Concrete Type

The degradation of concrete or cement grout can be caused by chemical agents in the soil or groundwater that react with concrete to either dissolve the cement paste or precipitate larger compounds within the concrete, causing cracking and flaking. The concentration of water-soluble sulfates in the soils is a good indicator of the potential for chemical attack of concrete or cement grout. The American Concrete Institute (ACI) in their publication Guide to Durable Concrete (ACI 201.2R-08) provides guidelines for this assessment.

The concentration of water-soluble sulfates measured was variable. Based on the results we recommend assuming a Class 2 exposure of sulfate attack on concrete exposed to the soils per CDOT Standard Specifications for Road and Bridge Construction, 2019, Section 601.04. Requirements for sulfate resistance are also presented in Section 601.04 of the CDOT Standard Specifications for Road and Bridge Construction, 2019.

5.0 ADDITIONAL SERVICES & LIMITATIONS

5.1 ADDITIONAL SERVICES

Attached to this report is a document by the Geoprofessional Business Association (GBA) that summarizes limitations of geotechnical reports as well as additional services that are required to further confirm subgrade materials are consistent with that encountered at the specific boring locations presented in this report. This document should be read in its entirety before implementing design or construction activities. Examples of other services beyond completion of a geotechnical report are necessary or desirable to complete a project satisfactorily include:

- Review of design plans and specifications to verity that our recommendations were properly interpreted and implemented.
- Attendance at pre-bid and pre-construction meetings to highlight important items and clear up misunderstandings, ambiguities, or conflicts with design plans and specifications.
- Performance of construction observation and testing which allows verification that existing materials at locations beyond our borings are consistent with that presented in our report, construction is compliant with the requirements/recommendations, evaluation of changed conditions.

5.2 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of VIVID's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. VIVID makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Client. If Client does not retain VIVID to review any plans and specifications, including any revisions or modifications to the plans and specifications, VIVID assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from VIVID's engineer that such changes do not affect our recommendations. Failure to do so will vitiate VIVID's recommendations.

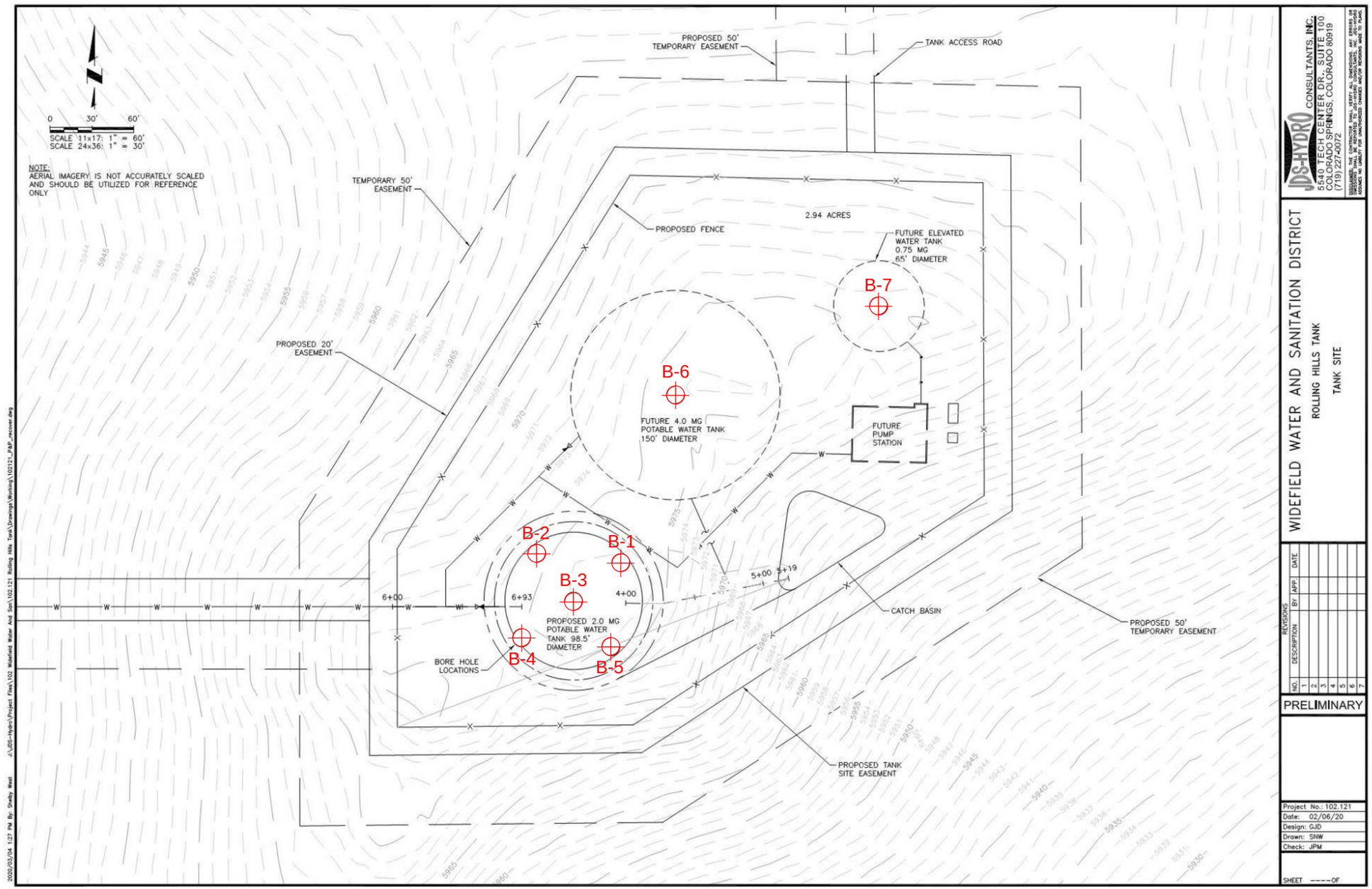
Figures

Not to Scale. Base image obtained from www.mapquest.com, 2020.

VIVID Engineering Group	Project No: D20-2-282 Date: February 12, 2020 Drawn by: MBR Reviewed by: BTM	**VICINITY MAP** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	Figure **1**

LEGEND

⊕ = APPROXIMATE LOCATION OF TANK BORING

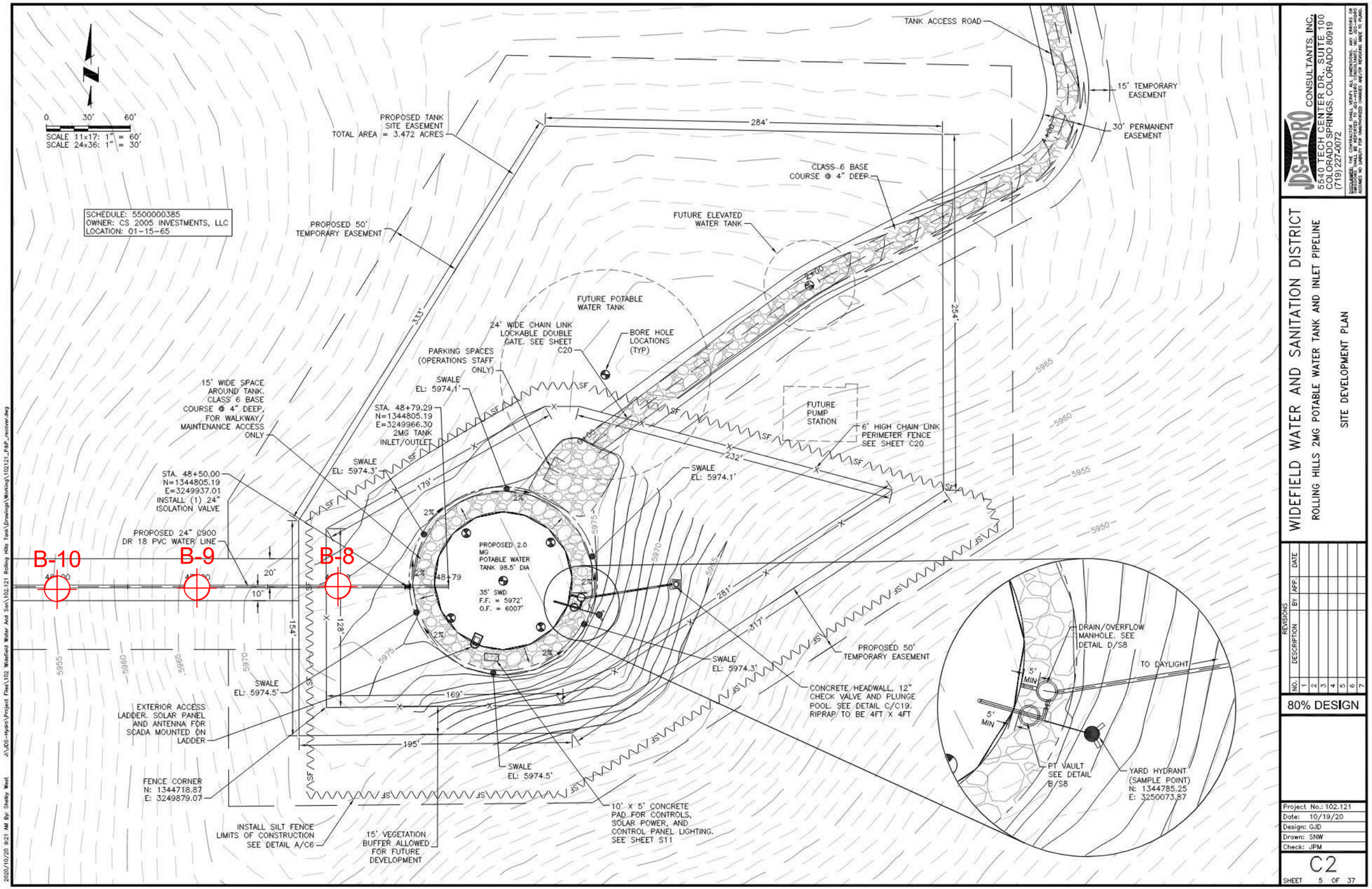


Base image dated 02/06/2020 and provided by JDS-Hydro Consultants, Inc. on 03/04/2020.

VIVID Engineering Group, Inc. 1053 Elkton Drive Colorado Springs, Colorado 80907 719.896.4356	Project No: D20-2-282 Date: March 5, 2020 Drawn by: MBR Reviewed by : BTM	**BORING LOCATION PLAN - CONCEPTUAL** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	Figure **2**

LEGEND

⊕ = APPROXIMATE LOCATION OF PIPELINE BORING



Base image dated 10/19/2020 and provided by JDS-Hydro Consultants, Inc.

JDS-HYDRO CONSULTANTS, INC.
5540 TECH CENTER DR. SUITE 100
COLORADO SPRINGS, COLORADO 80919
(719) 227-0072

WIDEFIELD WATER AND SANITATION DISTRICT
ROLLING HILLS 2MG POTABLE WATER TANK AND INLET PIPELINE
SITE DEVELOPMENT PLAN

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE
1				
2				
3				
4				
5				
6				
7				

80% DESIGN

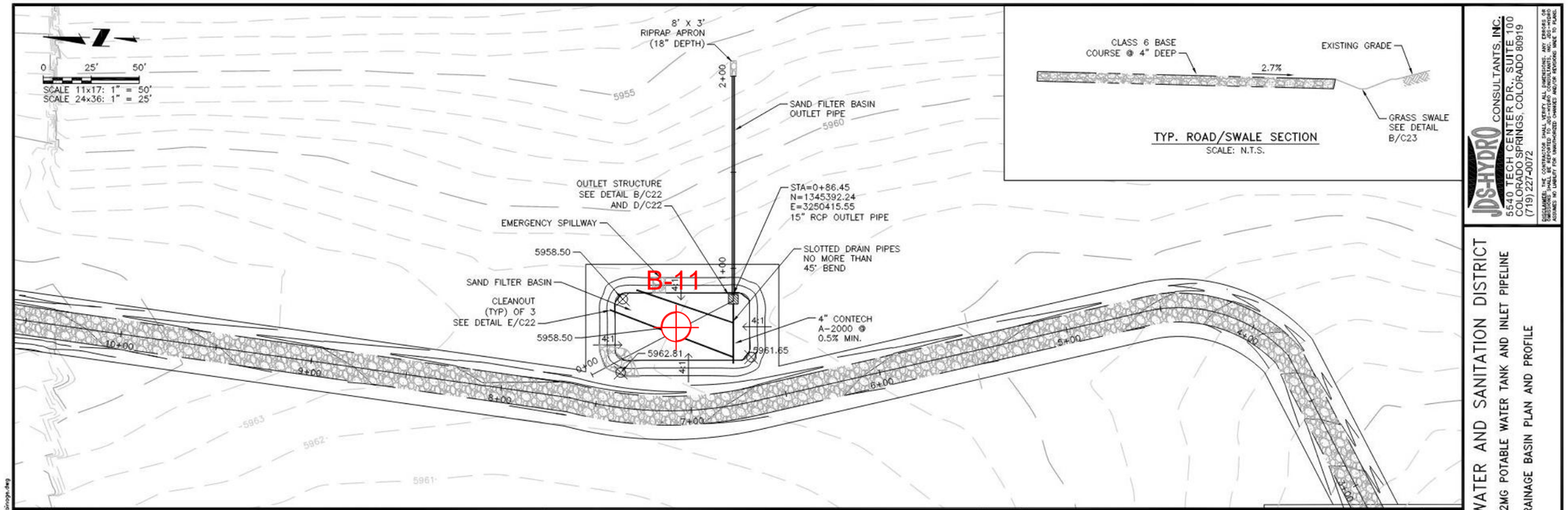
Project No.: 102.121
Date: 10/19/20
Design: GJD
Drawn: SNW
Check: JPM

C2
SHEET 5 OF 37

VIVID Engineering Group, Inc. 1053 Elkton Drive Colorado Springs, Colorado 80907 719.896.4356	Project No: D20-2-282 Date: December 28, 2020 Drawn by: MBR Reviewed by : BTM	**BORING LOCATION PLAN - CONCEPTUAL** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	Figure **3**

LEGEND

⊕ = APPROXIMATE LOCATION OF BORING



Base image dated 10/19/2020 and provided by JDS-Hydro Consultants, Inc.

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(719) 227-0072

DISCLAIMER: THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS. ANY ERRORS OR OMISSIONS SHALL BE REPORTED TO THE ENGINEER BEFORE ANY WORK IS PERFORMED. JDS-HYDRO ASSUMES NO LIABILITY FOR UNAUTHORIZED CHANGES AND/OR REVISIONS MADE TO PLANS.

WIDEFIELD WATER AND SANITATION DISTRICT
ROLLING HILLS 2MG POTABLE WATER TANK AND INLET PIPELINE
DRAINAGE BASIN PLAN AND PROFILE

NO.	DESCRIPTION	BY	APP.	DATE
1				
2				
3				
4				
5				
6				
7				

REVISIONS

80% DESIGN

Project No.: 102.121
Date: 10/19/20
Design: GJD/EMS
Drawn: SNW
Check: JPM

C18
SHEET 21 OF 37

2020/10/20 8:31 AM By: Shelby West J:\JDS-Hydro\Project Files\102 Widefield Water And San\102.121 Rolling Hills Tank\Drawings\Working\102121_Drainage.dwg

VIVID Engineering Group, Inc. 1053 Elkton Drive Colorado Springs, Colorado 80907 719.896.4356	Project No: D20-2-282 Date: December 28, 2020 Drawn by: MBR Reviewed by : BTM	**BORING LOCATION PLAN - CONCEPTUAL** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	Figure **4**

Appendix A

Logs of Exploratory Borings

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Fax: 719-896-4357

KEY TO SYMBOLS

CLIENT JDS-Hydro Consultants, Inc.

PROJECT NAME Proposed Rolling Hills Water Tank

PROJECT NUMBER D20-2-282

PROJECT LOCATION El Paso County, Colorado

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)


SANDSTONE


SC: USCS Clayey Sand


SHALE


SM: USCS Silty Sand


WEATHERED SANDSTONE

SAMPLER SYMBOLS


Grab Sample


2" I.D. Modified California Sampler (MC)


Standard Penetration Test (SPT)

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
MC - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
FINES- PERCENT PASSING NO. 200 SIEVE
UCS - UNCONFINED COMPRESSIVE STRENGTH


Water Level at Time of Drilling, or as Shown


Water Level at End of Drilling, or as Shown


Water Level After 24 Hours, or as Shown

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BORING NUMBER B-1

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5976 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Weathered SANDSTONE, olive brown, slightly moist, hard
	SPT	30-30-35 (65)	MC = 6.0% LL = NP PL = NP Fines = 23.0%		
	GB				
				3.0	5973.0
	MC	50/6"	Swell = 0.3% when wetted under 1,000 psf load		**Pierre Shale Formation** Silty-Clayey SANDSTONE interbedded with CLAYSTONE, olive to olive brown and rust, moist, very hard
5					
	MC	50/2"	MC = 14.8%		
10					
	MC	50/2"	MC = 9.6% LL = 22 PL = 17 Fines = 29.0%		
15					
	MC	50/1"			
20					
	MC	50/1"			
25					
	MC	50/3"		29.0	5947.0
				29.3	5946.7
					Pierre Shale Formation SHALE, dark gray, moist, very hard
					Bottom of borehole at 29.3 feet.

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BORING NUMBER B-2

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5975 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB		MC = 13.7% LL = 25 PL = 19 Fines = 35.0%		Weathered SANDSTONE, olive, dry to slightly moist, medium hard based on drill rig observations
	MC	50/5"		2.0	5973.0
					Pierre Shale Formation Silty SANDSTONE, olive to yellowish brown, slightly moist to moist, very hard
5	SPT	32-34-27 (61)			
	MC	50/4"	MC = 13.2% DD = 104.7 pcf LL = NP PL = NP		
	MC	50/2"	MC = 10.8% LL = NP PL = NP Fines = 26.0%		
10					
	MC	50/2"	No movement when wetted under 1,000 psf load		
15					
	MC	50/1"			
20					
				24.0	5951.0
	MC	50/3"			**Pierre Shale Formation** SHALE, dark gray, slightly moist, very hard
25					
	MC	50/3"		29.2	5945.8
					Bottom of borehole at 29.2 feet.

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BORING NUMBER B-3

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5976 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Weathered SANDSTONE, olive, slightly moist, medium hard
	SPT	12-17-24 (41)	MC = 7.3% LL = 25 PL = 20 Fines = 28.0%		
	GB				
	MC	50/4"	MC = 11.1% DD = 106.5 pcf LL = 26 PL = 21 Fines = 31.0%		
10	MC	50/4"	Swell = 0.5% when wetted under 1,000 psf load		
	MC	50/2"			
20	MC	50/3"	Swell = 0.1% when wetted under 1,000 psf load		
					3.5 — 5972.5 **Pierre Shale Formation** Silty-Clayey SANDSTONE interbedded with CLAYSTONE, olive and yellowish brown with rust, slightly moist to moist, very hard
					25.0 — 5951.0 **Pierre Shale Formation** SHALE, dark gray, moist, very hard, with highly cemented layers
30	MC	50/2"			
40	MC	50/3"			
					-Highly cemented layer encountered at about 45 feet. Drill rig refusal due to melted bit occurred from multiple attempts to advance boring.
					45.0 — 5931.0

Refusal at 45.0 feet.
Bottom of borehole at 45.0 feet.

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BORING NUMBER B-4

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5975 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Weathered SANDSTONE, olive, slightly moist, medium hard based on drill rig observations
	SPT	50/6"	Chloride = 0.0006%, pH = 4.2, Redox Potential = 455.2 mv, Resistivity = 1656 ohm.cm, Sulfate = 0.029%, Sulfide = Negative		2.0 5973.0 **Pierre Shale Formation** Silty SANDSTONE, olive and yellowish brown, slightly moist, very hard
5					
	MC	50/2"	MC = 9.1% LL = NP PL = NP Fines = 28.0%		
10					
15					
	MC	50/2"			
20					
					24.0 5951.0 **Pierre Shale Formation** SHALE, dark gray, moist, very hard
25					
	MC	50/3"			29.3 5945.7 Bottom of borehole at 29.3 feet.

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BORING NUMBER B-5

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5975 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Weathered SANDSTONE, olive, slightly moist, medium hard based on drill rig observations
2.5					5972.5
					Pierre Shale Formation
5	MC	50/9"	Swell = 1.3% when wetted under 500 psf load		Silty-Clayey SANDSTONE interbedded with CLAYSTONE, olive to yellowish brown, slightly moist to moist, hard to very hard
					-well cemented layer encountered from approximately 7 to 7.5 feet below ground surface
10					
15	MC	50/3"	MC = 16.8% DD = 98.7 pcf LL = 27 PL = 20 Fines = 41.0%		
15.0					5960.0
					Pierre Shale Formation
					SHALE, dark gray, moist, very hard, with highly cemented layers
20					
25	MC	50/3"			
29.0					5946.0

Bottom of borehole at 29.0 feet.

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BORING NUMBER B-6

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5975 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Clayey SAND, olive, slightly moist, medium dense
	MC	15-15	MC = 5.7% DD = 96.9 pcf		
	SPT	10-9-9 (18)	MC = 6.7% LL = 24 PL = 16 Fines = 40.0%		
	GB				
5	MC	7-8	Compression = 2.7% when wetted under 1,000 psf load, Chloride = 0.0097 %, pH = 7.3, Redox Potential = 369.6 mv, Resistivity = 490 ohm.cm, Sulfate = 0.271%, Sulfide = Negative		6.0 5969.0 Silty SAND, light brown, slightly moist, medium dense
	SPT	5-6-8 (14)			8.0 5967.0
	MC	50/5"			**Pierre Shale Formation** SANDSTONE, yellowish brown, olive, and reddish brown, slightly moist, very hard
10			MC = 7.6% LL = 22 PL = 19 Fines = 28.0%		
	MC	50/3"			
15			MC = 5.7% DD = 102.2 pcf		
					-well cemented layer encountered from approximately 18 to 18.5 feet below ground surface
	MC	50/2"			
20					
	MC	50/3"			
25					
	MC	50/2"			29.2 5945.8 Bottom of borehole at 29.2 feet.

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BORING NUMBER B-7

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/30/20 **COMPLETED** 1/30/20
GROUND ELEVATION 5975 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY A. Al Eyoon **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB				Clayey SAND, olive, slightly moist, medium dense
	MC	9-9			
	SPT	11-9-7 (16)	MC = 5.4% LL = 24 PL = 16 Fines = 39.0%		
	GB				
5	MC	15-25	MC = 8.9% DD = 108.6 pcf Compression = 1.6% when wetted under 1,000 psf load		3.5 5971.5 Weathered SANDSTONE, olive, slightly moist, medium hard 5.0 5970.0
	SPT	30-50			**Pierre Shale Formation** SANDSTONE interbedded with CLAYSTONE, olive brown, slightly moist, hard to very hard
10	MC	50/3"	MC = 16.6% LL = 33 PL = 19 Fines = 61.0%		
15	MC	50/6"	MC = 11.0% DD = 105.1 pcf		
20	MC	50/1"			
25	MC	50/2"			24.0 5951.0 **Pierre Shale Formation** SHALE, dark gray, slightly moist, very hard
	MC	50/3"			29.2 5945.8 Bottom of borehole at 29.2 feet.

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BORING NUMBER B-8

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 12/23/20 **COMPLETED** 12/23/20
GROUND ELEVATION 5973 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR GDI Drilling, Inc. (Diedrich D-90 Truck)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY M. Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					**Pierre Shale Formation** Weathered SANDSTONE, light brown, slightly moist, medium hard
	SPT	7-5-4 (9)			
3.0					5970.0
					Pierre Shale Formation SANDSTONE, moderately cemented with well-cemented layers, yellowish-brown, slightly moist, very hard
	SPT	50/1"	MC = 11.6% LL = NP PL = NP Fines = 31.0%		
5					
	SPT	50/5"			
	SPT	50/5"			
10					
14.2	SPT	50/2"			5958.8

Bottom of borehole at 14.2 feet.

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BORING NUMBER B-9

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 12/23/20 **COMPLETED** 12/23/20
GROUND ELEVATION 5966 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR GDI Drilling, Inc. (Diedrich D-90 Truck)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY M. Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					**Pierre Shale Formation** Weathered SANDSTONE, yellowish-brown, slightly moist, medium hard to hard based on drilling observation
	SPT	50/10"			
2.5					5963.5
					Pierre Shale Formation SANDSTONE, light brown, gray, slightly moist to moist, hard
	SPT	50/11"			
5					
	SPT	50/10"	MC = 16.4% LL = 34 PL = 24 Fines = 36.0%		
	SPT	50/8"			
10					
	SPT	50/8"			
14.7					5951.3

Bottom of borehole at 14.7 feet.

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BORING NUMBER B-10

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 12/23/20 **COMPLETED** 12/23/20
GROUND ELEVATION 5955 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR GDI Drilling, Inc. (Diedrich D-90 Truck)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY M. Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					Silty SAND, yellowish-brown, slightly moist	
					1.0	5954.0
					Pierre Shale Formation Weathered SANDSTONE, yellowish-brown, grayish-brown, slightly moist, medium hard	
	SPT	7-14-28 (42)	MC = 9.4% LL = NP PL = NP Fines = 26.0%			
					4.5	5950.5
5	SPT	20-25-25 (50)			**Pierre Shale Formation** SANDSTONE, light gray, yellowish-brown, hard	
	SPT	50/10"				
10	SPT	50/10"				
	SPT	50/10"				
					14.8	5940.2

Bottom of borehole at 14.8 feet.

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BORING NUMBER B-11

CLIENT JDS-Hydro Consultants, Inc.
PROJECT NAME Proposed Rolling Hills Water Tank
PROJECT NUMBER D20-2-282
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 12/23/20 **COMPLETED** 12/23/20
GROUND ELEVATION 5958.5 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR GDI Drilling, Inc. (Diedrich D-90 Truck)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY M. Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Silty SAND, yellowish-brown, slightly moist, medium dense to loose
	SPT	7-5-6 (11)			
5	SPT	5-4-5 (9)	MC = 4.9% LL = NP PL = NP Fines = 19.0%		
	SPT	6-3-3 (6)			
10	SPT	5-3-5 (8)			
15	SPT	5-3-4 (7)			
15.5					5943.0

Bottom of borehole at 15.5 feet.

Appendix B

Geotechnical Laboratory Test Results

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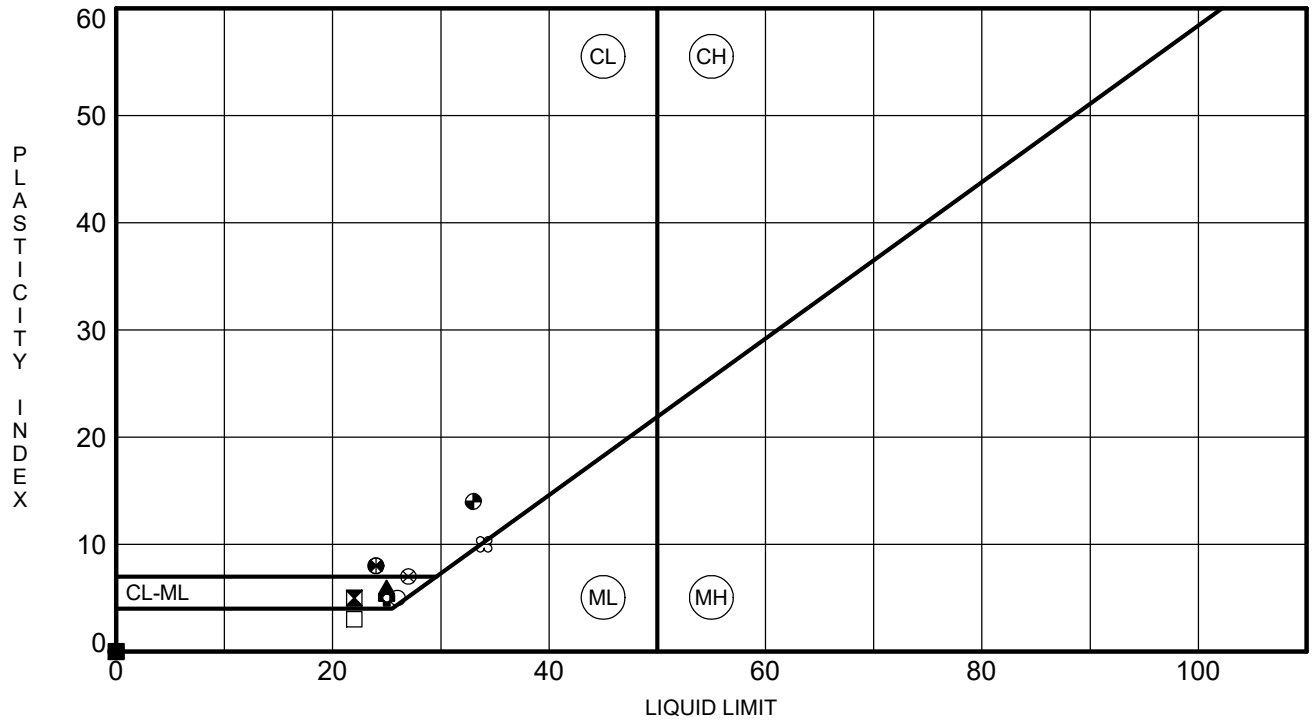
ATTERBERG LIMITS' RESULTS

CLIENT JDS-Hydro Consultants, Inc. **PROJECT NAME** Proposed Rolling Hills Water Tank

PROJECT NUMBER D20-2-282 **PROJECT LOCATION** El Paso County, Colorado



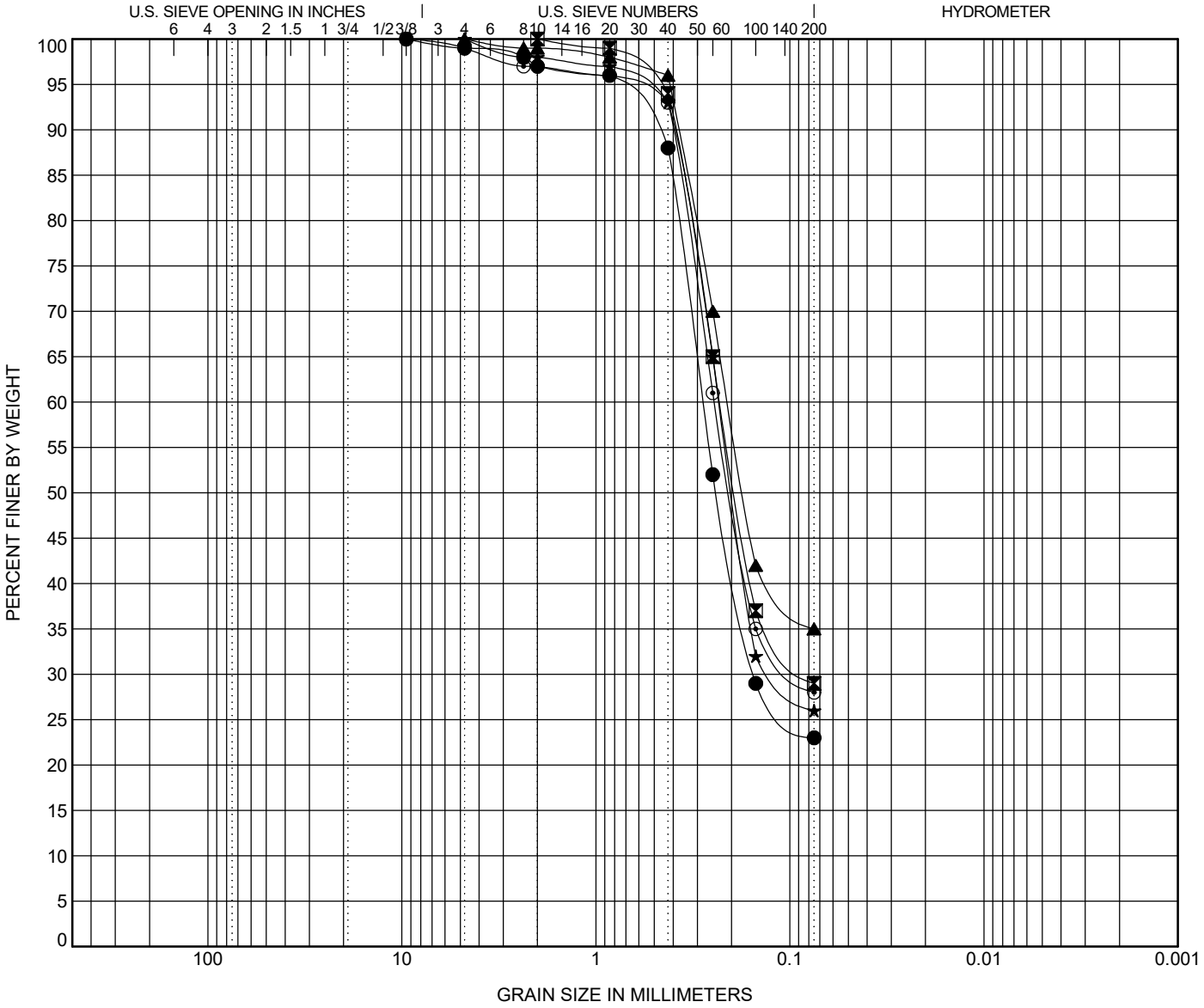
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	B-1	1.0	NP	NP	NP	23	SILTY SAND(SM) / WEATHERED SANDSTONE
⊠	B-1	14.0	22	17	5	29	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE
▲	B-2	0.0	25	19	6	35	SILTY, CLAYEY SAND(SC-SM) / WEATHERED SANDSTONE
★	B-2	7.0	NP	NP	NP		SANDSTONE
⊙	B-2	9.0	NP	NP	NP	26	SILTY SAND(SM) / SANDSTONE
✿	B-3	1.0	25	20	5	28	SILTY, CLAYEY SAND(SC-SM) / WEATHERED SANDSTONE
○	B-3	4.0	26	21	5	31	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE
△	B-4	9.0	NP	NP	NP	28	SILTY SAND(SM) / SANDSTONE
⊗	B-5	14.0	27	20	7	41	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE
⊕	B-6	2.0	24	16	8	40	CLAYEY SAND(SC)
□	B-6	7.0	22	19	3	28	SILTY SAND(SM)
⊛	B-7	2.0	24	16	8	39	CLAYEY SAND(SC)
◕	B-7	7.0	33	19	14	61	SANDY LEAN CLAY(CL) / CLAYSTONE
☆	B-8	4.0	NP	NP	NP	31	SILTY SAND(SM)/ SANDSTONE
⊠	B-9	7.0	34	24	10	36	SILTY SAND(SM) / SANDSTONE
■	B-10	2.0	NP	NP	NP	26	SILTY SAND(SM) / WEATHERED SANDSTONE
◆	B-11	4.0	NP	NP	NP	19	SILTY SAND(SM)

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

GRAIN SIZE DISTRIBUTION

CLIENT JDS-Hydro Consultants, Inc. **PROJECT NAME** Proposed Rolling Hills Water Tank

PROJECT NUMBER D20-2-282 **PROJECT LOCATION** El Paso County, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE		DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-1	1.0	SILTY SAND(SM) / WEATHERED SANDSTONE	NP	NP	NP		
⊠	B-1	14.0	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE	22	17	5		
▲	B-2	0.0	SILTY, CLAYEY SAND(SC-SM) / WEATHERED SANDSTONE	25	19	6		
★	B-2	9.0	SILTY SAND(SM) / SANDSTONE	NP	NP	NP		
⊙	B-3	1.0	SILTY, CLAYEY SAND(SC-SM) / WEATHERED SANDSTONE	25	20	5		

BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	1.0	9.5	0.281	0.153		1.0	76.0	23.0	
⊠	B-1	14.0	2	0.228	0.082		0.0	71.0	29.0	
▲	B-2	0.0	4.75	0.208			0.0	65.0	35.0	
★	B-2	9.0	4.75	0.231	0.119		0.0	74.0	26.0	
⊙	B-3	1.0	9.5	0.245	0.091		1.0	71.0	28.0	

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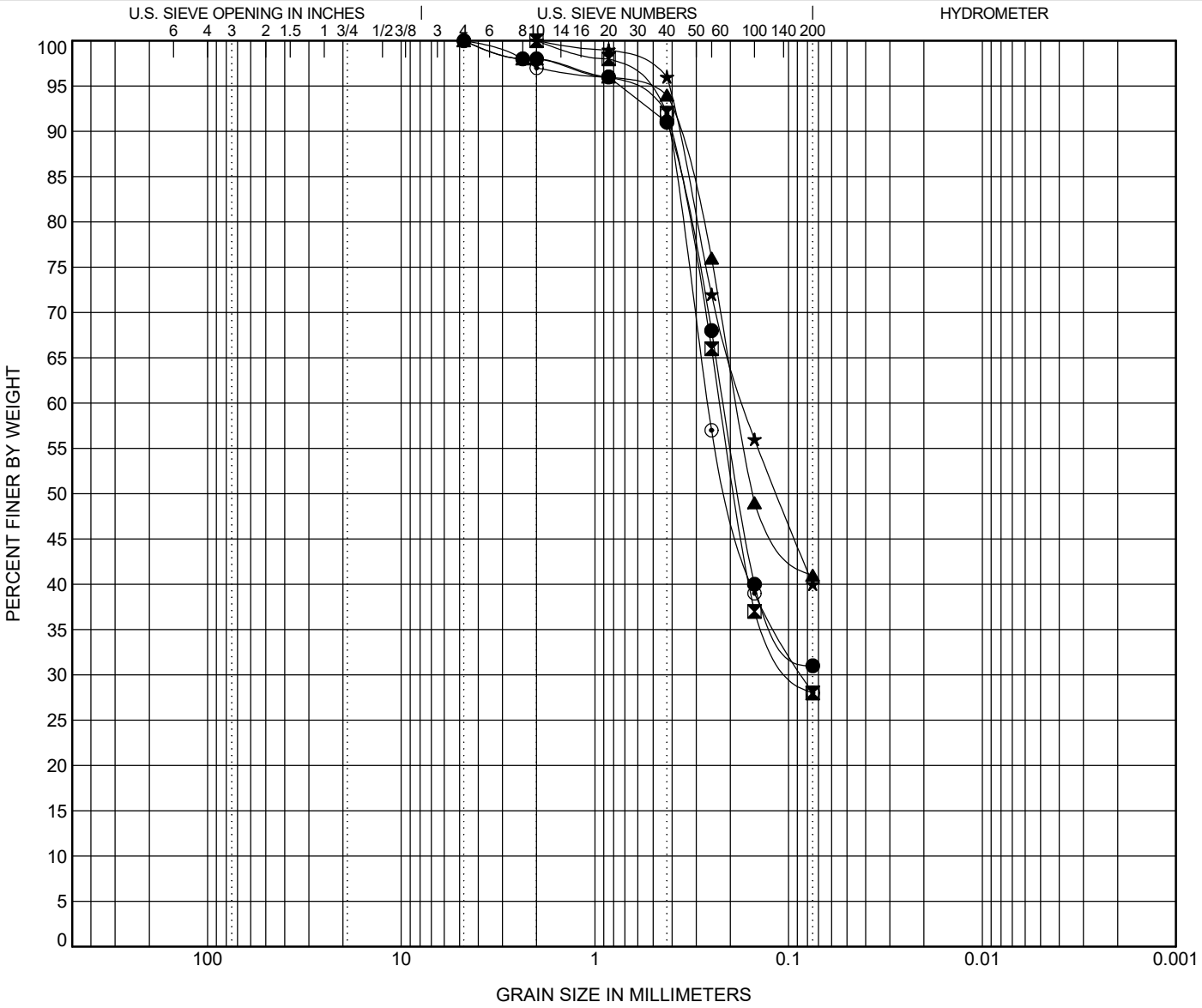
PROJECT NUMBER D20-2-282 **PROJECT LOCATION** El Paso County, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
● B-3	4.0	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE	26	21	5		
⊠ B-4	9.0	SILTY SAND(SM) / SANDSTONE	NP	NP	NP		
▲ B-5	14.0	SILTY, CLAYEY SAND(SC-SM) / SANDSTONE	27	20	7		
★ B-6	2.0	CLAYEY SAND(SC)	24	16	8		
⊙ B-6	7.0	SILTY SAND(SM)	22	19	3		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-3	4.0	4.75	0.216			0.0	69.0	31.0	
⊠ B-4	9.0	2	0.225	0.087		0.0	72.0	28.0	
▲ B-5	14.0	4.75	0.185			0.0	59.0	41.0	
★ B-6	2.0	2	0.17			0.0	60.0	40.0	
⊙ B-6	7.0	4.75	0.262	0.085		0.0	72.0	28.0	

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GRAIN SIZE DISTRIBUTION

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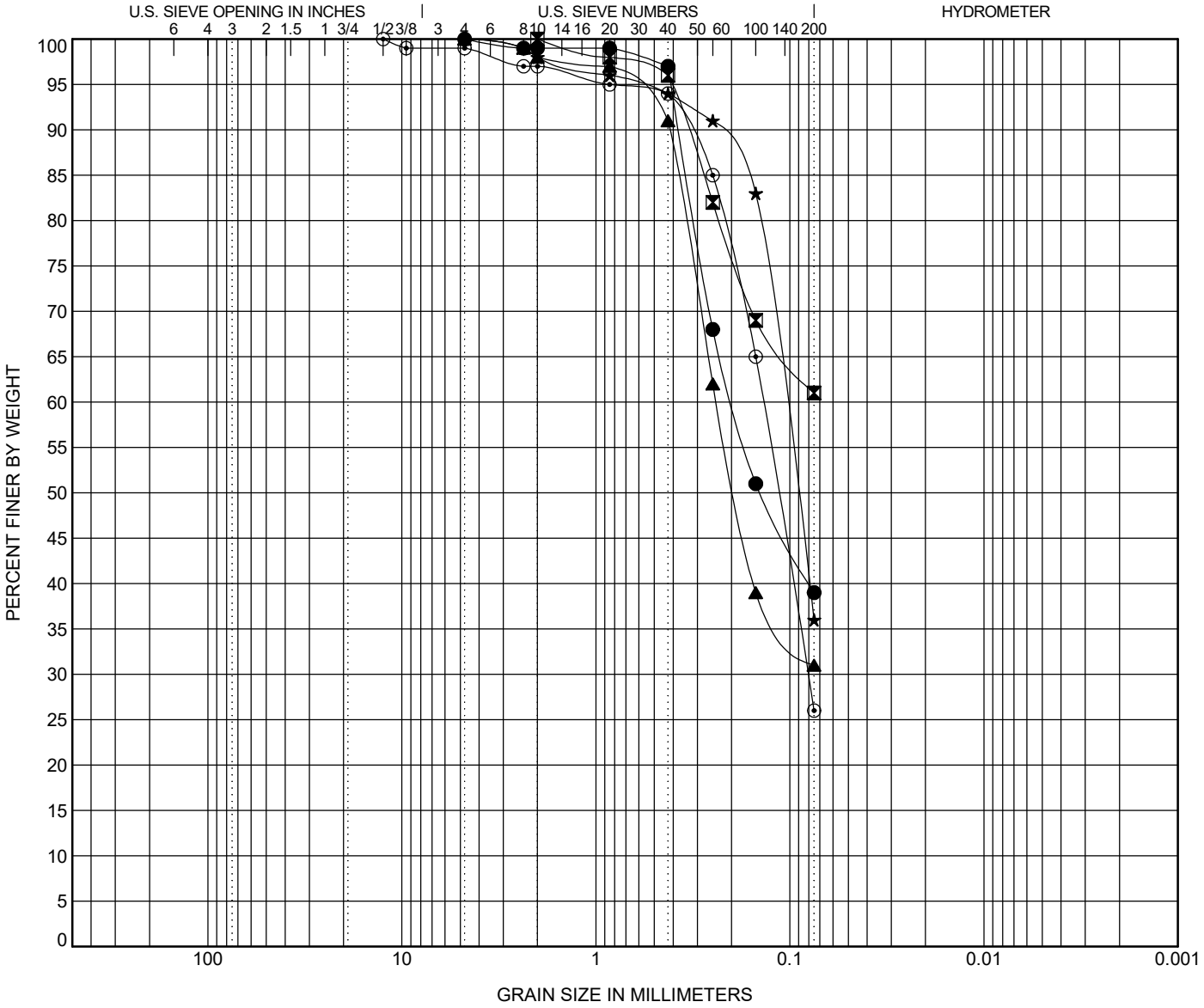

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-7	2.0	CLAYEY SAND(SC)	24	16	8		
⊠	B-7	7.0	SANDY LEAN CLAY(CL) / CLAYSTONE	33	19	14		
▲	B-8	4.0	SILTY SAND(SM) / SANDSTONE	NP	NP	NP		
★	B-9	7.0	SILTY SAND(SM) / SANDSTONE	34	24	10		
⊙	B-10	2.0	SILTY SAND(SM) / WEATHERED SANDSTONE	NP	NP	NP		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-7	2.0	4.75	0.197			0.0	61.0	39.0	
⊠	B-7	7.0	2				0.0	39.0	61.0	
▲	B-8	4.0	4.75	0.239			0.0	69.0	31.0	
★	B-9	7.0	4.75	0.107			0.0	64.0	36.0	
⊙	B-10	2.0	12.5	0.137	0.081		1.0	73.0	26.0	

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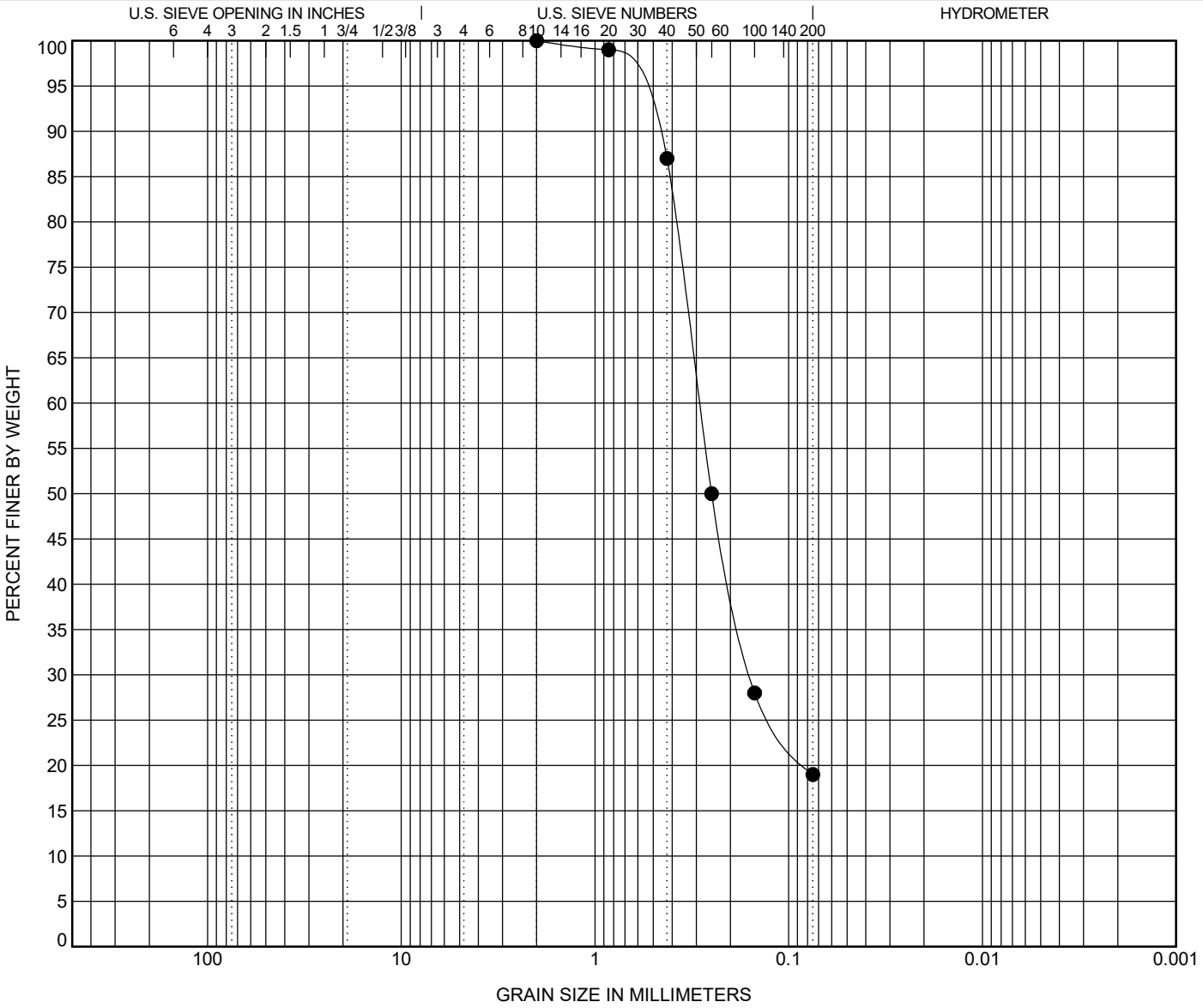
PROJECT NUMBER D20-2-282 **PROJECT LOCATION** El Paso County, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
● **B-11**	**4.0**	**SILTY SAND(SM)**	**NP**	**NP**	**NP**		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-11**	**4.0**	**2**	**0.289**	**0.157**		**0.0**	**81.0**	**19.0**	

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Colorado Springs, Colorado 80907
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SUMMARY OF LABORATORY RESULTS

CLIENT JDS-Hydro Consultants, Inc. **PROJECT NAME** Proposed Rolling Hills Water Tank

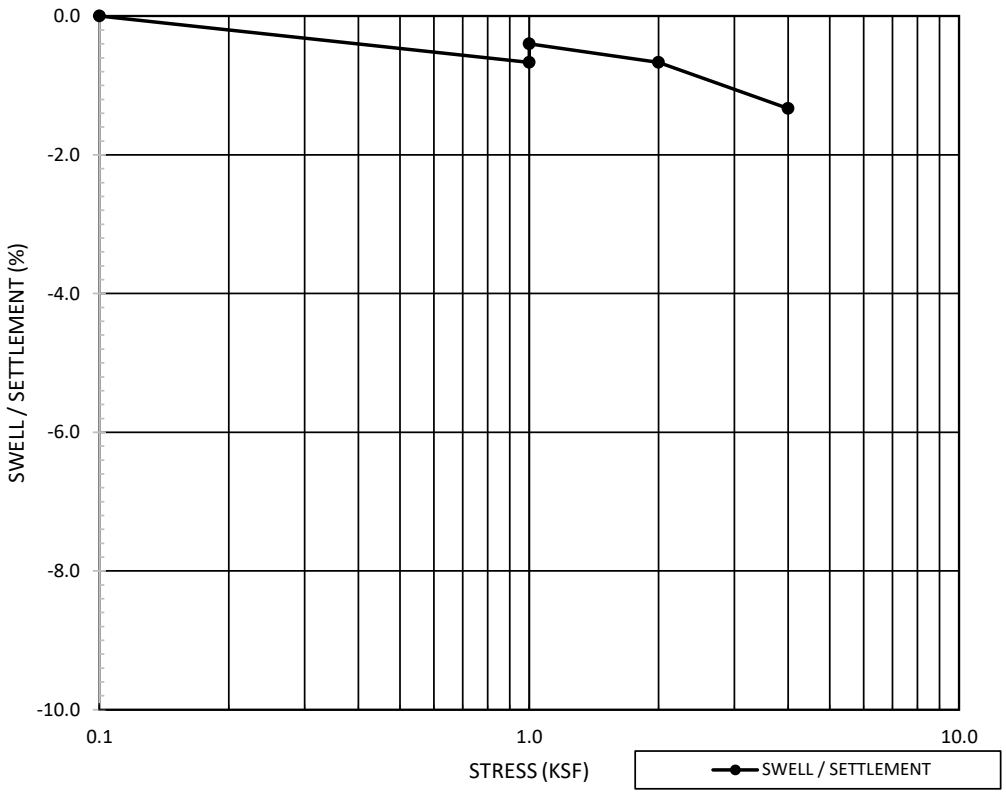
PROJECT NUMBER D20-2-282 **PROJECT LOCATION** El Paso County, Colorado

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)		
B-1	1.0	NP	NP	NP	9.5	23	SM	6.0			
B-1	9.0							14.8			
B-1	14.0	22	17	5	2	29	SC-SM	9.6			
B-2	0.0	25	19	6	4.75	35	SC-SM	13.7			
B-2	7.0	NP	NP	NP				13.2	104.7		
B-2	9.0	NP	NP	NP	4.75	26	SM	10.8			
B-3	1.0	25	20	5	9.5	28	SC-SM	7.3			
B-3	4.0	26	21	5	4.75	31	SC-SM	11.1	106.5		
B-4	9.0	NP	NP	NP	2	28	SM	9.1			
B-5	14.0	27	20	7	4.75	41	SC-SM	16.8	98.7		
B-6	1.0							5.7	96.9		
B-6	2.0	24	16	8	2	40	SC	6.7			
B-6	7.0	22	19	3	4.75	28	SM	7.6			
B-6	9.0							5.7	102.2		
B-7	2.0	24	16	8	4.75	39	SC	5.4			
B-7	4.0							8.9	108.6		
B-7	7.0	33	19	14	2	61	CL	16.6			
B-7	14.0							11.0	105.1		
B-8	4.0	NP	NP	NP	4.75	31	SM	11.6			
B-9	7.0	34	24	10	4.75	36	SM	16.4			
B-10	2.0	NP	NP	NP	12.5	26	SM	9.4			
B-11	4.0	NP	NP	NP	2	19	SM	4.9			

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/3/2020
Project No.:	D20-2-282		
Boring ID.:	B-1	**Sample Depth (ft)**	4
Sample Description:	Sandstone, Clayey, Iron Oxide Stain, Calc Deposits, Light Red Gray		

	%
Swell @ Wetting Weight:	**0.3**

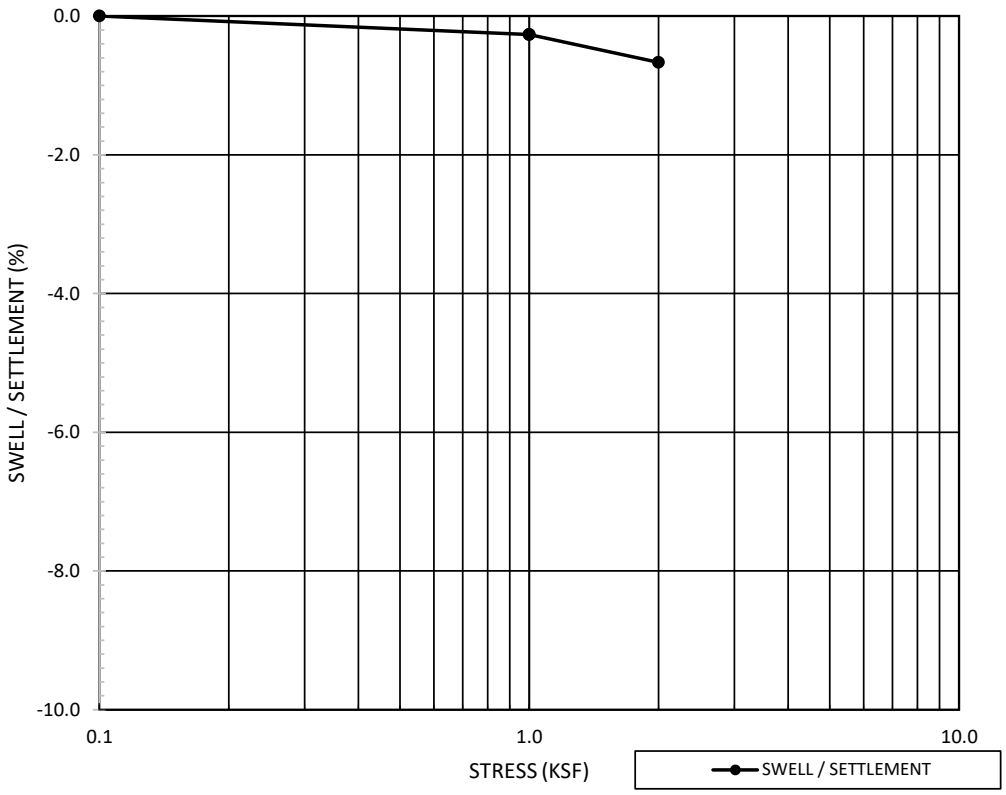


Initial Condition	
Moisture Content %	**14.1**
Dry Density (pcf)	**108.0**
Post-Swell Condition	
Moisture Content %	**19.0**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/3/2020
Project No.:	D20-2-282		
Boring ID.:	B-2	**Sample Depth (ft)**	14
Sample Description:	Sand, Clayey, Iron Oxide Stain, Sl Moist, Gray Reddish Brown		

	%
No Movement @ Wetting Weight:	**0.0**

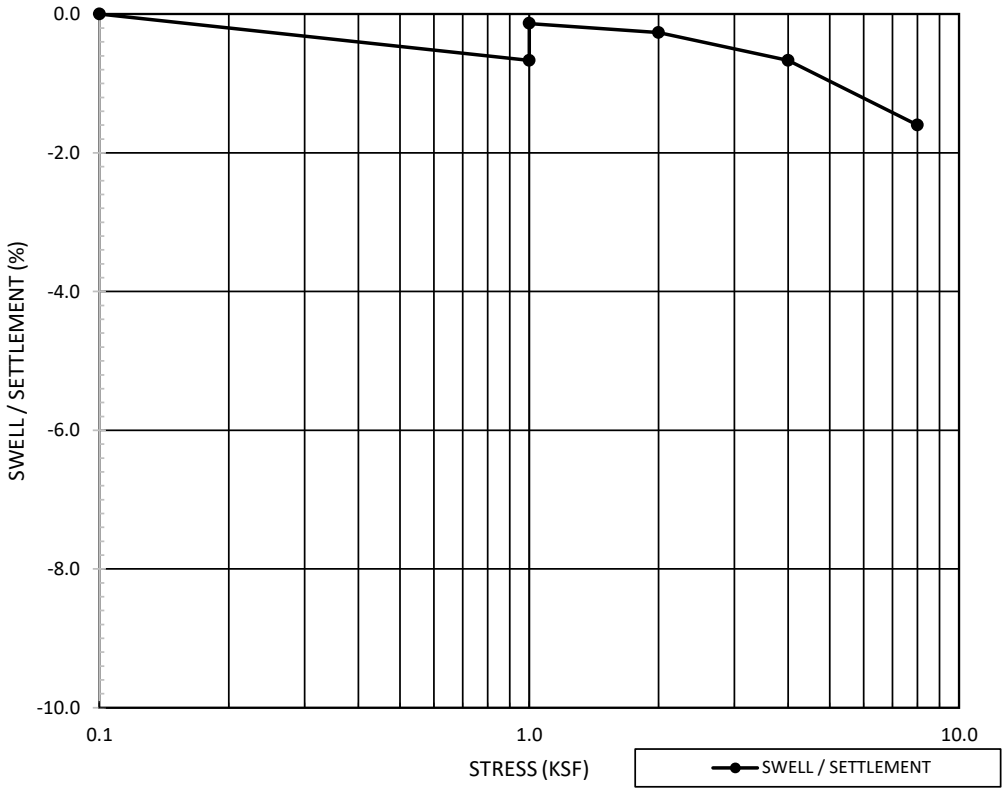


Initial Condition	
Moisture Content %	**15.5**
Dry Density (pcf)	**100.2**
Post-Swell Condition	
Moisture Content %	**23.1**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/3/2020
Project No.:	D20-2-282		
Boring ID.:	B-3	**Sample Depth (ft)**	9
Sample Description:	Clay, Sandy, Iron oxide stain, Calc deposits, Sl Moist, Gray & Red		

	%
Swell @ Wetting Weight:	**0.5**

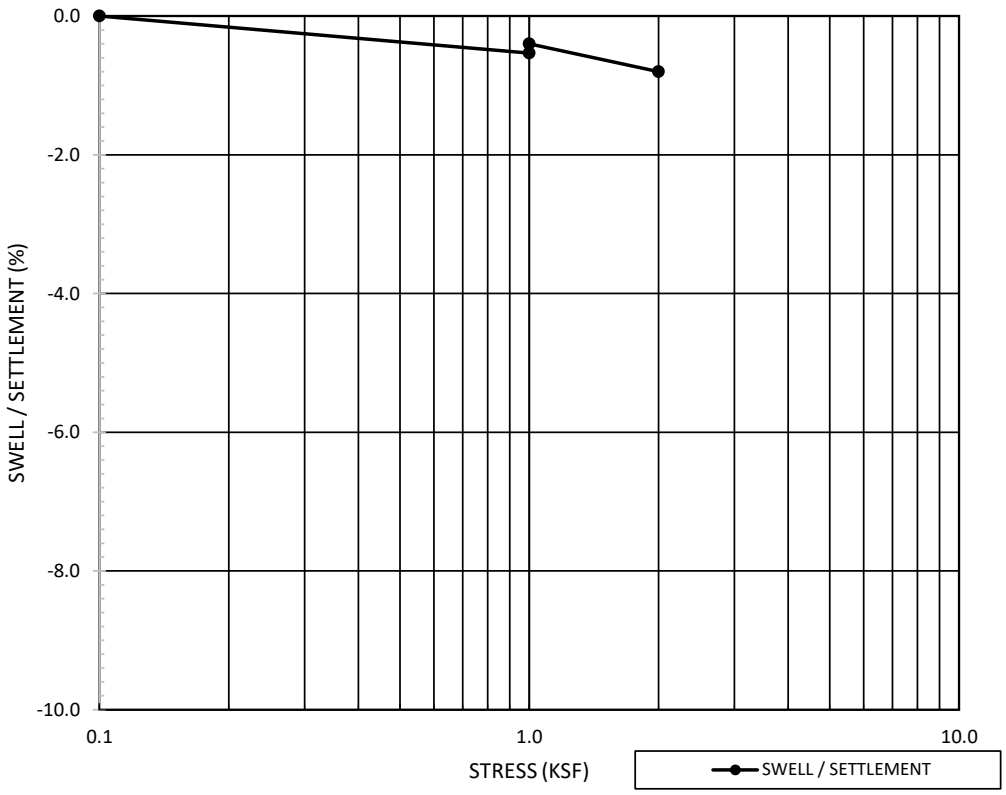


Initial Condition	
Moisture Content %	**16.8**
Dry Density (pcf)	**109.9**
Post-Swell Condition	
Moisture Content %	**21.1**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/3/2020
Project No.:	D20-2-282		
Boring ID.:	B-3	**Sample Depth (ft)**	19
Sample Description:	Clay, Sandy, Iron oxide stain, Moist, Gray Brown		

	%
Swell @ Wetting Weight:	**0.1**

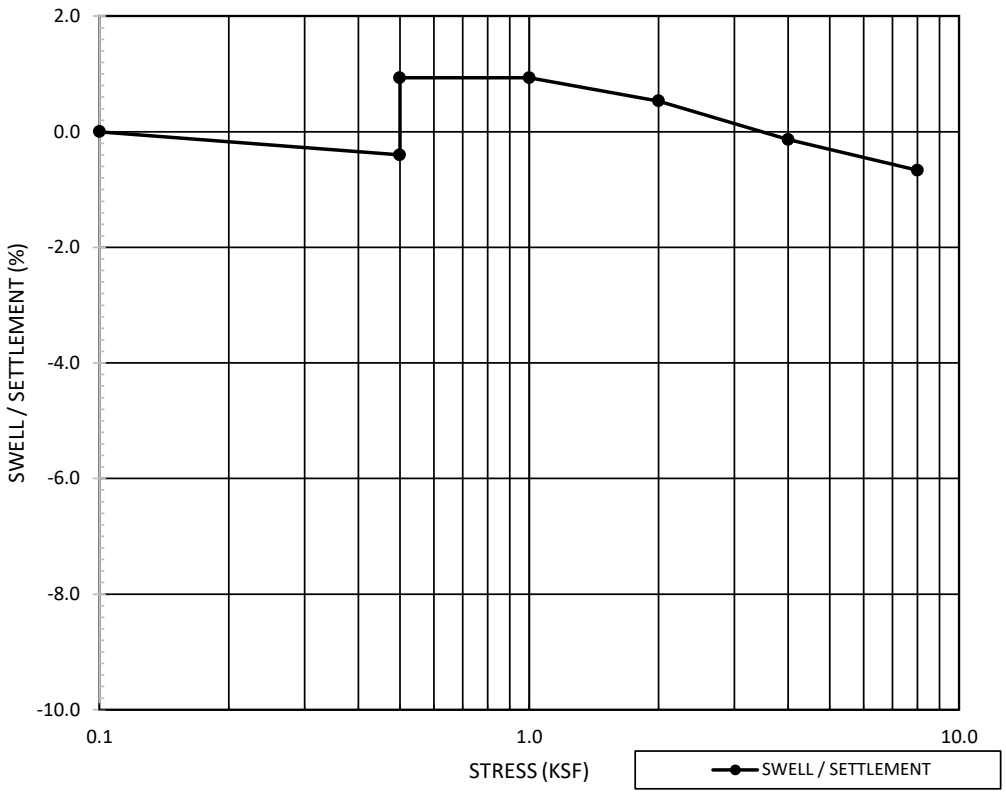


Initial Condition	
Moisture Content %	**16.3**
Dry Density (pcf)	**99.5**
Post-Swell Condition	
Moisture Content %	**25.2**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/6/2020
Project No.:	D20-2-282		
Boring ID.:	B-5	**Sample Depth (ft)**	4
Sample Description:	Gray claystone over sandstone, Iron oxide stain, calc deposits		

	%
Swell @ Wetting Weight:	**1.3**

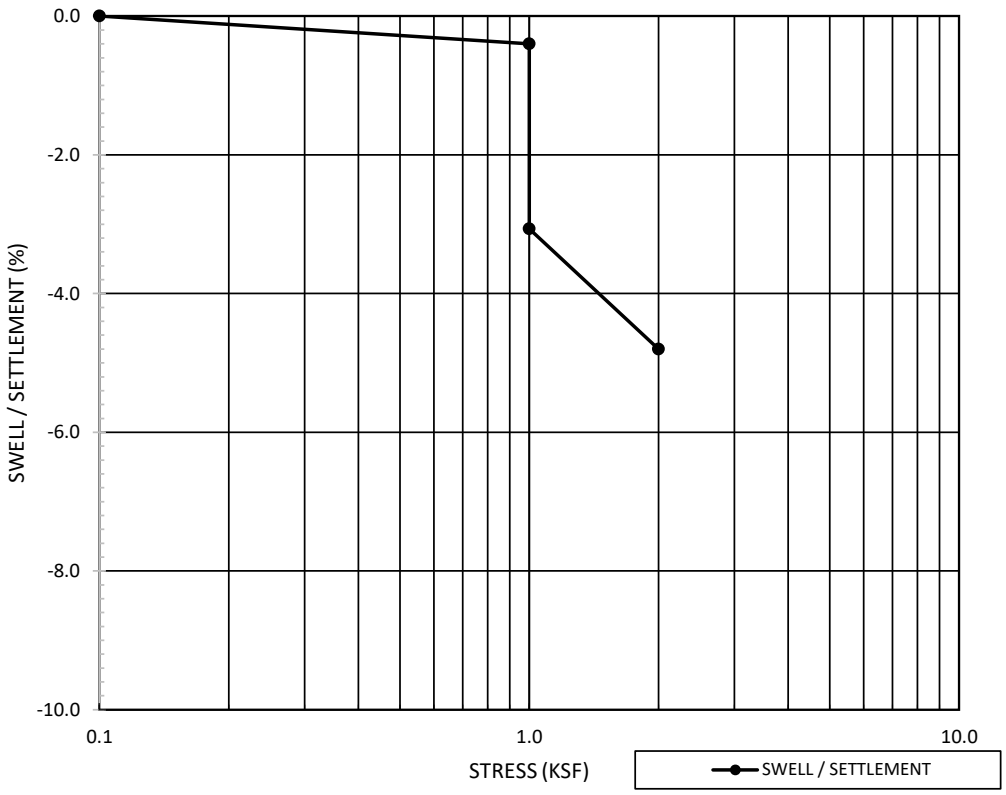


Initial Condition	
Moisture Content %	**17.4**
Dry Density (pcf)	**104.5**
Post-Swell Condition	
Moisture Content %	**22.3**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/6/2020
Project No.:	D20-2-282		
Boring ID.:	B-6	**Sample Depth (ft)**	4
Sample Description:	Sand, Slightly Clayey, Brown		

	%
Compression @ Wetting Weight:	**-2.7**

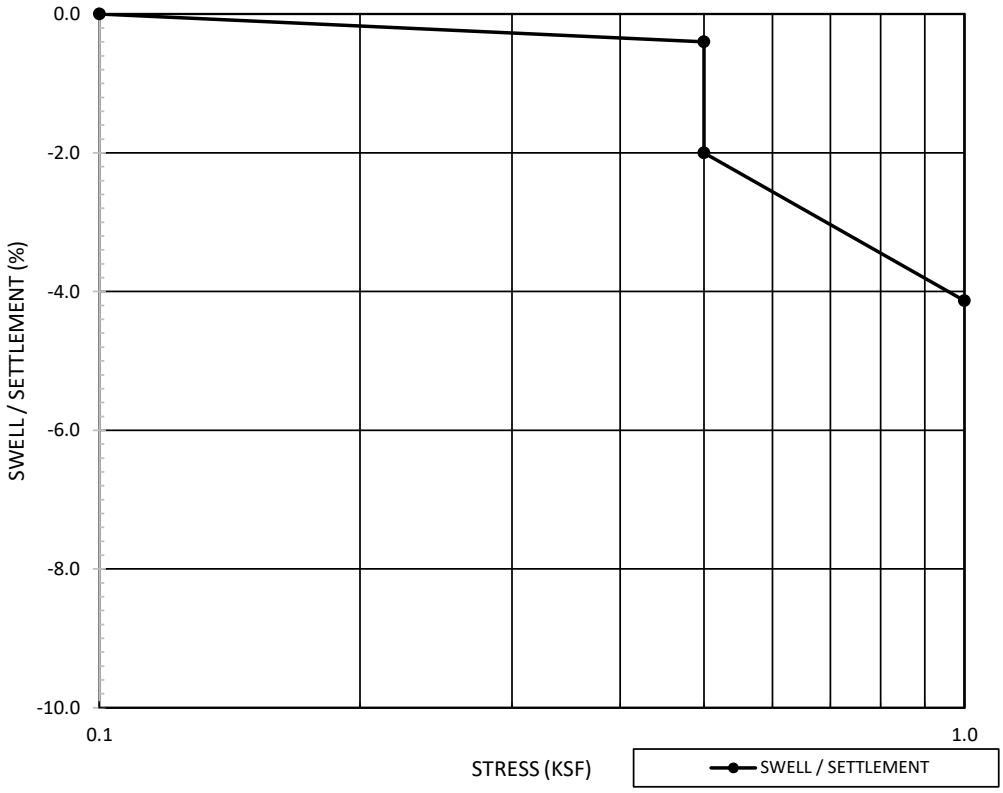


Initial Condition	
Moisture Content %	**8.1**
Dry Density (pcf)	**95.7**
Post-Swell Condition	
Moisture Content %	**22.4**

VIVID Engineering Group, Inc.

Project Name:	Rolling Hills Tank	**Date**	2/6/2020
Project No.:	D20-2-282		
Boring ID.:	B-7	**Sample Depth (ft)**	4
Sample Description:	Sand, Silty, Light Brown Dry		

	%
Compression @ Wetting Weight:	**-1.6**



Initial Condition	
Moisture Content %	**6.3**
Dry Density (pcf)	**91.2**
Post-Swell Condition	
Moisture Content %	**25.2**

Appendix C

Analytical Laboratory Test Results

Colorado Analytical LABORATORIES, INC.

Analytical Results

TASK NO: 200212060

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs CO 80907

Task No.: 200212060
Client PO:
Client Project: Rolling Hills Tank D20-2-282

Date Received: 2/12/20
Date Reported: 2/19/20
Matrix: Soil - Geotech

Customer Sample ID B-4 @ 2Ft
Lab Number: 200212060-01

Test	Result	Method
Chloride - Water Soluble	**0.0006 %**	AASHTO T291-91/ ASTM D4327
pH	**4.2 units**	AASHTO T289-91
Redox Potential	**455.2 mv**	ASTM D1498
Resistivity	**1656 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.029 %**	CDOT CP-L 2103 / ASTM D4327
Sulfide	**Negative**	AWWA C105

Customer Sample ID B-6 @ 4Ft
Lab Number: 200212060-02

Test	Result	Method
Chloride - Water Soluble	**0.0097 %**	AASHTO T291-91/ ASTM D4327
pH	**7.3 units**	AASHTO T289-91
Redox Potential	**369.6 mv**	ASTM D1498
Resistivity	**490 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.271 %**	CDOT CP-L 2103 / ASTM D4327
Sulfide	**Negative**	AWWA C105

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

DATA APPROVED FOR RELEASE BY

Appendix D

Site Photos

DRILLING BORING B-1 - LOOKING NORTHWEST

DRILLING BORING B-2 - LOOKING NORTHEAST

VIVID Engineering Group	Project No: D20-2-282 Date: 2/6/2020 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	FIGURE **D-1**

DRILLING BORING B-3 - LOOKING NORTH

DRILLING BORING B-4 - LOOKING WEST

VIVID Engineering Group	Project No: D20-2-282 Date: 2/6/2020 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	FIGURE **D-2**

DRILLING BORING B-5 - LOOKING NORTH

DRILLING BORING B-6- LOOKING NORTHWEST

VIVID Engineering Group	Project No: D20-2-282 Date: 2/6/2020 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	FIGURE **D-3**

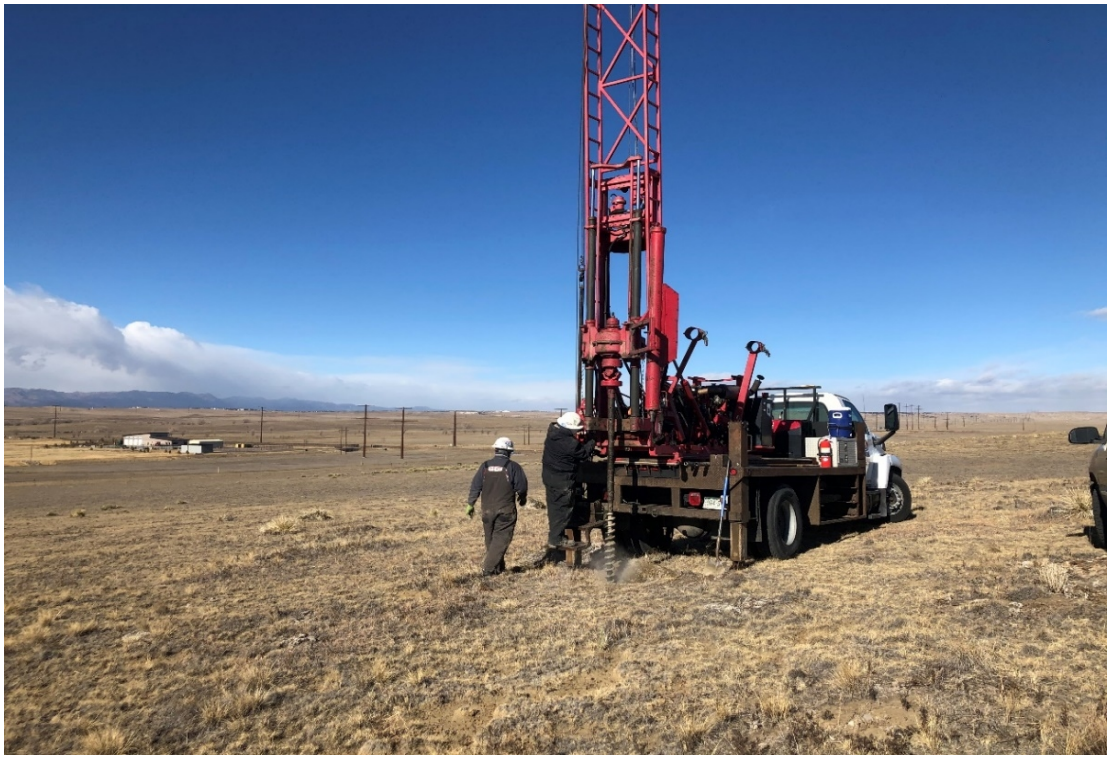
DRILLING BORING B-7 - LOOKING NORTHEAST

VIVID Engineering Group	Project No: D20-2-282 Date: 2/6/2020 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	FIGURE **D-4**

DRILLING BORING B-8 - LOOKING NORTH

DRILLING BORING B-9 - LOOKING NORTHWEST

VIVID Engineering Group	Project No: D20-2-282 Date: 1/4/2021 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Rolling Hills Water Tank Vicinity of Drennan Road and Mockingbird Lane El Paso County, Colorado	FIGURE **D-5**



DRILLING BORING B-10 - LOOKING NORTHWEST

DRILLING BORING B-11 - LOOKING NORTH

VIVID Engineering Group	Project No: D20-2-282	**SITE PHOTOS**	FIGURE
	Date: 1/4/2021	Proposed Rolling Hills Water Tank	**D-6**
	Drawn by: MBR	Vicinity of Drennan Road and Mockingbird Lane	
	Reviewed by: WJB	El Paso County, Colorado	

Appendix E

Important Information About This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering 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 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. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- 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;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the 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. *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.*

This Report May Not Be Reliable

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

- for a different client;
- for a different project;
- 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, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been 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 your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed*. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment 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 from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

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 judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed 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.*

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 full-time 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 on hand quickly 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 observation.

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've included the material for informational 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, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. 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.

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. 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.

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 relate any 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 yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

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, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled 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.***

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